FINAL TECHNICAL REPORT

USES OF THE INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM MELBOURNE, FLORIDA

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TABLE OF CONTENTS

TABLE OF CONTENTS, Continued

TABLE OF CONTENTS, Continued

LIST OF TABLES

LIST OF TABLES, Continued

LIST OF FIGURES

LIST OF FIGURES, Continued

LIST OF FIGURES, Continued

INTERNATIONAL SYSTEM (SI METRIC)/ 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

1.0
INTRODUCTION

The National Estuary Program targets significant estuaries for assessment and the development of management plans that will substantially enhance the water and ecological qualities of these productive coastal water bodies. The Indian River Lagoon system was added to the National Estuary Program in 1990, with an important step in the assessment process being the characterization of the current state and of the probable future trends within the Lagoon system.

This volume represents one of a series of technical reports that together comprise this information summary of the Indian River Lagoon Characterization Report. The seven other reports in this series cover the physical features, biological resources, water quality characteristics, and pollutant loads of the Lagoon. This report describes how the Lagoon has been utilized in the past, as well as various estimates of current and future use.

The uses of the Lagoon and its watershed by people represent both important sources of impacts on the Lagoon and also values which are returned by the Lagoon to human society. These interact such that impacts can negatively affect the value as a direct result of the degree of use, if not ameliorated or mitigated. This report describes several important social, geographic, and economic factors which affect the character of the Lagoon, as well as the values received from the Lagoon.

This report opens with a summary of the history of the use of the Lagoon (Section 2) from the earliest reported uses to the recent past. This historical narrative lends a perspective to the degrees and types of changes that have occurred along the Lagoon and to the trends and rates of change over time.

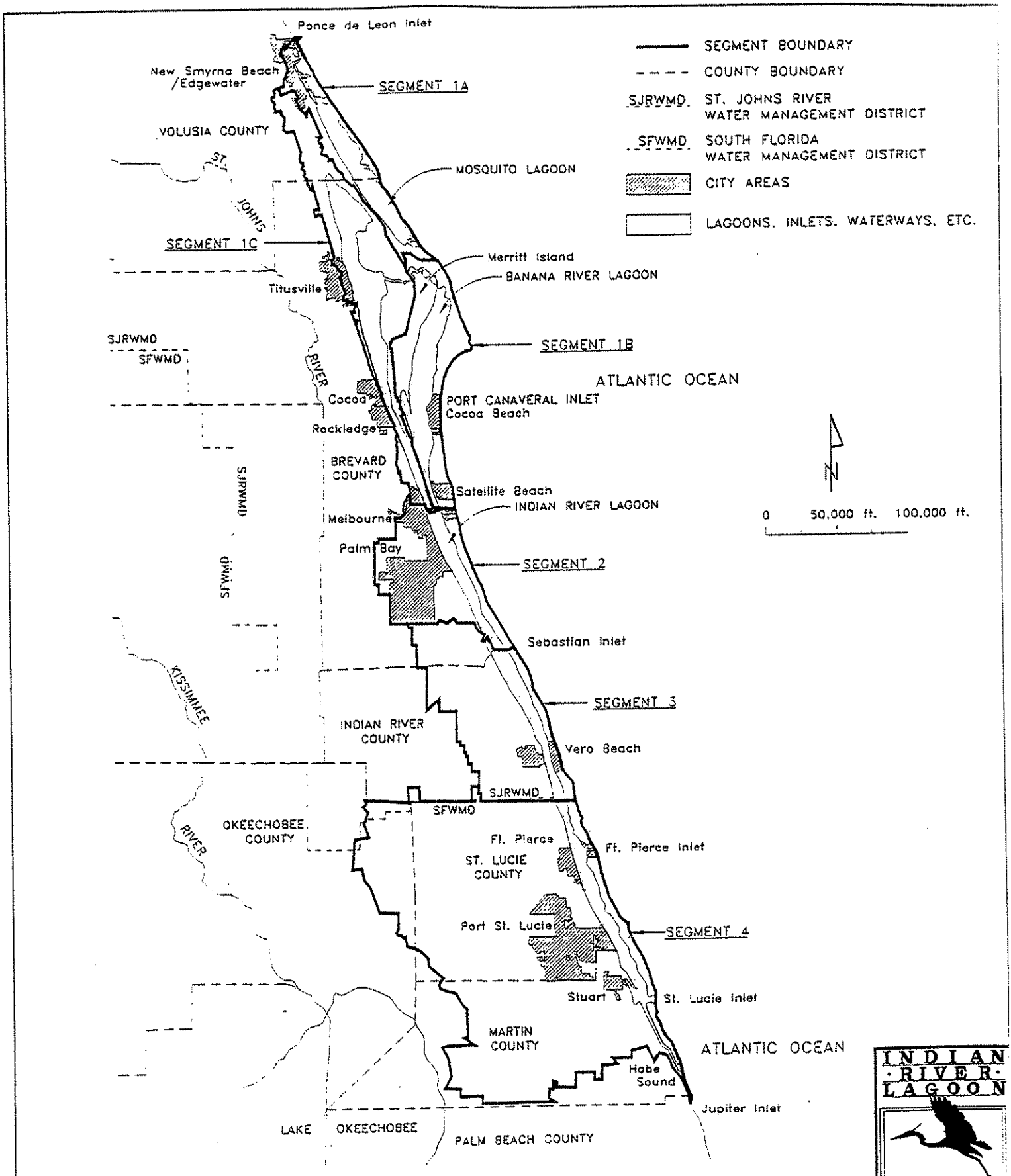
Section 3 describes the human population of the Lagoon's watershed or basin. Population is the basic characteristic that drives all of the anthropomorphic (caused by man) impacts on the Lagoon. As such, an understanding of the trends in population change is necessary for understanding impacts to the Lagoon and for projecting future changes and trends. Population is reflected in land use within the watershed, which in

turn drives the type and amount of runoff of rainfall, sediments, and contaminants to the Lagoon. Population also directly influences the amount of wastes and waste waters which must be disposed of within the region. This section provides an analysis of past and present population, and projects future population to the year 2010.

Existing and future land uses within the watershed are assessed in Section 4. Section 4 also evaluates the data base used to project future land use and the effects of the County Growth Management Plan projections which were used to derive this information. The resultant land use values have been used to model existing and future non-point source stormwater loadings in the watershed (See Loadings Assessment Technical Report) to assess the impacts that changes in land use will have on the Lagoon.

Sections 5 and 6 discuss economic factors within the region, which may directly or indirectly affect the Lagoon or which are a reflection of the value of the Lagoon to our society. These factors include agriculture and boating activities which may affect the Lagoon and recreation and commercial fisheries which represent values derived from the Lagoon that are directly dependent on the health and quality of the Lagoon. Section 7 summarizes the findings and conclusions of this report.

To provide orientation to the physical setting of the Indian River Lagoon, Figure 1-1 shows the six segments (and associated watersheds) of the Indian River Lagoon that have been used in this and other reports to evaluate information on a more site specific level. Figure 1-2 shows major landmarks and reference locations for the Indian River Lagoon region.



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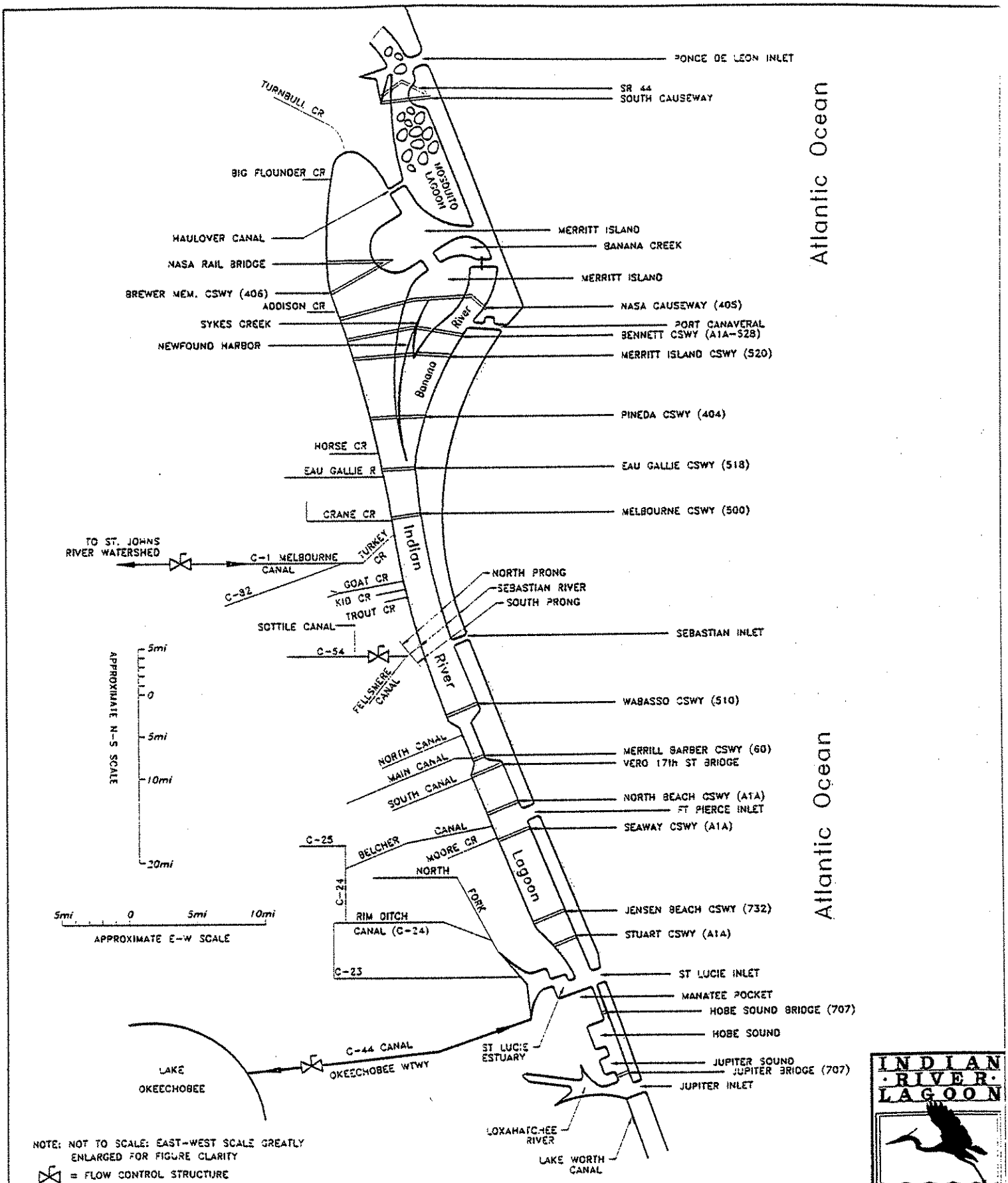
DATE: 7-5-94

FIGURE 1-1 SEGMENTS OF THE INDIAN RIVER LAGOON COMPLEX



•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: INDIANGS.DWG DATE: 7-5-94	FIGURE 1-2	MAJOR LANDMARKS OF THE INDIAN RIVER LAGOON SYSTEM

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

2.0
HISTORICAL NARRATIVE

2.1 EVOLUTION OF INDIAN RIVER LAGOON

The Indian River Lagoon system as it exists today is a product of the long-term natural landscape creation process and short-term impacts caused by man's alteration of hydrologic and environmental conditions. Geomorphologically, the Indian River Lagoon system and its watershed are part of the Eastern Coastal Ridge and Flatwoods District. The physiography of this basin consists of five distinct sub-districts that apparently originated in the late Pleistocene Era (Brooks, 1982). Brooks describes the basins as a series of well drained ridges interspersed with relic inlet features and terraces. The barrier islands forming the east boundary of the Lagoon are perched on top of coquina and sand shell ridges that originated in the middle to late Pleistocene era.

M.T. Brown (1985) described the impacts of human reorganization of landscape features surrounding the estuarine and wetland environments. This reorganization has been caused by urban community infrastructure development and increased agricultural land uses. The historic "primitive" Florida coastal environment consisted of a gentle meandering drainage pattern of sloughs, creeks, rivers, and wetlands which absorbed floodwaters, allowed groundwater recharge, assimilated nutrients, and removed suspended sediments. The landscape reorganization and man's uses of the Lagoon watershed have transformed the Lagoon basin into an altered, complex hydrologic situation with rapid runoff from impervious areas; increased runoff with pollutants from cleared land; inter-connected canals that lower groundwater and remove standing water; rerouted drainage patterns; and direct discharges. All of these have led to increased pollutant loadings and sedimentation in the Lagoon, as described in the Loadings Assessment and Status and Trends Technical Report volumes.

The historical utilization of the Lagoon and its resources is described below by chronological periods. The purpose of this historical narrative is not to present every historical fact that is related to the Lagoon. Rather it is the intent to provide a

reasonable background of information as related to the continued development of the landscape.

2.2 125,000 YEARS BEFORE PRESENT (B.P.) TO 1500 A.D.

The geomorphological evolution periods of the Indian River Lagoon basin can be described as follows: marine environment, subaerial environment, brackish water environment, and Lagoonal environment (Almasi, 1985). These evolutionary periods appeared and disappeared primarily in response to the rise and fall of sea level and the resulting geologic and biologic transformations of exposed and submerged lands.

During the late Pleistocene era (approximately 125,000 years B.P), the present day barrier island was most likely a submerged offshore sand bar due to higher sea level conditions. The interior mainland ridge areas functioned as the coastline of a possible inland Lagoon area occupying the depression (Eastern Valley) west of the existing coastal mainland ridge (Atlantic Coastal Ridge), which would have formed the barrier island system at that time (Almasi, 1985).

The subsequent glacial age from 125,000 to 35,000 B.P. transformed the former marine environment of the area into a subaerial (upland) environment. This lowering of the sea level caused the offshore sandbar to emerge as a new barrier island, creating the Lagoon feature between the barrier island and mainland ridge, somewhat similar in nature and location to the present day Indian River Lagoon conditions. Sediment analysis indicates that the exposed sediments lithified (turned to rock) during this period, resulting in the Anastasia Formations (Almasi, 1985).

The next transformation, into the brackish water environment, from 35,000 to 30,000 years B.P. occurred after the evolution of the Anastasia Formation, during a period of sea level rise which re-inundated the Lagoon area with sea water, but not to the extent of the previous period of the late Pleistocene era.

The period from 30,000 to 6,000 B.P. saw the return of a subaerial environment and emergence of the present-day Lagoon and barrier island features. The sedimentary evidence of the past 5,000 to 6,000 years indicates that this re-inundation of the Lagoon,

accompanied with sediment depositions and accumulations within the Lagoon and barrier islands, has resulted in the somewhat stable morphology existing today.

The Indian River Lagoon region may have been populated by Paleo-Indians as long ago as 15,000 years. Research at several drowned archaeological sites around Florida's coast indicate that permanent settlements along the coast may have been developed by prehistoric tribal groups, in contrast to the previously held belief that the first people on the peninsula were strictly hunter/gatherers, who roved about the interior of the State (Doran and Dickel, 1988). In recent research, it has been discovered that there were once many village-like settlements of tribes along the coast, inhabited by people who were accomplished at fish and shellfish harvesting and at collecting fruits, nuts and other plant materials. These early peoples also manufactured stone, bone and shell tools. Some of these coastal settlements have been determined to be about 12,000 years older than the previously established period of occupation by Paleo-Indians. These coastal settlement sites are now underwater due to sea level rise.

The tribes in the Lagoon region included the Jaega and Ais to the south of Cape Canaveral (DuBois, 1957), and the Timucua to the north (St. Clair, 1992). These tribes had numerous distinct characteristics in their dress, pottery, toolmaking and ceremonial rites. Recent archaeological research suggests that even among the primary tribes there were differences that indicate these early Floridians were not distinct cultures, but were a diverse population who adapted regionally and sub-regionally to different macro-environmental conditions, mostly related to food sources and weather. Many lived only part of the year along the coast and established other settlements along the Lagoon tributaries and freshwater rivers such as the St. Johns River.

These early inhabitants did share in common the trait of eating just about anything they could find, including alligators, deer, manatees, salamanders, snakes, snails and all manner of birds. The huge shell mounds common along the coast clearly indicate a common diet of shellfish of all types. Cultivation did occur, but was predominantly north of Cape Canaveral along tributaries such as Spruce Creek (St. Clair, 1992).

From the evidence that has been presented, it can be concluded that prior to Spanish arrival in 1513, the aboriginal inhabitants of the Indian River Lagoon region had

minimal impact on the resources and surface features of the area. They were able to survive and meet their subsistence needs without substantially altering the existing natural conditions, and they adopted their lifestyles to the changes that were seen to occur.

2.3 PERIOD FROM 1500 TO 1800 A.D.

The period of early European colonial exploration and settlement began with Ponce de Leon's landfall in 1513. After this date, early Spanish influence on Florida slowly but steadily increased with increasing exploration and colonization efforts. Even with these excursions from Caribbean settlements, the impacts on the Indian River Lagoon remained minimal. Environmental conditions for settlements were harsh and the Indian tribes were reluctant to share their lands and resources. The threat of a hostile natural environment and native population, combined with diseases, further inhibited colonization and settlements within the Indian River Lagoon region.

Historical milestones of the colonization period in the general vicinity of the Indian River Lagoon (Barile, 1988) include:

- 1513 Ponce de Leon's arrival and establishment of St. Augustine
- 1564 French Huguenot settlement on the St. Johns River
- 1565 Pedro Menendez Spanish explorations south of St. Augustine
- 1565 Juan Medrano began settlement of Santa Lucia (Ft. Pierce)
- 1605 Alvaro Mexia's expansion of settlements with Ais Indians
- 1645 Jonathan Dickinson arrival in Jupiter
- 1762 British Rule established
- 1768 Turnbull Colony settled in New Smyrna
- 1783 Anglo/Spanish Treaty adopted

Following the ceding of Florida to England by Spain in 1763, a vigorous program to repopulate Florida was undertaken by the English to replace the Spaniards who left Florida at the end of Spanish rule. Permanent settlement was encouraged. The positive advantages of the territory were widely advertised in England and land grants were made available with easy terms. The appeal of the area south of St. Augustine, in the area of

present day Volusia and Brevard Counties, was primarily due to its accessibility via coastal waters, as well as through the St. John's River and overland routes (St. Clair, 1992). The lands south of Cape Canaveral were harder to access, as overland routes were not well established due to swampy conditions and the fact that the St. Johns River was hard to navigate south of Lake Monroe for any vessel larger than a small dinghy.

Early settlements along the Indian River Lagoon included the 1645 English colony near present day Jupiter and St. Lucie, which was settled by the Spanish in 1565. Neither of these communities had a significant lasting effect on the land or Lagoon. However, St. Lucia did undergo waves of resettlement, becoming a major trading post landing on the Lagoon, and eventually evolving into the City of Ft. Pierce.

Andrew Turnbull's colony, New Smyrna, which began with 1,255 settlers in 1768, only existed for about a decade. However, it was responsible for probably the most significant construction of drainage canals adjacent to the Lagoon undertaken to that date. These canals were constructed in the area of New Smyrna Beach and permitted the improvement of nearly 3,000 acres (ac.) of seasonally wet lands for agricultural use by the early 1770's (St. Clair, 1989).

Lagoon resources at that time were abundant and subject only to the seasonal temperature variations and periods of drought and flood. The Lagoon contained numerous fisheries, tropical fruits and vegetation, and abundant game and wildlife. Even though St. Augustine had an explosion of settlers arriving after the Anglo/Spanish Treaty of 1783 gave control back to Spain after a twenty-year period of English rule, the surrounding lands remained essentially uninhabited. The subsequent period of 1800 to 1900 appears have been the period in which major cultural impacts to the Lagoon basin began as a result of stabilized colonization efforts, transportation route developments, agricultural land cultivation, and population growth (Barile, 1988).

2.4 PERIOD FROM 1800 TO 1900 A.D.

Florida was ceded to the United States by Spain in 1821, which brought the arrival of new settlers, villages, and land cultivation to the Lagoon area. Even so, the census of territory in 1825 had only 317 persons living in the south Florida region (Hutchinson, 1987). In 1830, the reported population in Mosquito County, which included all of the Lagoon region, had increased to 733 people (Barile, 1988).

Plantations established on the Lagoon around 1809 by early English settlers included orange groves (Griffin and Miller, 1978). Orange and other citrus groves in the Turnbull Hammock area were noted by LeConte in 1822 (Addicks, 1978). However, commercial production appears have begun with Douglas Dummett's 3,000 acre orange grove on Merritt Island. Dummett's grove was in production by 1828, and was the only cultivated citrus crop in Florida reported to have survived the great freeze in 1835 (McPhee, 1966). Dummett's citrus crop seed and grafts were subsequently used to reestablish the other groves, thereby becoming the precursor of many Indian River orange varieties and groves. Other early agricultural activities on the barrier island included pineapple and coconut groves on Jupiter and Hutchinson Islands from about 1885 (Richardson, et al., 1992) and palmetto fruit harvesting along Mosquito Lagoon (Luther, 1987).

Colonization and settlement attempts were continually thwarted by indian wars, the most serious being the second Seminole War period from 1835 to 1842. The Armed Occupation Act of 1843 encouraged settlers to inhabit the Indian River Lagoon shorelines and uplands, but transportation and commerce for the local businesses were limited and could not support the settlers. In addition, mosquitoes and disease ravaged the settlements and had driven most of the population out of the Lagoon basin by 1856, when only 8 families were reported to be living within the Lagoon region (Mahon, 1985). The Indian River colony existed in the area from Sebastian to Jupiter for seven years, but was finally abandoned in 1849 (Martin County Historical Society, 1975).

The first organized use of the Lagoon for transportation was to connect military outposts and settlements. Waterway transportation prior to the Intracoastal waterway construction in the early 1800s was limited to shallow draft vessels such as canoes, rafts, small sailboats, and flat-bottomed steamboats. The increase in steamboat traffic about

1865 and the Homestead Act of 1866 provided the impetus to re-build the local settlements and expand the trade and commerce with timber, vegetable, fruit and game from the region. By 1870 the population of the basin was estimated to be 1,216 persons, five times that of 1860 (Barile, 1988). The Indian River was the primary "highway" for transportation, trading, and supplies distribution during the early 1800s, since the inland routes by wagon were dangerous, slow and distant from the main settlements along the shores of the river.

The establishment of a waterway transportation route thus became the most important factor for development of the various communities. Waterway transportation provided the base for expanding trade in commercial crops and industries.

As far south as Sewalls Point, near the present day St. Lucie Inlet, postal delivery and pickup points were established to provide communication along the Lagoon (Thurlow, 1992). Lighthouses were constructed to guide ships and other vessels through the dangerous offshore and nearshore coastal shoals of the existing natural inlets at Mosquito Inlet (Ponce de Leon Inlet), Indian River Inlet (near present day Ft. Pierce Inlet), and Jupiter Inlet. The major milestone events that helped in the evolution of water transportation routes included the establishment of key navigation aids and construction of new access points (inlets) to the Lagoon (Barile, 1988) including the following:

- 1822 - Canaveral Light constructed to warn ships of the offshore shoals
- 1835 - Ponce de Leon Inlet Light (first inlet lighthouse) constructed (destroyed in 1844) and Gilberts Bar Inlet opened (near present site of St. Lucie Inlet)
- 1854 - Haulover Canal constructed to facilitate transport from Mosquito Lagoon to Indian River
- 1861 - Jupiter Inlet Lighthouse constructed
- 1882 - Intracoastal Waterway Construction initiated

- 1886 - Sebastian Inlet first opened
- 1887 - Ponce de Leon Inlet Lighthouse reconstructed at present site
- 1892 - St. Lucie Inlet opened
- 1898 - St. Lucie Inlet enlarged

The primary mode of water transportation for "trade boats" was the flat-bottomed sailboat until 1885, when the steamboat "Indian River" started servicing the route from Titusville to Melbourne (Hutchinson, 1987). Titusville was a significant northern departure site because of its close proximity to new northern Florida railroad service from St. Augustine and Jacksonville, and the St. Johns River water transportation trade routes.

Steamboat fleets of the Indian River Lagoon consisted of shallow draft (less than approximately 2-3 feet), vessels, propelled by side-paddle wheels, stern-paddle wheels, or twin-screws that could navigate the various shallow Lagoon passages of the Lagoon. The Indian River Steamboat Company was organized in 1886 and provided competition with the Jacksonville, Tampa, and Key West Railroad company for the freight and passenger service business from Titusville to Jupiter (Hutchinson, 1987).

The steamboats varied in size and width, with the "St. Sebastian" being one hundred thirty feet long and twenty four feet wide and the "St. Augustine" being one hundred ten feet long and twenty four feet wide. These particular steamboats were fitted with staterooms, and along with other steamboats like the "Georgianna" built in Palatka in 1888, carried a relatively large volume of mail, freight and passengers along the Indian River Lagoon (Hutchinson, 1987). The increasing volume of freight and passenger service indicated to railroad pioneers like Henry Flagler that there was a need for extending railroad service to the expanding southern markets of the Indian River Lagoon and ultimately to Palm Beach and Miami. Flagler's new railroad line eventually eliminated the need for steamboats, and steamboat service had all but been discontinued at all locations by the turn of the century.

Henry Flagler's Florida Coast and Gulf Railroad began extending the railroad service south of St. Augustine in 1892. After the railroad service passed Daytona Beach the name was changed to the Jacksonville, St. Augustine and Indian River Railroad. The service was extended to Palm Beach by 1894 to allow access to the resorts of Palm Beach and Flagler's new Royal Poinciana Hotel. Today, the same railroad route has been expanded for increased transportation and is known as the Florida East Coast Railroad (Hutchinson, 1987).

The railroad constructed some of the first bridges over the tributary streams and rivers of the Indian River Lagoon. Drainage patterns of the pine flatlands and wetlands of the coastal ridge began to be altered by the railroad and resulting secondary development. A major trade route was now established, allowing the natural resources of the watershed to be used and exported. The expanding agricultural activities began to divert runoff normally destined for the St. Johns River to the Indian River Lagoon in order to "reclaim" the fertile freshwater floodplain for crop production. The new methods for agriculture, commerce, and trade for the region brought a population increase to Indian River Lagoon villages and towns and a need for new modes of transportation by roads and highways.

The first land route on Florida's east coast was the King's Highway which the Spanish developed in 1632, following portions of Indian trails. In 1768, the British enlarged the route by cutting a roadway thirty feet wide from the St. Mary's River, near Jacksonville, south through St. Augustine to New Smyrna. The terminus at New Smyrna was a huge coquina stone wharf that jutted out into the Indian River Lagoon. The remains of that wharf can still be clearly seen today. After 1785, the road south of St. Augustine deteriorated due to lack of maintenance until it was reconstructed in the early 1830s after Florida became a United States territory. (Luther, 1987)

Military forts, established by the United States during the period 1835 to 1842 to deal with the Seminole Indian Wars, increased the demand for local support and helped establish the surrounding villages. The villages accommodated the soldiers and ancillary needs of the forts which were located from Jupiter to St. Augustine. The military supply requirements resulted in the construction of an inland route for ground transportation of troops and supplies. In 1835, the Capron Hernandez Trail was established along the

mainland ridge between the Indian River Lagoon and St. Johns River basins. It was the first major inland ground transportation route connecting the interior lands with the coast for trade and passage to the south (Motte, 1953). Eventually this route became the location of U.S. Highway 1 linking north and south Florida communities. By the 1900s other roads were being established along the railroad lines, with local roads developed within the communities, including U.S. Highway 1/Dixie Highway, which provided automobile access for tourists.

Between 1800 and 1900, cultural activities were already impacting the natural resources of the region. Drainage patterns began to be altered, navigational improvements were started, land clearing of large tracts was undertaken and community wastes were generated. A significant agricultural product of the Lagoon at this time was the pineapple. From the Civil War into the early 1900s, Lagoon farmers shipped pineapples out of the area, first by steam boats, then later by train, to international destinations. Grown throughout the Lagoon from Merritt Island to Stuart, pineapple production peaked at a million boxes in 1909, before freezes, disease, and real estate speculation combined to end the industry. Another, more indigenous Lagoon crop of this time was the Palmetto berry, used for medicine and other purposes.

A significant agricultural product of the Lagoon at this time was the pineapple. From the Civil War into the early 1900s, Lagoon farmers shipped pineapples out of the area, first by steam boats, then later by train, to international destinations grown throughout the Lagoon from Merritt Island to Stuart. Pineapple production peaked at a million boxes in 1909, before freezes, disease, and real estate speculation combined to end the industry. Another, more indigenous Lagoon crop of this time was the Palmetto berry, used for medicinal and other purposes.

2.5 PERIOD FROM 1900 TO 1950 A.D.

The creation of the new inlets along the barrier island at Sebastian and St. Lucie Inlets around the turn of the century provided improved access for ships to local ports and docking facilities in Ft. Pierce and Stuart. They also helped to open additional trade and passenger service to up-river communities in Brevard County. The immediate impact of the sea water released into the Lagoon by opening the inlets was noted by early

settlers to have killed large areas of marsh grass existing in the Indian River Lagoon (Hutchinson, 1987). The new inlets created a new mechanism of flushing within the Lagoon that had occurred previously only during brief periods when temporary inlets were created by the washover and scour caused by passing hurricanes and northeasters. The new openings to the Atlantic Ocean also provided additional salt and brackish water habitat in the Lagoon to be used as a spawning ground for fish and other marine life. This accelerated the development of active fish, clam and shrimp industries in the communities adjacent to the inlets.

Other industries came and went due to natural and man-made impacts. The citrus crop that was devastated by the great freeze of 1895 was reestablished, but the pineapple industry finally collapsed in the late 1920s as a result of disease, the 1895 and other repeated freezes and price wars and never regained production (Hutchinson, 1987; Richardson, et al., 1992). The agri-horticultural industries, local businesses and land development activities were able to overcome these adversities and began to flourish in the 1900s. The 1910 population of 8,792 for the counties adjacent to the Indian River Lagoon had increased to 12,603 by 1916, to 15,391 by 1920 and was estimated to be around 45,000 by 1950. The key events that accounted for the growth increase were not only transportation and industry developments, but also the 1916 Drainage Acts of Florida and the implementation of mosquito control districts in 1927. In addition, improvements and modifications to Ft. Pierce Inlet, Sebastian Inlet and St. Lucie Inlet (1920s), combined with the completion of the Intracoastal Waterway (1935) and construction of Port Canaveral and the Canaveral Barge Canal in the 1940s through 1960s, helped establish safe passage for larger boats and greatly expanded port operations and commerce. The establishment of port authority taxing districts with the purpose of creating large scale port and marina facilities resulted in significant alterations to the Indian River Lagoon bottomlands and shorelines. Many acres of highly productive estuarine littoral zone were destroyed in this period to create recreational and commercial dockage.

The 1916 Drainage Acts of Florida allowed the establishment of other special taxing districts to promote agricultural production and to provide flood and drainage control. The drainage and agricultural water works constructed from 1916 to 1950 under this Act extended many of the naturally meandering tributary streams and rivers and inter-

connected Lagoon sub-basins and watersheds through newly constructed canals. These rerouted drainage patterns permanently lowered groundwater tables in areas where standing water naturally existed for six or more months each year, allowing large citrus groves to be established. Wetlands were drained to create grazing land for cattle. Other lands were specifically drained for urban developments (Luther, C., 1976). These districts eventually became what is now know as Chapter 298 Drainage Districts, which include the following:

- Melbourne-Tillman Drainage District (now known as the Water Control District of South Brevard)
- Fellsmere Farms Water Control District
- Sebastian Farms Water Control District
- Indian River Farms Water Control District
- Ft. Pierce Farms Water Control District

Special taxing districts were also established to promote control of the mosquitoes along the Indian River Lagoon. The mosquito control districts south of Cape Canaveral utilized ditching and impoundment control techniques learned from northern states and incorporated pesticide spraying throughout the basin from 1927 to 1950 (Miley, 1980). These concerted efforts managed to bring under control the pesky mosquito population that had been hampering the growth and expansion of Florida settlements since the 1500s.

In Volusia County, a system of 140 miles of ditches was dug specifically for the purpose of mosquito control. The first local helicopter used for inspection and spray treatment, a Bell 47 (a few of which are still used today), was put into service in 1965 in eastern Volusia County.

During World War II, the principal impacts on the Indian River Lagoon were associated with the rapid development of a variety of military facilities. One commercial impact

of these defense initiatives was a result of the military decision to allow most of the Atlantic Coast inlets to shoal in order to eliminate the threat of enemy boat entry into the inland waters, which subsequently reduced commercial vessel traffic. As an example of this, aerial photographs from January 1943 show Sebastian Inlet to be open, while May 1943 photographs show the mouth blocked by sand.

In contrast, Ponce Inlet was deepened by dredging in 1941, and PT boat captains were trained at a Navy base established the location of the current at Riverfront Park in New Smyrna Beach. Local residents claim that as much as fifty feet of riverfront shoreline was lost adjacent to the Intracoastal Waterway from downtown New Smyrna Beach to Ponce de Leon Inlet due to huge wakes of the powerful PT boats racing out to sea during training (Luther, G., 1987).

The infrastructure necessary to support the war effort included construction of airfields, storage facilities and troop housing for training facilities. Training activities included amphibious landing exercises, jungle warfare and bombing practice. The site of the current St. Lucie County Historical Museum and the City of Ft. Pierce Wastewater Treatment plant housed a U.S. Navy frogman school during the war (Thurlow, 1992).

The Ft. Pierce Underwater Demolition Training (UDT) School, Banana River Naval Air Station (now Patrick AFB), and the many air training fields now being used as smaller municipal airports all played a big part in the war effort, and changed the physical characteristics of many areas of the Lagoon. Target bombing practice took place routinely throughout the Lagoon waters and marshes (Day, 1993). It also was home for a seaplane base. Large areas of the southern Banana River were dredged for this base. The Banana River NAS was a major naval flight training school and the "lost squadron" of torpedo bombers that disappeared in the Bermuda Triangle took off from the airfield (Day, 1993).

Many military personnel who were introduced to the Lagoon region during the war effort stayed or returned to settle in the area after their service years. This is especially true in the vicinity of the Canaveral Air Force Station and the Patrick Air Force Base complex, where Werner Van Braun's work on V-2 rockets took place following World War II.

Cultural impact to the Lagoon basin continued after the war by way of development of transportation routes to the appealing coastal areas of the barrier islands. Prior to 1940 access to the barrier islands was almost exclusively accomplished by way of boats and ferries. The increased development demand eventually required improved access resulting in the construction of new causeways and bridges.

Table 2-1 presents a summary of the numerous Lagoon causeway and bridge structures (from north to south) constructed and/or improved by the Florida State Road Department, which was established in the 1920s and renamed the Florida Department of Transportation in 1969.

Early bridges were typically long, wooden pile-supported spans. These wood piling structures most likely did not alter the wind- and tide-driven currents that drive the circulation of Lagoon waters to the extent of the modern causeways. The numerous wood pile sections created fringe communities supporting fish habitats, stone crabs, barnacles and oyster clutches. From 1920 to 1970, some wooden bridges were replaced by filled road grades (causeways) constructed into the river, perpendicular to the shoreline. Causeway construction was favored over continued long-span bridge construction due to the low cost of placing fill material in the shallow Lagoon waters. The causeway sections were connected near the middle at the Intracoastal Waterway channel by pier-supported fixed bridges with moveable sections (draw-bridge or swing-bridge) to accommodate the boat traffic up and down the Lagoon. As each wood bridge was replaced by the causeway/bridge combination, the habitat and circulation patterns of the surrounding area were altered.

Each subsequent causeway and bridge structure that replaced the wooden bridges further changed the circulation patterns and marine habitats associated with the bridge piles. The causeways effectively separated the Lagoon into sub-basins with the north-south exchange of Lagoon waters coming only through the bridge openings. Recent improvements to some of these structures included construction of short fixed bridge spans in the east and west causeways to serve as relief openings for improvement of water exchange and circulation. Further improvements since 1970 at the New Smyrna Beach South Causeway, Cape Canaveral Parkway, Cocoa Beach Causeway, Eau Gallie Causeway, Melbourne Causeway, and Ft. Pierce's South Beach Causeway have included

TABLE 2-1

LAGOON CAUSEWAY AND BRIDGE STRUCTURES CONSTRUCTED AND/OR IMPROVED BY THE FLORIDA STATE ROAD DEPARTMENT/ DEPARTMENT OF TRANSPORTATION

COUNTY	NUMBER OF BRIDGES/CAUSEWAYS	NAME OF BRIDGES/CAUSESWAYS	ORGINALLY CONSTRUCTED	DATE IMPROVED/REPLACED
Volusia County	2	New Smyrna Beach N. Causeway/SR 44	1920	1952 (improved)
		New Smyrna Beach S. Causeway/A1A Hwy	1925-26	1966/1988 (replaced with fixed span)
Brevard County	8	Titusville/SR 406	1949	N/A
		Kennedy Space Center Orsino Causeway/SR 405	1964	N/A
		Cape Canaveral Parkway/SR 528	1964	1970 (improved)
		Cocoa Beach Causeway/SR 520	1917/22*	1941 (replaced); 1970 (improved)
		Pineda Causeway	1973	N/A
		Mathers Bridge	N/A	N/A
		Eau Gallie Causeway	1949	1980 (improved with fixed span)
		Melbourne Causeway/US 192	1941	1980 (improved with fixed span)
Indian River County	3	Wabasso Causeway	1970	N/A
		Merrill Barber Causeway/SR 60	1951	N/A
		Vero Beach 17th Street Bridge	1981	N/A
St. Lucie County	2	Ft. Pierce N. Causeway/A1A	1963	N/A
		Ft. Pierce S. Causeway/A1A	1960s	1974 (improved with fixed span)
Martin County	2	Jensen Beach Causeway/Wacha Bridge	1965	N/A
		Stuart Causeway/Lyons Bridge	1957	N/A

Sources: Evink, 1980
Rabac, 1986

N/A = Not Available or Not Applicable
* = Original date of construction prior to State Road Department control

removal of part or all of the causeway and low bridge structures (with moveable span sections), and replacement with large pile-supported, fixed span bridges.

2.6 PERIOD FROM 1950 TO PRESENT

In the period after 1950, Florida's urban and agricultural expansion were augmented by a major growth in industry spurred by the federal space program, tourism, and the elimination of most natural impediments. Many of the early intolerable natural conditions had now been managed or altered by man. Mosquitoes were under control through aerial spraying, impoundments, and ditching. Waterways, rivers and inlets were stabilized, deepened and widened for commerce and recreation. Highways and bridges provided vehicular access to all reaches of the Lagoon. Flatwoods areas west of the coastal ridge were drained into the Lagoon and modified for urban and agricultural development. The widespread availability of air conditioning also allowed an increasingly urban society to cope with the humidity of coastal summer conditions.

The advent of the space program at Cape Canaveral in 1950 provided the main growth impetus in Brevard County and the upper Lagoon basin. The aerospace industrial complex of the space program at Cape Canaveral (later renamed as Kennedy Space Center) included Patrick Air Force Base, Cape Canaveral Air Force Station, and numerous other service industries necessary to produce space technology components. By 1960, the estimated population in the Lagoon region was over 200,000, nearly five times that of 1950, and much of this increase was due to the space program (Barile, 1988).

The large Federal lands needed for security, safety, and expansion of the Kennedy Space Center resulted in the acquisition of 140,000 acres of beaches, dunes, flatwoods, wetlands, and marshes. The Merritt Island National Wildlife Refuge and Canaveral National Seashore areas were created in the 1960s and 1970s on these lands to manage and protect endangered species' and migratory/water bird habitat. These large tracts of Federal lands were not accessible for development and, as a result, the water quality was largely protected from degradation by urban sources. However, impoundment of extensive areas of Lagoon mangrove forests and salt marshes in order to control mosquitoes and encourage water bird habitation has also destroyed fish and shellfish

spawning areas. At least one bird species, the dusky seaside sparrow, became extinct partly as a result of these management practices.

Ditching and spraying of mosquito breeding wetlands was replaced throughout the Lagoon by the new management practice of impoundment in which wetlands were surrounded by dikes and flooded to prevent breeding. By the early 1970s, these impoundments had isolated large areas of mangrove marsh systems from the Lagoon's open waters (Ray and Kain, 1989). These marsh areas had previously been contributing to the Lagoon habitats as fishery spawning areas, detrital food supply, and filtering marshes for nutrients and sediments. Although some of the mangroves managed to repopulate the Lagoon shoreline over time, an estimated 70% of the total area of mangroves were initially impacted by the mosquito impoundments, with a majority of them located in Brevard County (Haddad, 1985).

The census of 1970 counted 303,858 people living in the five counties adjoining the Indian River Lagoon. During this period urban and suburban areas were beginning to grow and flourish in the unincorporated areas of Titusville, Cocoa Beach, Melbourne, Vero Beach, Ft. Pierce, Port St. Lucie, and Stuart. Unincorporated areas that developed as platted "mail-order" type residential subdivisions include Port Malabar, Port St. John, Vero Beach Highlands, and Palm Bay. Impacts of the land uses associated with the urban, industrial and agricultural growth in these areas included: increased domestic waste treatment and treatment plant discharge into the Lagoon, increased stormwater discharge, increased freshwater flows from drainage ditches, reduced estuarine habitat quality, reduced aquifer recharge, and the resultant lowering of the groundwater table. Additional development and growth impacts on endangered species such as manatees and sea turtles by increased contact and habitat loss were noted.

The rapid population growth and increase of urban development from the 1950s through the 1970s brought increased problems of environmental degradation, which resulted in increased environmental awareness on both a state-wide and national scale. State-wide efforts to promote environmental protection accelerated in 1955 when the Florida legislature established the Florida Resources Study Commission and a resulting expansion of water law in the state. The Department of Water Resources was given authority for issuing permits for ground and surface water use.

State water protection efforts intensified in the 1960s with the creations of the Florida Air and Water Pollution Control Board followed by reorganization of this and other state departments into the Florida Department of Environmental Regulation (FDER) in 1976.

During the late 1960s and early 1970s, several actions of specific importance for the Indian River Lagoon also occurred. In 1969 six aquatic preserves covering about 60% of the Lagoon were established by resolution of the govern and cabinet (Virnstein and Campbell, 1987). In 1975 the Florida Aquatic Preserve Act coordinated management of these areas under the Florida Department of Natural Resources (FDNR) Bureau of Land and Aquatic Resource Management.

The St. Johns and South Florida River Water Management Districts were established in 1972 to promote protection and wise use of water resources, including those of the Indian River Lagoon watershed. The Surface Water Improvement and Management (SWIM) act was passed by the Florida legislature in 1987 and amended in 1991 with a specific directive for SJRWMD and SFWMD to develop a plan "to improve and manage the Indian River Lagoon system to a level of quality that provides aesthetic and recreational pleasure for the people of the state; habitat for native plants, fish, and wildlife, including threatened and endangered species, and attracts visitors and accrues other economic benefits." (SJRWMD and SFWMD, 1993). The legislature also passed the Indian River Lagoon Act in 1990 to further protect the Lagoon. This act directed that all wastewater treatment plants cease direct discharge to the Lagoon by 1995.

Even as the state management authorities and programs for the Indian River Lagoon were being established, other major events and environmental protection legislation on both the state and federal levels were beginning to take place in the 1960s through the 1980s, also affecting the Lagoon. The Water Pollution Control Act (Clean Water Act) was established by Congress in 1972 and amended in 1984. This act had wide-ranging effects on the Lagoon, including the establishment of a federal discharge permitting program, extension of dredge and fill regulations to many additional coastal and freshwater wetlands, and eventually the establishment of the National Estuary Program, which was eventually to include the Indian River Lagoon in 1990. The year 1972 also saw the passing of the Coastal Zone Management Act (CZM), which provided further

resources for protecting coastal resources. Other major federal legislation of this period included the Fish and Wildlife Coordination Act of 1958 and the National Environmental Policy Act (NEPA) of 1969.

The state of Florida also was strengthening protection of water resources with the passage of Chapters 253, 373 (Florida Water Resources Act of 1972), and 403 (Environmental Control) of the Florida Statutes. These three chapters form the authority for establishment of almost all of the state programs and regulations that help to protect the resources of the Indian River Lagoon.

The freshwater discharges from large domestic wastewater treatment plants (Steward and VanArman, 1987) and the many other small "package plants" are now being eliminated through the Indian River Lagoon Act requiring disposal of the effluent by methods other than direct discharge. Urban stormwater management programs for new development are attempting to control the nutrient, metal and sedimentation contributions from stormwater runoff, untreated stormwater runoff and partially treated wastewater have changed the Lagoon's bottom characteristics in places from the pre-development predominant sandy composition to that of a mixed sand, clay and organic muck composition (Almasi 1985; Trefry and Stauble, 1987).

The regional watershed management and drainage control programs of the South Florida and St. Johns River Water Management Districts, in conjunction with other local government projects, have recently begun to encourage improved recharge of surficial aquifers and prevention of saltwater intrusion in wells and water supplies. Passage of the Endangered Species Act has helped establish protection programs and wildlife preserves for endangered habitats and species occupying the scrub forests, wetlands and beaches comprising the Lagoon's watershed. Local land acquisition programs, with state and federal partners like the P-2000 program, have allowed preservation of some of the unique habitats of the Lagoon system.

All of these programs and many others, show a concerted attempt by man to balance the preservation, protection and enhancement of the natural resources, fisheries and wildlife of the Lagoon with urban requirements. However, many of the new residents have only lived in the Lagoon region for a short time and do not have a clear understanding of the

impacts. The "grandfathering" of existing urban and agricultural developments without adequate infrastructure means the impacts caused by these land uses will not be lessened unless government agencies undertake programs such as stormwater utilities and attack the problems on a regional basis.

The wide variations and characteristics of the Indian River Lagoon habitats, resources and waters, presented in other technical reports, indicate that the estuary is a complex ecosystem and requires a comprehensive understanding of the benefit of its natural values, functions and interactions. Ultimately, the Indian River Lagoon National Estuary Program's management initiatives and environmental enhancement objectives will assist local governments and citizens in working with the Lagoon's natural settings and avoid continued disruption and destruction of its resources.

3.0
PAST, PRESENT, AND PROJECTED POPULATION

3.1 SCOPE AND INTRODUCTION

The purpose of this section of the Uses of the Lagoon Technical Report is to evaluate the size and distribution of the past, present and future human populations within the Indian River Lagoon system watershed, and to identify areas of potential physical impacts which may accompany these populations. As the Lagoon's surrounding land areas become more developed, continuing the historic progression of development from natural vegetation to agrarian and urban utilizations, the need to identify these specific areas and populations becomes increasingly critical in mitigating associated impacts to the Lagoon's natural resources.

3.2 METHODS OF DATA COLLECTION AND PROJECTION

Existing population data was analyzed for the entire Indian River Lagoon system from a variety of sources and on different levels of geographic scale. These sources included but were not limited to, U.S. Bureau of Census counts of various years (particularly the three most recent censuses conducted in 1970, 1980, and 1990), various Population Studies by the University of Florida's Bureau of Economic and Business Research (BEBR), recent Comprehensive Growth Management Plans of the various counties and municipalities within the Lagoon study area, and the Indian River Lagoon Reconnaissance Report's (Recon Report) Chapter 7 on Population and Land Use (Glatzel and Swain, 1987).

This population analysis uses of the six major hydrologic basins of the Lagoon watershed that have been established as the primary geographic areas for all of the Technical Reports. The derivation of these land basins, or Segments, is described in the companion Technical Report "Physical Features of the Indian River Lagoon. Figure 1-1 previously showed the location of these segments. These segments were defined on the basis of topographic and drainage patterns rather than on political or census tract boundaries. Therefore these segment areas do not necessarily correspond to the political

or census tract study area boundaries used by the census and other studies such as the BEBR studies.

The population analysis in the Recon Report (Glatzel and Swain, 1987) was based on hydrologic basins or segments similar to those used in this study to reflect hydrodynamics as well as hydrological factors and to reflect recent interbasin diversions. The changes have been discussed in the Physical Features Technical Report. However, the basin boundaries have been altered somewhat since the Glatzel and Swain study to reflect hydrodynamic and hydrological factors and to reflect recent interbasin diversions. These changes have been discussed in the Physical Features Technical Report. Thus, the data presented in that report are not directly comparable to data in this study and could not be directly referenced.

Therefore, in order to generate population data for the basins, each basin of the Lagoon had to be mapped and the mapped boundaries compared to boundaries of the politically defined population units or census tracts. Population units entirely within a drainage basin were combined for a basin total. Where a population unit was split by basin boundaries, the population of the unit had to be allocated between the two basins. This was done initially in proportion to the ratio of the land area falling within each basin. The allocation was then refined using specific local information such as local Comprehensive Plans, various maps (i.e. land use, topography, and wetlands), and consultation with local government staff members and residents.

The results of this analysis were computed for past (1970) and present (1990) populations and for the projected future (2010) populations by Lagoon basin. The past and present scenarios represent estimates of population distribution among the basins based on factual census data for county and municipal political units. The future scenario represents population estimates based on interpolation of trends from previous census years. These projections have been taken from various sources, but they normally represent straight-line extensions of the change in population between two previous census periods.

The primary source of population data, upon which all other sources used herein are based, is the U.S. Department of Commerce's Bureau of Census Counts. Census data

is available for each previous decade through 1990. The 1990 data base was used for the "present" scenario because it is the most recent census available. The 1970 census was used as a representative of "past" conditions for several reasons. First, it most closely matched a time period (1972-74) in which a historic land use survey is available. Another reason was that it provides a sufficiently long period of time prior to the 1990 census to project an average population trend line for calibration of future estimates from other sources. It also brackets a period of recent rapid growth throughout the watershed.

While the census is the most wide-ranging data source in geographic scope, it also presents the most precise units of measurement, with data specific to the level of discrete city block areas. The census also provides an advantage because its findings are often scrutinized and verified by local governments. These results are scrutinized because they are used to apportion certain federal and state funds to local governments. This local check occurs only sporadically, since many local governments do not have the financial resources to verify these figures.

A second significant source of population data is the University of Florida's Bureau of Economic and Business Research (BEBR) which provides annual revisions of census-based population data for each individual municipality and county in the state. These annual revisions are usually the most currently available information. The BEBR populations figures are also subject to local review and scrutiny, because they too are used as a basis for State funding apportionment. This connection of funding to population estimates can sometimes pose a problem in obtaining accurate population figures since higher municipal populations may mean more local funding.

BEBR also issues annual projections of future population for governmental units. These projections are provided for all of the counties but are not broken down for individual municipalities. The BEBR future projections are made for a wide range of possible scenarios, including low, medium, and high population growth rates, in five-year intervals for the each ensuing thirty year period. For example, three different estimated future population projections for Indian River County are provided in the 1992 BEBR Bulletin based on the low, medium, and high future growth scenarios respectively. These estimates are provided for each of the years 1995, 2000, 2005, 2010, 2015, and 2020.

Since the most recent census data and BEBR future population projection data bases were most comparable at the county level, county-wide census data and BEBR county projections data were the primary sources of population data for this analysis. Where future population projections were available for adjacent incorporated and unincorporated areas, it was assumed that larger concentrations of projected populations normally would be annexed into the incorporated areas. Thus population densities in those presently unincorporated areas adjacent to currently incorporated areas were assumed to increase as the adjacent municipality grew and annexed those areas.

3.3 FACTORS AFFECTING ACCURACY OF PROJECTED FUTURE POPULATION AND LAND USE

The BEBR county population projections also have been heavily relied upon by the counties and municipalities within the Indian River Lagoon region when they updated their own population projections in conjunction with the recent state-mandated local Comprehensive Plan update process. Some counties and municipalities appear to have cooperated in allocating the county-wide population totals projected by BEBR to the appropriate county or municipal entity at the time that their Comprehensive plans were under development. Other county and municipal entities were more independent in projecting their share of the applicable county total. In cases where they worked independently, the totals of the county and municipal projections do not always add up to the total county-wide populations projected by BEBR. Counties and municipalities also may have used projected growth rates that differed from each other (i.e. a county may have used a BEBR "high" growth projection, while the municipality may have used a "low" projection rate.

These population estimates have influenced the counties' future land use elements in their comprehensive plans, and these population projections are important in evaluating the accuracy of projected future land use scenarios. However, the BEBR projections used for these updates generally date from the period 1986 to 1988 and do not match the most current BEBR projections issued in 1992. Therefore, the county future projections do not always match the most recent BEBR projections and extrapolations based on the 1990 census.

Additionally, because of the latitude of choice allowed by the possible range of low, medium, and high future growth projections, some counties and municipalities based their Comprehensive Plan population projections on the BEBR conservative low or medium rates while other counties based theirs on the high projection rate because of their concerns about concurrency requirements and the effect they could have. Thus some of the Comprehensive Plan projections may then have been made based on a "worst case" scenario, rather than conditions actually seen as realistic projections. Because of these reasons, the population projections presented should be used with caution, particularly when considering future conditions.

3.4 OBSERVATIONS AND TRENDS

3.4.1 Regional Trends

The results of the population analysis are shown in Tables 3-1 and 3-2 for past (1970) and present (1990) populations and for the projected future (2010) populations by Lagoon basin or segment.

The Lagoon study area as a whole has generally followed the State of Florida's historic growth trends, especially along its coastal areas, with this trend projected to continue. The period from 1970 to 1990 saw a Lagoon-wide population growth rate of 124%, with total populations increasing from 301,978 to 678,763. This overall growth rate is an average, incorporating the low growth rates of 35% to 45% for the smaller, already developed Basins 1B and 1C as well as the high growth rate of 220% for the largest and most undeveloped basin 4 (Segment 4).

A 60% future growth rate for the period from 1990 to 2010 is projected for the Lagoon study area as a whole, with an anticipated 2010 population of 1,082,853. This figure also serves as an average of the various projected basin growth rates for this same time period. Individual Segment populations are projected to range in future growth from 18% and 22% for Segments 1B and 1C respectively to a high of 94% for Segment 4.

The Lagoon study area as a whole contains a relatively balanced mix of urban, rural and agricultural land uses. Populations remain centered around the traditional and/or

TABLE 3-1

POPULATION DATA AND PROJECTIONS FOR INDIAN RIVER LAGOON SEGMENTS

PARAMETER	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	REGIONAL TOTAL
1970 Population	11,905	60,709	54,689	60,143	36,542	77,990	301,978
Percentage of Growth in this Interval	188%	35%	45%	133%	155%	220%	124%
1990 Population	34,320	81,993	79,494	139,974	93,218	249,764	678,763
Percentage of Projected Growth in this Interval	58%	18%	22%	44%	57%	94%	60%
2010 Projected Population	54,520	96,470	97,106	249,764	146,782	486,210	1,082,853

Source: Bureau of Economic and Business Research, 1982-1992
United States Bureau of the Census, 1992

TABLE 3-2

POPULATION DENSITIES FOR INDIAN RIVER LAGOON SEGMENTS

PARAMETER	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	REGIONAL TOTAL
Segment basin area[1] (square mile)	65.0	95.8	175.3	165.4	279.6	1,120.1	1,901.2
1970 Population	11,905	60,709	54,689	60,143	36,542	77,990	301,978
1970 Population per square mile	183	634	312	364	131	70	159
1990 Population	34,320	81,993	79,494	139,974	93,218	249,764	678,763
1990 Population per square mile	528	856	453	846	333	223	357
2010 Population (est.)	54,520	96,470	97,106	201,765	146,782	486,210	1,082,853
2010 Population per square mile (est.)	839	1,007	554	1,220	525	434	570

Sources: Bureau of Economic and Business Research, 1982-1992
United States Bureau of the Census, 1992

1 = Land only, does not include water bodies

historical hubs of roadways (US 1, Interstate 95, various bridges and causeways, etc.) and along the shorelines. More recent rapid growth has occurred within previously platted large "mail order" subdivisions such as Palm Bay in Segment 2 and Port St. Lucie in Segment 4, where existing platted residential lots have been located far from historically urban areas. Further growth in these areas is expected to occur as well as in similar older subdivisions in Port St. John, Port Malabar, Sebastian Highlands, and Vero Beach Highlands. Population growth rates may vary from previous projections in these areas since recent State laws require availability of adequate urban infrastructure (i.e. roadways, utilities, etc.) to be concurrent with such development in more instances than in the past.

The bulk of the population growth is still expected to be centered around the existing cities, expanding outward. In the future, the Lagoon study area is still expected to retain significant agricultural area. With this population growth, it is assumed that more and more undeveloped and/or agricultural land will be converted to urban uses, and that remaining undeveloped land will then be converted to agriculture if necessary to replace any significant conversions from agriculture to urban.

The general population centers of the Lagoon are expected to remain the same, with the most densely populated Segment 1B (Banana River) remaining the most densely populated in 2010. Segment 4 will remain the least densely populated. The percentages of growth projected within the respective segments, as illustrated in Table 3-1, vary greatly, mostly because of the varying geographic size of the segments. The following sections describe the population characteristics of each segment in more detail.

3.4.2 Segment 1A - Mosquito Lagoon

The basin of this segment consists of the southeast portion of Volusia County and the very northeastern portion of Brevard County. It includes all or part of the Cities of New Smyrna Beach, Edgewater, and Oak Hill in Volusia County, unincorporated areas of Volusia County, and areas of unincorporated Brevard County that are largely under Federal ownership or control. In terms of basin area, this segment ranks as the smallest of the six, consisting of 168.3 kilometers ($km^{2)}$ [42,274 acres (ac)] of land area. However, its total surface water area is 158.8 km^2 (37,853 ac), comprising an area almost

equivalent to its watershed land area. This large amount of surface water area and associated shoreline has a distinct effect on the pattern and type of existing and proposed development.

In accordance with its ranking as the smallest of the six basin land areas, the population of the Mosquito Lagoon basin (Segment 1A) is also the smallest in number. This has been the case historically and is projected to continue. The 1970 population of 11,905 was much smaller than all other segment populations, being less than a third of that of the next smallest basin (Segment 3) and only about 15% of the largest basin (Segment 4). This relative level of difference is projected to continue into the future.

Although it has a comparatively small population, this basin has had one of the largest historic growth rates, increasing from the 1970 population at a rate of 188% to the 1990 population of 34,320, a rate in that interval second only to that of Segment 4. This second highest ranking in growth rate is projected to continue with a 2010 population projection for Segment 1A of 54,520. Although the projected 58% growth rate in this time interval is much less than in the preceding 1970-1990 period, this lessening of future population growth rates is seen uniformly throughout all the Lagoon study area basin segments for the same time period.

Population density within this segment (Table 3-2) has also risen at a similar rate, more than in all other basins except Segment 4. A 1970 population density of 183 people per square mile (psm) increased to 528 psm in 1990, and is projected to be 839 psm in 2010.

This segment's current land development patterns, like all others in the study area, contain some of each of the general classifications of urban and rural uses. The urban areas are almost exclusively at the segment's north end, where the cities are located, with mostly undeveloped land at the south end. The majority of the undeveloped land in this southern portion is Federal property, operating as Kennedy Space Center and the surrounding park and wilderness areas of Canaveral National Seashore and Merritt Island National Wildlife Refuge.

It should be pointed out that almost 40% of the 65 square mile land area of this segment is owned by the federal government and is unavailable for population growth.

Therefore, all of the future population growth will be in the non-federal lands in Volusia County in the north half of the watershed. When only this available portion is considered, the population density in 1990 is closer to 851 psm and the estimated 2010 density will be 1,353 psm. On this basis, the population density around the north end of the Mosquito Lagoon will be among the greatest of any segments.

Historic population growth patterns in this segment have been concentrated in the northern portion, centered around the existing Volusia County cities. Projected future growth of these cites into previously unincorporated areas of Volusia County will encompass most of this segment's population increases through 2010.

3.4.3 Segment 1B - Banana River

This segment consists of a portion of northern Brevard County from Merritt Island east to the barrier island fronting the Atlantic Ocean. At the northern end of the basin are the Federal facilities of Kennedy Space Center, Cape Canaveral Air Force Station, and a portion of Merritt Island National Wildlife Refuge. The southern portion contains the highly developed but unincorporated Merritt Island and the barrier island communities and Patrick Air Force Base. Municipalities in this segment include Cape Canaveral, Cocoa Beach, Satellite Beach, and Indian Harbor Beach.

The current development pattern in Segment 1B is very distinctive. Land uses consist of the specialized uses of the Federally owned and controlled space center and wildlife refuge at its north end and the almost exclusively urban land uses at the south end where the municipalities are located along ocean and river shorelines. Population is concentrated on Merritt Island and in the small municipalities along the barrier island, all of which are nearly at "built-out" capacity. Like neighboring Segment 1A, there is little agricultural use within this segment. The area available for future growth in this basin is more limited than in any other segment, with "urban in-fill" expected to provide much of that future growth.

In terms of land area, this segment ranks fifth of the six segments, consisting of 248.3 km^2 (61,326 ac), almost as small as the adjacent Segment 1A. Like that neighboring basin, it has a comparatively large amount of surface water area with 192.8 km^2 (47,763

ac) within its boundaries. The large amount of associated shoreline has a definite impact of the segment's pattern of development, with many people drawn at an early date to the large number of building sites in proximity to the water.

The Banana River segment's (1B) 1970 population of 60,709 increased to 81,993 in 1990, a growth rate of 35% in that interval. The future population projection for this basin for 2010 is 96,470, an 18% increase from 1990. The Banana River (Segment 1B) has had the lowest percentage of growth among the segments during this period because much of the available land was developed prior to 1970. The low growth rate trend is expected to continue and to decrease even more in the future.

The 1970 population density of 634 people per square mile was by far the highest of any basin, almost ten times the density of the largely agricultural Segment 4. Segment 1B is historically the most urban in land use with the next closest basin (Segment 2) having half that population density in 1970. This status remained the same for Segment 1B in 1990 and is projected to continue in 2010, with respective densities of 856 and 1,007 people per square mile. The increases in population density in all segments exceeded that of Segment 1B in the period from 1970 to 1990 and are expected to exceed it again in 2010.

The amount of federally owned land in this segment has an effect on population density even greater than in Segment 1A (Mosquito Lagoon). Since over 60% of the land in this segment is federally controlled, almost all of the population is compressed into about 40 square miles south of Port Canaveral. As a result, the population densities in the portion of the Banana River segment south of Bennett Causeway (SR 528) were closer to 2,050 psm in 1990 and is expected to exceed 2,400 psm by 2010.

3.4.4 Segment 1C - North Indian River Lagoon

The basin of this segment consists of a portion of southeast Volusia County west of the Mosquito Lagoon basin and a portion of northeast Brevard County which does not front the Atlantic Ocean beaches. It contains 454 km^2 (112,197 ac), over twice the land area of either of the adjacent basins (1A and 1B) and ranks third in land area among the six basins. This segment has the largest surface water area, with 286 km^2 (70,728 ac). The

proximity to surface waters and shorelines has encouraged urban development of the surrounding area.

The 1970 population of this basin was 54,689. Like the adjacent Segment 1B, its growth rate from 1970 to 1990 was comparatively small in relation to most other basins. The 45% population increase between 1970 and 1990 to a total of 79,494 reflects the same urban characteristics of neighboring Segment 1B. This trend is expected to continue through 2010 with a projected 22% population increase to 97,106 people.

Population density rose from 312 to 453 people psm between 1970 and 1990. It is projected to rise to 554 by 2010. This density was twice that of the Indian River Lagoon regional average in 1970, but is expected to be about equal to the regional average in 2010, reflecting the below average growth rate projected over the next 20 years. Based upon approximately 110 square miles of non-federal land in this segment, the density of the developed area on non-federal lands equates to approximately 715 psm for 1990 and 870 for 2010.

The major cities and urban areas of this basin include all of Titusville, Cocoa, Rockledge, Palm Shores, Indian Harbor Beach, a portion of Melbourne, and the western portion of unincorporated Merritt Island. These developed urban areas are expected to continue as the centers of most future growth, with the small amount of existing agricultural uses (consisting mainly of citrus production) expected to grow even smaller.

The unincorporated areas of Port St. John and Canaveral Groves in Brevard County have recently been, and will continue, to be areas of high development and growth due in large part to relatively low costs of developed lots. Some of this low cost can be attributed to the absence of a central sewer system, since most of Port St. John is served by septic systems.

3.4.5 Segment 2 - North Central Indian River Lagoon Basin

This basin segment consists only of the southeastern coastal area of Brevard County, and it ranks fourth in total land area with 429 km^2 (105,866 ac). The segment is one of the most densely populated, second only to the Banana River basin (1B) in 1990. A 1970

population of 60,143 increased by 133% to 139,974 in 1990 and is projected to increase again by 44% to a population of 201,765 in 2010.

Population density has increased and is projected to continue to increase at a similar rate from 364 psm in 1970 to 846 psm in 1990 and 1,220 psm in 2010. This population density has been among the most dense in the region historically. The projected 1,220 psm density in 2010 will be the highest density in the region, reflecting the major population centers around the existing urban areas of Melbourne, Melbourne Village, West Melbourne, Melbourne Beach, Indialantic, Palm Bay, and Malabar. The population density in this area will be almost identical to that of the southern Banana River basin by 2010.

Palm Bay and Malabar have experienced the basin's most recent rapid residential growth, expanding the basin's population base from its historically populated areas along highways US 1 and A1A near the shoreline of the Lagoon inland to the segment's southwestern extent at Palm Bay. However, significant areas of undeveloped land remain in this basin.

3.4.6 Segment 3 - South Central Indian River Lagoon Basin

This basin consists of portions of two Counties - the lower part of Brevard to the north and the eastern half of Indian River County to the south. It is the second largest of the six segments in land area, consisting of 724 km^2 (178,947 ac). It also ranks as the second least developed of the segments in terms of population density, containing only one major urban center (the City of Vero Beach) and one smaller urban center (the City of Sebastian) in Indian River County. It is very much agricultural in character. It contains the smallest surface water area of the six basins, consisting of 71 km^2 (17,486 ac), and the shoreline is relatively highly developed. However, the extended inland watershed lacks a high degree of urban development, being used instead for citrus and pastureland.

The 1970 population of 36,542 increased by 155% to a 1990 population of 93,218, and is projected to be 146,782 in 2010, an increase of 57% for that interval. Population density has been, and is projected to remain, close to the regional average, with levels of 131 psm in 1970, 333 psm in 1990, and 525 psm in 2010. Although there is very little

publically owned land in this segment, the great majority of land is expected to remain agricultural. Therefore, the future growth of this basin is projected to be concentrated along the shore of the Lagoon, with Vero Beach as a hub and much higher population density will occur adjacent to the Lagoon. As a result, population density close to the Lagoon may be similar to that of the south Banana River basin.

Population growth will continue north and south along the Lagoon shorelines to include the small cities of Orchid and Indian River Shores. Sebastian is projected to be a secondary hub. A large amount of unincorporated Indian River County potentially will be annexed into these cities. Indian River County's Comprehensive Land Use Plan projects that the municipality of Fellsmere will become a center for future growth, but its growth rate is expected to be lower than that of Sebastian or Vero Beach, perhaps because it is not on the coastline.

3.4.7 Segment 4 - South Indian River Lagoon Basin

This basin consists of portions of four Counties - St. Lucie County at the north, Martin County in the middle, the very northeast corner of Palm Beach County in the south, and the southeast corner of Okeechobee County in the west. It ranks as the largest basin in terms of land area by far, consisting of 2,903 km^2 (716,845 ac), being almost five times larger than the next largest basin. It is predominantly agricultural in land use with residential and urban development centered around the coastal urban areas of Ft. Pierce, Port St. Lucie, and Stuart. The 1970 population of 77,990 increased by 220% to 249,764 in 1990, the highest rate of increase among the six basins. This premier rate of population increase is projected to continue with a 94% projected growth to 486,210 in the year 2010.

This is the least densely populated segment, due simply to its large geographic size. The 1970 density of 70 psm was about half that of the next lowest segment density. The projected 2010 density of 434 will still be the lowest in the region but it will be much closer to the regional average, reflecting the projected very high growth rate of this segment. Since at least 1970, the absolute population of this segment has been higher than any other segment. This basin is expected to remain as the most heavily populated of the basins and to continue its historic highest rate of population increase among the

six basins. Since a significant portion of developable area still exists around the existing urban areas, future development is expected to remain concentrated around those urban centers.

3.5 FINDINGS

The population projections developed in this study agree well with previous estimation of population growth in the Indian River Lagoon system watershed. Estimates for the portion of the 1970 census population living within the watershed were within 0.6% of the value determined by Glatzel and Swain (1987), who evaluated potential growth for the period from 1985 to 2000. The Glatzel and Swain projected population of 901,462 in 2000 is consistent with this study's projection of a population of 1,082,853 by the year 2010. The regional growth rate to 2010 of 60% projected by this study is slightly higher than the 50% rate predicted by Glatzel and Swain to the year 2000. The higher regional rate appears to be a result of a higher growth rate predicted for the South Indian River Lagoon segment (94% vs 67%) as based on a more recent data base. Increases for the other five segments are similar to those predicted by Glatzel and Swain.

The 2010 population density predicted by this study (570 psm) appears to be slightly higher than that predicted by Glatzel and Swain for the year 2000 (492 psm), but the densities when adjusted for population differences, are within 1%. This indicates a good agreement between the two data bases for total area and total population, and provides a good check on the reliability of the estimates.

The largest percentage increases in population will occur in Segment 4, with the lowest increases in Segments 1B and 1C. However population density will remain lowest in Segment 4 because of its large land area. Population density of Segments 1A, 3, and 4 will increase at a rate greater than the regional average while density of the currently urbanized segments (1B, 1C) will decrease relative to the regional average.

4.0
LAND USE

4.1 SCOPE AND INTRODUCTION

This section describes present and future land uses within the Indian River Lagoon system watershed. This information will be used to assess impacts within the basins and within the Lagoon study area.

Land use is a very important factor to consider when evaluating and managing the resources of the Indian River Lagoon system. Assessment of changes and trends in land use produces information on trends in economic and population patterns as well as changes in amount and distribution of natural habitat within the region. Numerous studies have shown that the type and amount of materials carried in stormwater runoff is directly related to the land use of the area in which the runoff is generated. Stormwater runoff entering the Lagoon carries sediments, bacteria, nutrients, and other materials which can have a significant effect on water quality and biota of the Lagoon. Thus, land use analysis is a necessary step in evaluating water quality trends of the Lagoon.

4.2 METHODS OF DATA COLLECTION AND PROJECTION

Land use data was analyzed for the entire Indian River Lagoon study area utilizing a variety of sources on different levels of geographic scale. The principal sources included GIS-based information provided from the two Water Management Districts (SJRWMD and SFWMD), Chapter 7 of the Recon Report on Population and Land Use (Glatzel and Swain, 1987), and recent Comprehensive Plans of the various Counties and municipalities within the Lagoon study area. Other sources were also used as background information. These are identified in the References section of this report.

The baseline period used in this study for the existing land use is the period from 1988 to 1990. This period was selected because it is the period with the most recently

available data. The land use data base was provided by SJRWMD and SFWMD as GIS-based digital land use files (SJRWMD, 1993; SFWMD, 1993). Existing land use for each segment was determined by digitally overlaying GIS data defining segment boundaries onto the land use data. Acreages for land use in each segment were then calculated by the ARCINFO software. Some alteration of the two land use systems was necessary in order to develop conformity. Some changes in category classification were necessary to provide a single classification covering both Districts. In addition, there were some discrepancies in matching land use along the district boundaries that required edge matching and consistency review.

This data base is in the Florida Department of Transportation (FDOT) 1985 version of the Florida Land Use and Land Cover Classification System (FLUCCS). It utilizes FLUCCs Level IV which has a level of detail that distinguishes between such disparate uses as junkyards, medical institutions, riding stables, and recreational vehicle parks. FLUCCS Level IV also provides a detailed classification system for undeveloped lands which includes such types as rangeland, coniferous and non-coniferous forested wetlands, and salt and freshwater marshes.

The data sources utilized for the future land use condition were digital files of the projected future land use element of the various county and municipal Comprehensive Plans. The various plans that were reviewed are shown in the References section.

A significant distinction exists between the data base representing existing land use and the data base used to project future land use. This difference limits their ability to be used for direct correlation and comparison. Existing land use has been mapped based upon actual land cover as seen on aerial photographs and associated ground truthing, using FLUCCS as a base classification scheme. However, projected future land use data is largely based upon current planning criteria reflecting site physical and social appropriateness and regulatory restraints. As such, it represents the possible potential uses consistent with existing government policies. Several possible uses may be suitable for a site. Accordingly, the level of specificity is generally much less for future land use maps than that for existing land use maps.

Present land is classified by actual physical presence and use, while future land uses are arranged and classified primarily by social and physical planning theory. This distinction in classification makes it difficult to directly compare existing and future land use data sets. The present or actual land uses often are not consistent with zoning or Comprehensive Plan Future Land Use maps. Future land use classifications, based on projected uses, are much more general, and do not specifically map undeveloped lands unless they are designated as official conservation areas. In addition, adjoining municipalities may not be consistent in designating suitable uses for similar undeveloped lands. Since the counties and municipality comprehensive plans do not specify timetables for these changes in uses, future land use mapping is difficult to allocate to specific time periods such as the 2010 target date of this study. Future land use maps describe the potential "build-out" condition rather than status at a specific point in time.

Another consideration in future land use assessment is the fact that some counties and municipalities have adopted maximum development scenarios in the future land use element of their Comprehensive Plans. While a county's future land use plan classifications may depict certain areas as acceptable for future uses, it does not mandate growth to occur in all such designated areas or to the maximum development potential allowed by the classification. The actual level of development will depend on site and time specific factors. Therefore, it is not uncommon for future land use plans to designate an excess of lands for development purposes, beyond what projected populations and growths may require. The Water Management District staffs have also issued similar caution in applying the various municipal land use designations to their area-wide future land use maps. According to Water Management District staff (McLane, 1993), the highest possible level of development allowed under the local governments' future land use classification was often assumed in developing the regional future land use maps, and this level of development may or may not occur.

Accordingly, the existing and future land use data bases can not be used reliably as comparable tools. Instead they are best viewed as complementary in nature, since their specific purpose and mapping methods are so dissimilar. A good example of this is the classification of large Federally-controlled areas of Kennedy Space Center, Canaveral National Seashore, and Merritt Island National Wildlife Refuge. Existing land cover maps classify various segments of this property based on land use as Institutional,

Recreational, Agricultural, Upland Forests, Water, and Wetlands, while future land use maps classify the same land as Public/Institutional, Recreation/Open Space, or Conservation. Thus existing wetlands under the FLUCCS system for existing land use may be mapped in the future land use maps under the Public/Institutional category.

In order to make existing and future land use maps as comparable as possible, it was necessary to combine existing land use categories into much broader categories, and to do the same with future land use categories. It was necessary to combine both existing and future land use data sets into eight general categories to achieve comparability. Seven of these have a common category label for the two time periods if not the same exact composition. Existing land uses have thus been distilled from the original GIS-based system that used over a hundred various classifications.

4.3 OBSERVATIONS AND TRENDS

4.3.1 Segment 1A - Mosquito Lagoon

This basin, although the smallest in total area, contains the largest percentage of existing open and undeveloped (rangeland, recreational and open space areas, forest, and wetlands) lands of any of the basins within the Lagoon study area (Tables 4-1 and 4-2) at 75% of its total land area. Additionally, the waters of Mosquito Lagoon comprise an area almost equal to the land area (47% water versus 53% land) Thus it is largely undeveloped and contains only a small percentage of existing developed area, most of which is in the three classifications (low, medium, and high density) of residential area which together comprise 18% of the basin land area. Commercial, industrial, and agricultural areas comprise only 2.7%, 3.1% and 1.5% respectively of the land area.

This basin's future land use is expected to remain largely the same as the existing land use. Total residential use is projected to remain at roughly 19% of the total basin land area (Tables 4-3 and 4-4), and a large percentage of the land area (approximately 43%) is projected to remain as open and undeveloped lands, due to the presence of the Federally controlled properties and various Comprehensive Plan restrictions.

TABLE 4-1

EXISTING LAND USE FOR INDIAN RIVER LAGOON SEGMENTS (IN ACRES)

EXISTING LAND USE CLASSIFICATION	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	LAGOON-WIDE TOTAL
Residential low density	1,212	1,109	4,691	5,124	7,333	31,834	51,303
Residential medium density	5,701	5,414	5,549	27,489	15,834	16,030	76,017
Residential high density	520	1,390	1,209	1,701	2,457	67	7,344
Commercial/Public/ Institutional	1,121	5,721	2,874	4,710	3,066	8,269	25,761
Industrial[1]	1,313	3,235	3,885	5,296	4,726	10,325	28,780
Agricultural	647	1,648	10,619	9,980	61,175	375,145	459,214
Mining/Extractive	106	0	221	91	469	1	888
Rangeland/Rec/Open-Space/Forest/Wetlands	31,654	38,757	76,008	49,905	79,498	234,810	510,632
Subtotal Land (basin) Area	42,274	57,274	105,056	104,296	174,558	676,481	1,159,939
Total water area	37,148	51,812	75,865	24,652	20,287	29,037	238,801
Total segment area (land and water)	79,422	109,086	180,921	128,948	194,845	705,518	1,398,740

1 = Includes areas designated as Transportation/Communication/Utilities.

TABLE 4-2

EXISTING LAND USE AREA PERCENTAGES OF SEGMENT BASINS AND TOTAL INDIAN RIVER LAGOON WATERSHED REGION

EXISTING LAND USE CLASSIFICATIONS	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	LAGOON-WIDE TOTAL
Residential low density	2.87 (1.53)	1.94 (1.02)	4.47 (2.59)	4.91 (3.97)	4.20 (3.76)	4.71 (4.51)	4.42 (3.67)
Residential medium density	13.49 (7.18)	9.45 (4.96)	5.28 (3.07)	26.36 (21.32)	9.07 (8.13)	2.37 (2.27)	6.55 (5.43)
Residential high density	1.23 (0.65)	2.43 (1.27)	1.15 (0.67)	1.63 (1.32)	1.41 (1.26)	0.01 (0.01)	0.63 (0.53)
Commercial/Public/ Institutional	2.65 (1.41)	9.99 (5.24)	2.74 (1.59)	4.52 (3.65)	1.76 (1.57)	1.22 (1.17)	2.22 (1.84)
Industrial[1]	3.10 (1.65)	5.65 (2.97)	3.70 (2.15)	5.08 (4.11)	2.71 (2.43)	1.53 (1.46)	2.48 (2.06)
Agricultural	1.53 (0.81)	2.88 (1.51)	10.10 (5.87)	9.57 (7.74)	35.05 (31.40)	55.46 (53.17)	39.59 (32.83)
Mining/Extractive	0.25 (0.13)	0.00 (0.00)	0.21 (0.12)	0.09 (0.07)	0.27 (0.24)	0.00 (0.00)	0.08 (0.06)
Rangeland/Rec/Open-Space/Forest/Wetlands	74.88 (39.86)	67.70 (35.53)	72.35 (42.01)	47.85 (38.70)	45.54 (40.80)	34.71 (33.28)	44.02 (36.51)
Subtotal Land (basin) Area	100.00 (53.23)	100.00 (52.50)	100.00 (58.07)	100.00 (80.88)	100.00 (89.59)	100.00 (95.88)	100.00 (82.93)
Total water area	(46.77)	(47.50)	(41.93)	(19.12)	(10.41)	(4.12)	(17.07)
Total segment area (land and water)	**(100.00)**	**(100.00)**	**(100.00)**	**(100.00)**	**(100.00)**	**(100.00)**	**(100.00)**

Note: Top figures are percentages of land area only; percentages within parenthesis are for Total Segment Areas, including Lagoon and other surface waters

A = Includes areas designated as Transportation/Communication/Utilities.

TABLE 4-3

FUTURE LAND USE FOR INDIAN RIVER LAGOON SEGMENTS (IN ACRES)

FUTURE LAND USE CLASSIFICATIONS	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	LAGOON-WIDE TOTAL
Residential low density[1]	2,133	0	2,754	0	69,358	113,152	187,397
Residential medium density	5,524	14,082	28,644	74,859	53,757	34,809	211,675
Residential high density	7,714	1,823	1,767	4,463	31,564	4,811	52,142
Commercial/Public/ Institutional	14,181	44,905	47,632	10,207	9,905	36,252	163,082
Industrial[2]	394	1,606	4,248	5,479	2,201	26,207	40,135
Agricultural	0	940	8,865	11,532	26,009	377,507	424,853
Rangeland/Rec/Open-Space/Conservation	34,171	2,321	22,006	1,411	1,905	26,780	88,594
Ummapped[3]	15,837	43,411	67,008	20,902	96	86,000	233,254
Total segment area (land and water)	79,954	109,088	182,924	128,853	194,795	705,518	1,401,132

1 = Includes areas designated as unspecified Urban and Built-up.
2 = Includes areas designated for Transportation/Communication/Utilities
3 = Includes areas designated for Water Bodies.

TABLE 4-4

FUTURE LAND USE AREA PERCENTAGES OF SEGMENT BASINS AND TOTAL INDIAN RIVER LAGOON WATERSHED REGION

FUTURE LAND USE CLASSIFICATIONS	SEGMENT 1A	SEGMENT 1B	SEGMENT 1C	SEGMENT 2	SEGMENT 3	SEGMENT 4	LAGOON-WIDE TOTAL
Residential low density[1]	2.69	0.00	1.51	0.00	35.60	16.04	13.37
Residential medium density	6.91	12.91	15.66	58.10	27.60	4.93	15.11
Residential high density	9.62	1.67	0.96	3.46	16.20	0.68	3.72
Commercial/Public/ Institutional	17.74	41.16	26.04	7.92	5.08	5.14	11.64
Industrial[2]	0.49	1.47	2.32	4.25	1.13	3.71	2.86
Agricultural	0.00	0.87	4.85	8.95	13.35	53.51	30.32
Rangeland/Rec/Open-Space/Conservation	42.74	2.13	12.03	1.10	0.99	3.80	6.33
Unclassified[3]	19.81	39.79	36.63	16.22	0.05	12.19	16.65
Total segment area (land and water)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1 = Includes areas designated as unspecified Urban and Built-up.
2 = Includes areas designated for Transportation/Communication/Utilities
3 = Includes areas designated for Water Bodies.

4.3.2 Segment 1B - Banana River

As seen in Tables 4-1 and 4-2, this basin shares many of the same characteristics of neighboring Basin 1A, such as a large percentage of existing open and undeveloped lands (68% of the total land area) and an even higher percentage of surface water area (47.5 % water surface versus 52.5% land surface). The large amount of land classified as open space (68%) is due to the presence of Federally-owned natural areas at Kennedy Space Center, Canaveral National Seashore, and Merritt Island National Wildlife Refuge. Although the residential area in this basin also comprises a significant percentage (14%) of the land surface, it is concentrated in the relatively small portion of the south half of the basin that is not owned by the Federal government. The northern portion of the basin is relatively undeveloped due to the Federal lands. The high percentage of existing institutional/commercial area (10%) is also due to the Federal lands classified as Institutional Lands. Port Canaveral comprises the bulk of the small percentage (3%) of the industrial lands outside of the Kennedy Space Center.

The future land use of this segment is skewed by future land use classification irregularities such as the absence of any areas classified as Low Density Residential, the small amount of undeveloped area (2.1%), and the large amount of area classified as Commercial/Institutional (41%). The large percentage of Institutional land and the associated small percentage for open space land use for the future condition are due to inclusion of all Federal properties, including large amounts of natural area, in the Institutional category rather than the open space category in the future land use maps. Despite this, the character of this area is projected to remain similar to the existing condition, especially in light of the small projected population growth rate, which is substantially less than the growth rate that the county's projected increase in residential land use area would indicate.

In this case, Brevard County's Future Land Use Plan has provided for an abundance of land within this segment which can be used for medium density residential land use. It may not be possible to develop all of such designated lands to this density given current government regulation and actual condition of the land. This represents a somewhat conservative approach on the part of the county, with a possible overestimation of future development and density.

4.3.3 Segment 1C - North Indian River Lagoon

This basin contains the most surface water of any of the basins (75,865 ac, comprising 42% of the total basin area). Correspondingly it has the greatest length of associated shoreline. Undeveloped areas are almost three-fourths (72%) of the total land area, due again to large amounts of Federal properties, which are largely forests and wetlands. The current land area contains about 11% residential and 10% agricultural land uses. Commercial/institutional and industrial areas comprise about 2.7% and 3.7%, respectively of total land area.

Segment 1C is projected to have a large future increase in residential area, increasing from 11% to about 18% of total land area, as indicated by Brevard County's Comprehensive Land Use Plan future land use designation system. Despite this increase, little change in the character of this basin is projected since the projected future population growth rate is one of the lowest in the Lagoon region.

4.3.4 Segment 2 - North Central Indian River Lagoon

This basin contains the largest percentage (33% of the total land area) of existing residential area of all of the basins. It has a smaller percentage of undeveloped areas (48% of total land area) than the adjacent basins, since it does not have large Federally-controlled park and wilderness areas. Agriculture comprises 10% of the basin's land area, with commercial/institutional and industrial land uses comprising 4.5% and 5.1% respectively.

The projected future condition for Segment 2 shows residential land uses to be 62% of the total basin area under the municipal and Brevard County Comprehensive Plan Future Land Use designations. However, the growth in residential land use may not be as large as indicated since the projected population increase of 44% is less than the projected 131% increase in residential area. In addition, the increase in residential population within this basin will most likely occur first within those large areas that have already been platted and mapped for residential land use. Portions of Palm Bay may be a good example of this development pattern. As a result, the actual increase in

residential land use may be less than the acreage projected by the county's Future land Use Plan.

4.3.5 Segment 3 - South Central Indian River Lagoon

In comparison with the basins to the north, this basin contains a much larger percentage of existing agricultural area (35% of total land area) and a much smaller percentage of surface waters (10% of total basin area). The large agriculture area is composed largely of citrus. Being further south than the preceding basins, this basin has a more temperate climate for agriculture, which may account for the large percentage of agricultural area. The combination of large amounts of agricultural use and open space land uses (46% of total land area) makes this basin much less intensely urbanized than the northern basins. Only 15% of the basin land area is residential, with commercial and industrial uses comprising only 1.8% and 2.7% respectively.

With the City of Vero Beach serving as the only regional urban center in this large basin, future growth is expected to occur along the largely undeveloped shorelines adjacent to Vero Beach and Sebastian. Despite this basin's future planning designations that show a large percentage (79%) of area projected for future residential land uses, the western portion of this segment is largely wetlands and may remain as open space or conservation lands. This assumption is reinforced by the fact that the projected increase in residential area (481%) is far greater than the 57% projected increase population increase.

4.3.6 Segment 4 - South Indian River Lagoon

Although this basin contains several urban hubs, it is also highly agricultural (56% of total land area) and it is projected to remain so. Undeveloped land area currently comprises 35% of the total basin land area. Urban land use extent is fairly low, with residential areas comprising 7% of the basin's land area. Commercial and industrial land uses, which are normally associated with urban areas, comprise only 1.2% and 1.5% respectively of the basin area.

This segment, like Segment 3, also has an abundance of areas that have been designated as future residential use (22% of the land total as compared to an existing condition of 7%). It is probable that not all be of this will be required for residential use since the projected population growth rate is only about one-third of the projected residential land use increase. Although anticipated to retain its highest ranking in population growth rate, this basin does contain an excess of currently available land designated for this purpose, including the large already platted area of Port St. Lucie. A large percentage (53%) of the segment is still proposed to remain agricultural in the future.

4.4 FINDINGS

The Indian River Lagoon region has been undergoing a steady conversion from natural land cover to agricultural and urban uses for many years. Hoffman and Haddad (1988) indicate that the percentage of urban land cover in this region, extending as far west as the St. Johns River, increased by 895% between 1940 and 1987 while agricultural lands increased by 352%. This analysis predicts that urban land will increase by over 240% by the year 2010 in the Indian River Lagoon system watershed, but that agricultural land will decrease by about 6%.

The land use predictions for the year 2010 are based on the Future Land Use Plans of the various municipalities and counties. As mentioned previously, many of these plans have been based on maximum development or possible "built-out" conditions, which represents the total number of housing units or total population that an area is expected to have under a specific comprehensive plan and set of zoning ordinances (Glatzel and Swain, 1987). For example, the predicted population increase (Section 3) in Segment 4 is 94%. However, the increase in residential land use predicted or allowed by the comprehensive plans is 219%. This land use increase thus is more representative of the built-out condition rather than the actual condition at this point in time. It appears that the future land use designations based on comprehensive land use plans are predicting a scenario in which some areas available for residential growth are passed over and development is continued on the expanding fringe areas.

Glatzel and Swain (1987) state that the built-out condition is an ecological threat to the Lagoon. They also reviewed many of the comprehensive plans that were available at

that time and concluded that the plans did not consider activities in coastal watersheds or upland areas to have any impacts on the Lagoon. The analysis of non-point source pollutant loadings to the Lagoon developed in the companion Technical Report "Non-point and Point Source Loadings Assessment" shows that land use of these areas does have a significant effect on loadings to the Lagoon, and that the built-out condition does result in significant increases in loadings of many pollutants to portions of the Lagoon. Allowable development and land use change under currently existing (1993) comprehensive plans and development regulations will result in significant non-point source loadings increases for the Lagoon.

The present study has identified land use trends on a regional scale. More detailed analysis of land use changes is still required to identify specific needs, areas of impact, and effects of management options. For example, Gilbrook (1990) performed such an analysis on the non-federally controlled portions of Brevard County only. His analysis showed that future conservation areas under the comprehensive plans accounted for only 1.2% of the existing open space. Our regional analysis indicates that about 70% of the land in Brevard County will remain as open space,but that most of this will be in the Federally controlled areas. Gilbrook estimated that only 8% of existing wetlands, 1% of existing upland forest, and 3.5% of existing coastal scrub will remain as conservation land under existing local government planning projections, although other wetlands may be protected under other government regulations.

Several options may exist for addressing the potential scope of these changes. Since many of the projections appear be based on maximum development or built-out scenarios, it may be possible for local governments to review future land use plans and reduce the amount of projected urban lands to levels more consistent with anticipated population growth and carrying capacity for the Lagoon. Infill of existing residential areas can be encouraged to reduce urban sprawl. Other local options may also exist. Gilbrook also examined projected land use changes in smaller sub-basins and estimated that if local governments required preservation of an additional 10% of existing forested lands in residential developments, then the amount of upland forest conservation area would triple in these areas.

5.0
ECONOMIC USES

5.1 SCOPE AND INTRODUCTION

Historically, the Indian River Lagoon system forms a focus for the lifestyle and the development of communities within the Indian River Lagoon basin. There has been considerable growth and resultant diversification in the region since the 1950s, when industries other than agriculture and fisheries began to develop. Today, the economic base of the region includes such major industries as manufacturing and tourism, along with the resultant real estate, financial, service, and government sectors which serve the expanding population base. The development of Palm Beach County in the 1950s and 1960s as a center for retirement and seasonal residence and the growth of NASA and the space program at Kennedy Space Center in Brevard County in the 1960s and 1970s were the initial stages of the growth and diversification of the region.

Steamboats no longer ply the waters of the Lagoon with freight and passengers. Today, direct economic use of the Lagoon is largely confined to the fishery and recreation/tourism sector. Although direct employment from these industries forms a fairly small proportion of the total employment in the region [Florida Department of Commerce (FDC), 1993], the value of the Lagoon as an economic resource extends well beyond these narrow limits. The Indian River Lagoon forms a focus for the lifestyle and development of the communities. Much of the industry and population growth has been directly influenced by the presence of the Lagoon system and the attractions that it offers. The quality of life within the region is directly dependent upon the quality of the Lagoon for its aesthetic, recreational, and gastronomic features.

Thus, when reviewing the major economic and direct employment indicators of the region, it is important to be aware of these additional influences that the Indian River Lagoon system exerts on all of the industries and employment sectors of the region and to recognize the beneficial indirect effects on life style and the economy of the region.

Economic and employment data are not specifically available for the Indian River Lagoon watershed area. These data have been compiled by FDC (1993) and BEBR (1983) only on a county-wide basis. However, in most of the region, the Indian River Lagoon watershed area comprises the vast majority of the employment base of the counties. The exceptions to this are in Volusia County where the watershed forms a fairly small proportion of the highly populated areas of the county and in Palm Beach County where it represents a very small portion. However, the trends within the Lagoon watershed portion of these counties are assumed to be consistent in these counties with the general county-wide trends.

5.2 EMPLOYMENT SECTORS

Table 5-1 shows employment within major industry groups for each county for the year 1991 (FDC, 1993). Employment data have not been broken down according to watersheds. However, in Brevard, Indian River, Martin, and St. Lucie Counties, almost all of the employment occurs within the boundaries of the Indian River Lagoon system. Only small portions of Palm Beach and Okeechobee Counties are in the Indian River Lagoon system area, but employment patterns in these portions are probably similar to those in the entire county. For Volusia County, these figures may not be representative of the Indian River Lagoon system because much of the employment is in interior parts of the county near DeLand or in the north in the Daytona Beach area.

Natural resources employment, which includes fisheries (among the trades), accounts for more than 10% of total employment only in St. Lucie County (10.6%). Most of these workers are employed by the citrus industry (FDC, 1993). Except in St. Lucie, Indian River, and Martin Counties, the natural resource dependent jobs represent the smallest employment sector. The services sector is the largest source of employment in all counties, with the trades being the second largest sector.

5.3 ECONOMIC USES OF THE INDIAN RIVER SYSTEM

One measure of the value of the Lagoon system to the local economy may be linked to tourism and recreational indicators, since the Lagoon system is one of the primary tourist and recreational attractions of the region. The degree of tourism and recreational use

TABLE 5-1

SUMMARY OF EMPLOYMENT IN THE COUNTIES OF INDIAN RIVER LAGOON REGION BY MAJOR SECTOR FOR 1991[1]

NUMBER OF PERSONS EMPLOYED BY SECTOR	COUNTY						
	VOLUSIA	BREVARD	INDIAN RIVER	ST. LUCIE	MARTIN	OKEECHOBEE	PALM BEACH
Forestry, Fisheries, and Agricultural Services	2,542	2,214	3,262	6,181	2,457	364	14,051
Trades	42,196	42,705	9,915	13,210	12,845	2,491	110,110
Construction	12,400	12,539	4,463	5,321	5,536	783	34,199
Manufacturing	12,572	31,214	2,594	2,530	3,778	320	33,667
Transportation and Utilities	4,825	5,147	780	2,870	1,804	347	16,706
Financial Institutions and Real Estate	13,341	12,902	4,942	4,523	5,632	623	50,459
Services	49,426	65,851	14,169	15,497	15,760	2,606	161,958
Government	21,476	28,597	4,333	7,965	4,934	1,435	47,405
Other	23	86	102	43	19	0	858
Total Nonfarm Employment	158,801	201,255	44,560	58,140	52,765	8,969	469,413

Source: Florida Department of Commerce, 1993
Note: Data shown in county-wide and not specific to those areas within the Indian River Lagoon system

1 = 1990-91 data

is often reflected by to the number of hotels and restaurants in an area. Table 5-2 lists the number of restaurant and hotels in the seven-county region. The seven counties that include the Indian River Lagoon system account for 16% of the total restaurant and hotel outlets in the state, with the largest concentrations in Brevard, Palm Beach, and Volusia Counties. Almost all of the Brevard, Indian River, St. Lucie, and Martin County units are located within the Indian River Lagoon watershed, whereas only a small portion of those shown in Table 5-2 in Palm Beach and Volusia Counties are within the watershed. This implies that Brevard County is the center of tourist/recreation activity along the Lagoon. A large percentage of the recreation value in all but Volusia and Palm Beach Counties probably is associated with the Lagoon or the Atlantic beaches along the Lagoon's barrier islands. Daytona Beach and the Daytona International Speedway undoubtedly account for much of Volusia County's tourist industry, while the Kennedy Space Center and the Port Canaveral cruise ship industry are important components of Brevard County's tourist base.

Table 5-2 also shows sales taxes receipts estimated by the FDC (1992) to have come from tourist/recreational uses in 1991. The sales tax base from the Indian River Lagoon system watershed represents 15% of the recreational sales taxes collected in Florida. The population per capita tax received is substantially higher in the coastal/Lagoonal counties as opposed to landlocked Okeechobee County, indicating the additional tax generating value of the coastal resources.

Table 5-3 shows the natural resources production of the counties in the 1990-91 season. Forest products represented an insignificant contribution in all counties except Volusia. However, only a small portion of this was produced within the Indian River Lagoon system watershed.

Fisheries production in terms of total pounds of fresh landings was substantial, accounting for over 16% of the state's total production. Brevard County accounted for almost one-third of the total Indian River Lagoon regional landings, with the remainder distributed approximately equally among the remaining coastal counties. Further detail is provided in Section 6.0.

TABLE 5-2

SUMMARY OF RECREATION AND TOURISM VALUE INDICATORS IN THE COUNTIES OF THE INDIAN RIVER LAGOON REGION FOR 1991

COUNTY	ECONOMIC INDICATOR			
	NUMBER OF FOOD SERVICE OUTLETS	NUMBER OF HOTELS AND MOTELS	NET TOURIST/RECREATION SALES TAX PAID ($)	PER CAPITA TOURIST/ RECREATION SALES TAX ($)
Volusia	1,513	337	46,325,000	123.20
Brevard	1,216	114	41,041,000	100.34
Indian River	289	31	9,054,000	98.41
St. Lucie	503	39	27,504,000	177.45
Martin	384	26	11,597,000	112.59
Okeechobee	116	10	1,773,000	59.10
Palm Beach	3,064	230	125,347,000	141.96
Indian River Regional Total[1]	7,085 (16.3)	787 (16.6)	262,641,000 (15.0)	...
State of Florida	43,570	4,738	1,754,878,000	133.02

Source: Florida Department of Commerce, 1993
Note: Data shown in county-wide and not specific to those areas within the Indian River Lagoon system

1 = ( ) = % of state total

TABLE 5-3

SUMMARY OF NATURAL RESOURCES PRODUCTION INDICATORS IN THE COUNTIES OF THE INDIAN RIVER LAGOON REGION FOR 1990-91

COUNTY	ECONOMIC INDICATOR		
	CASH RECEIPTS FROM AGRICULTURAL MARKETS IN 1990 ($000)	VOLUME OF FOREST PRODUCTS IN 1991 (CUBIC FT)	VOLUME OF FISHERIES LANDINGS IN 1991 (000 LBS)
Volusia	106,416 (17)	11,635 (18)	2,052 (13)
Brevard[1]	30,799 (39)	502 (52)	5,164 (6)
Indian River	119,400 (14)	137 (56)	1,578 (16)
St. Lucie	153,053 (9)	364 (55)	1,731 (15)
Martin	133,416 (11)	0 (62)[3]	1,558 (17)
Okeechobee	133,281 (12)	0 (62)[3]	0 (62)
Palm Beach	1,035,893 (1)	0 (62)[3]	1,053 (23)
Indian River Regional Total[2]	1,712,258 (29.7)	12,638 (2.4)	13,136 (16.7)
State of Florida	5,773,170	522,914	78,883

Source: Florida Department of Commerce, 1993
Note: Data shown in county-wide and not specific to those areas within the Indian River Lagoon system

1 = ( ) for counties = rank among counties in state
2 = ( ) for regional total = % of state total
3 = Tied for last in state

Agricultural fresh market receipts are also a revenue source for the region, generating almost 30% of the state's total fresh market receipts (FDC, 1993). Palm Beach ranks first in the state in total sales, with significant contributions from all of the other counties. The exact proportion of the seven-county revenue that is generated within the Indian River Lagoon system is unknown, but is probably about 50% of each county's revenue, except in Palm Beach and Volusia Counties, where much less of the counties are included within the watershed.

5.4 AGRICULTURAL PRODUCTION

The Indian River Citrus Region has been recognized as producing some of the highest quality fresh citrus in the world. As an example of what this means in an economic sense, the Florida Department of Agriculture and Consumer Services (1992a) reported that the average price of a box of Indian River white seedless grapefruit in 1991 was $9.10 whereas the price for a similar box from interior Florida was $6.60. In addition to premium quality of fruit, the Indian River Lagoon region has a more predictable harvest due to the ameliorating effect of the Lagoon and ocean waters on the severe freezes which often impact harvests.

The Indian River Citrus Region produced 78,353,000 boxes of fresh citrus in 1990-91, which represented over 38% of the total Florida harvest (Table 5-4). Production is centered in St. Lucie and Indian River Counties, which rank first and third respectively in citrus production in the state. In 1990-91, Florida produced about 18% of the world's citrus crop [Florida Department of Agriculture and Consumer Services (FDACS), 1992a]. On this basis, the Indian River Citrus Region is estimated to have accounted for about 7% of the world production.

Commercial citrus production in Florida was first documented in 1866-67 as 1.26 million boxes (FDACS, 1992a). Production peaked in 1979-80 with a total of 283.5 million boxes (FDACS, 1992a). The 1990-91 harvest of 205.6 million boxes falls within the upper range of harvests since 1981. A series of severe freezes coupled with conversion of citrus land to urban uses has accounted for the decline since 1980 (FDACS, 1992a).

TABLE 5-4

SUMMARY OF CITRUS PRODUCTION IN THE COUNTIES OF THE INDIAN RIVER LAGOON REGION FOR 1990-91 SEASON

COUNTY	FRESH FRUIT PRODUCTION		CITRUS PRODUCING ACREAGE	
	FRESH FRUIT SHIPMENTS - ALL CITRUS (BOXES)	RANK OF COUNTIES IN STATE	ACRES OF CITRUS PRODUCTION	RANK OF COUNTIES IN STATE
Volusia	203,000	21	1,198	24
Brevard	3,380,000	15	10,519	16
Indian River	21,866,000	3	66,116	4
St. Lucie	26,926,000	1	94,878	1
Martin	16,320,000	7	46,283	8
Okeechobee	3,030,000	16	8,541	18
Palm Beach	6,628,000	10	15,545	13
Indian River Regional Total	78,353,000	(38.4)[1]	243,080	(33.8)[1]
State Total	203,860,000	...	719,876	...

Source: Florida Department of Agriculture and Consumer Services, 1992

1 = ( ) = Total seven counties of Indian River Lagoon region production as percent of state total

Since 1987-88, statewide producing citrus acreage has grown from 697,929 acres to 719,876 acres (FDACS, 1992a). In the same period, Indian River Citrus Region acreage has grown from 231,007 to 243,080 (FDACS, 1992a). This additional Indian River Citrus Region acreage represents 55% of the statewide growth during this period, indicating that the region is increasing its importance in citrus production and is on the rebound from the destructive events. Indian River Citrus Region production as a percentage of the state total has also risen from 36.6% in 1987-88 to 38.1 in 1990-91 (FDACS, 1989, 1992a).

Citrus represents by far the greatest agricultural sector in the Indian River system. Table 5-5 shows that vegetable crop (exclusive of sugar cane) acreage in the region totaled 17,320 acres in 1990-91, only 2.4% of the total citrus acreage. Almost all of the vegetable crop land is located in Palm Beach County, and only a small percentage of that land is actually located within the Indian River Lagoon system watershed.

Cattle ranching is most important in Martin and St. Lucie Counties, but some ranching activity also exists in the Lagoon watershed in Brevard and Indian River Counties. Most cattle ranching in these four counties is outside of the Indian River Lagoon watershed.

TABLE 5-5

SUMMARY OF VEGETABLE CROP ACREAGE IN THE COUNTIES OF THE INDIAN RIVER LAGOON REGION FOR 1990-91 SEASON

COUNTY	ACREAGE BY VEGETABLE CROP						
	SNAP BEAN	CUCUMBER	EGG PLANT	GREEN PEPPER	TOMATO	SQUASH	WATERMELON
Volusia[1]					1,120		
Brevard							
Indian River							
St. Lucie[1]							
Martin				500			
Okeechobee							300
Palm Beach	1,000	4,150	800	5,200	3,650	600	
Indian River Regional Total	1,000	4,150	800	5,700	4,770	600	300

Source: Florida Department of Agriculture and Consumer Services, 1992b

1 = Minor production of tomatos and green peppers in St Lucie County and green peppers in Volusia County

6.0
FISHERIES AND BOATING USES

6.1 SCOPE AND INTRODUCTION

This section of the report presents a summary of the types and potential of the fisheries and boating resources of the Indian River Lagoon complex. It is not intended to be an exhaustive treatment of the subject. Several thorough reviews of the history and economics of fisheries of the Indian River Lagoon have been prepared by Adams (1985), Yingling (1987), and Rathjen and Bolhassen (1988). Much of the information in this section has been derived from these sources.

Information on fisheries resources for an area is usually fragmented, often lacking specific data for certain periods, areas, or resources. This is true for the Indian River Lagoon region. Part of the reason is the fact that fisheries resources fall under the jurisdiction of numerous state and federal agencies or departments, and spheres of influence or interest are not always well defined. Thus statistics for different resources may be collated and reported by different agencies that have little overlap or coordination in other responsibilities. Other reasons include changes in species names, changes of reporting methods over time, and changes in fishing methods over time. Thus general trends can be identified, but care must be used in interpreting reasons and numerical values behind the trends.

For this project, the Indian River Lagoon complex has been defined as the Indian River Lagoon from its north end south to Jupiter Inlet, the Banana River, and Mosquito Lagoon north to Ponce de Leon Inlet. The Indian River Lagoon system includes these water bodies and their associated drainage basins, which include parts of Volusia, Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Okeechobee Counties.

Fisheries data used for this analysis have been reported by county. Since the county boundaries do not all correspond with the watershed of the Lagoon, the data for Palm Beach and Volusia Counties include information from areas which are not a part of the Indian River Lagoon complex. It is not possible to separately delineate the Indian River

portion of this data. In addition, several species and activities occur in both the Lagoon and in the open ocean. Data involving such items as fish landings, fishing licenses, and fisheries-related employment generally lumps Lagoon- and non-Lagoon information into one category.

6.2 HISTORICAL PATTERNS

6.2.1 Pre-1900 Period

Oyster, clam, coquina and conch utilization by the nomadic Timucuan and Ais Indians have been documented as far back as 8,000 years (Hale, 1984). Indian middens such as Turtle Mound on the shore of Mosquito Lagoon attest to this use (Rathjen and Bolhassen, 1988). Remains of sharks, sea catfish, sea turtles, and other species from the estuary have also been found associated with Indian remains (Rouse, 1951; Donan and Dickel, 1988)

Commercial exploitation of the Indian River Lagoon fisheries probably did not begin until the late 1800s. Rathjen and Bolhassen (1988) cite authors (Earll, 1887) of that period in describing the first attempt to establish a cannery for sea turtles, fish, and oysters along the Lagoon in 1866. In the 1870s and 1880s, the Lagoon was utilized by fishing crews sailing from Savannah and other ports to the north who seined fish from the inlets for transport to markets in the north (Earll, 1887). Due to the very sparse settlement, there was a very limited local market through the 1800s. Due to the shallow and isolated nature of the Lagoon complex, access for large boats from other regions also was limited. As a result, commercial fisheries were not significant in the Lagoon until the late 1890s when the opening of new inlets and dredging of channels improved boat access, and improved rail transportation and increasing local population improved markets for products (Rathjen and Bolhassen, 1998).

Evermann and Bean (1898, in Rathjen and Bolhassen) reported only 254 persons employed in conjunction with commercial fisheries between Titusville and Stuart in 1895. The Titusville and Ft. Pierce areas had the largest employments, with about 50 people in each city. About 2.5 million pounds of fisheries products were shipped from Ft.

Pierce in 1895, and over half of the total consisted of mullet (Wilcox, 1898, in Rathjen and Bolhassen)

6.2.2 1900 to 1950 Period

Commercial fisheries expanded within the Indian River Lagoon area in the era between 1900 and 1950. However, little documentation exists for this period (Rathjen and Bolhassen, 1988). Apparently most of the commercial fisheries were concentrated in the Atlantic Ocean rather than in the Lagoon. Photographic records from this period document large catches of sawfish, jewfish, sea trout, snook, and other species within the Lagoon during this period (IRLNEP, 1993). Industries that flourished for short terms region included a longline fishery for large sharks from about 1935 to 1950 in the St. Lucie-Salerno area. The primary objective was to obtain shark livers as a source of vitamin A for animal feeds (Springer, 1963). Commercial harvesting of *Gracilaria* sp., an algae, occurred in the south central and southern parts of the Lagoon during World War II when traditional sources of agar were unavailable (Humm, 1951).

6.2.3 1950 to Present Period

Rathjen and Bolhassen (1988) determined that significant statistical information on fisheries was not available prior to 1958. They have provided a detailed analysis of the data from 1958 through 1985, which is summarized in this report. They also cite several references (Siebenaler, 1955: Tabb, 1960, 1961) that indicate that commercial fishing methods (gill netting, trolling) and the total amount of fishing effort and fishing units (i.e. gill nets) in the Lagoon through about 1960 was very similar to that which occurred between 1880 and 1950.

Tabb (1960) reported that commercial fishing effort was relatively evenly distributed throughout the Lagoon until the late 1950s, and that trolling for spotted seatrout was a major commercial activity. In Brevard and Indian River Counties, this activity accounted for about half of the Florida seatrout production. This fishery declined rapidly after about 1958 due to increased urbanization and the conversion of the economy from a fisheries base to a technological base with the expansion of the Kennedy Space Center in Brevard County (Rathjen and Bolhassen, 1988).

Rathjen and Bolhassen (1988) also report that commercial fisheries between Ponce Inlet and Melbourne from 1959 through 1962 averaged 6 million lbs/year, with black mullet (also known as striped mullet), spotted seatrout, red snapper, blue crab, spot, whiting, and pompano being the primary species. Recreational catches during this period were estimated to be 3.2 million lbs/year (Anderson and Gehringer, 1965). By the late 1960s, commercial catches of spotted seatrout and many other species had declined, and mullet had become the leading catch.

From 1970 through 1985, commercial landings showed an upward trend (Rathjen and Bolhassen, 1988) in all counties from Martin through Volusia, with significant oyster and mullet landings during this period. Mullet were the most abundant fish landed during this period, although the landings were about half those recorded from the late 1950s. Adams (1985) estimated a primary economic impact (harvesting, processing, wholesaling, equipment purchases) of $114 million for Martin, St, Lucie, Indian River, and Brevard Counties for 1983. This was based on a dockside landings value of $24.4 million, which represented 14% of the landings for all of Florida.

Much of the increase in commercial landings since 1980 have been due to increased harvests of hard clams and calico scallops (Rathjen and Bolhassen, 1988; Adams, 1985). The hard clam harvest has been entirely from within the Indian River Lagoon estuary complex, while calico scallops are an exclusively offshore fishery resource.

6.3 COMMERCIAL FISHERIES

Annual landings data was published by the National Marine Fisheries Service through 1984, but has been reported through the Florida Department of Natural Resources Marine Fisheries Information system since then. The most recent finalized information available for this report covered the 1988 period, when data for 86 categories of finfish and 29 categories of invertebrates and shellfish was reported. Data is regularly recorded from most of these 115 categories from counties in the Indian River Lagoon region. However, only a small portion of these represent Indian River Lagoon estuarine species that account for significant catches. The 24 categories selected by Rathjen and Bolhassen (1988) have been used as representative of Indian River commercial fisheries

for this section. Table 6-1 shows the species categories tracked by Rathjen and Bolhassen for this analysis.

Data for the period 1958 through 1984 has been obtained from the analysis provided by Rathjen and Bolhassen (1988) and checked against original data from FDNR. This data has been supplemented through 1988 with final data from the FDNR Marine Fisheries Information System (FDNR; 1987, 1988, 1990a, 1990b). Some data has been utilized from the Marine Fisheries Information System for the period from 1989 to 1993, but this data is preliminary and unedited data. Rathjen and Bolhassen reviewed the list of fish species landed and limited their evaluation only to those species that are dependent upon the Lagoon for a portion of their life cycle (Yingling, 1987).

6.3.1 Total Landings

Figure 6-1 shows total reported landings of these 24 categories for the period from 1958 through 1988. Annual catches range from a low of 7,366,604 pounds in 1960 to a peak of 19,953,188 pounds in 1977. The data indicates a general gradual rise in landings since before 1960, with a period in the 1970s representing the greatest harvest period. Landings for all counties were generally similar prior to about 1965 and ranged between 1 and 3 million pounds per county (Figure 6-2). Landings for Brevard County increased significantly in the late 1960s to average over 4 million pounds. Landings for Martin and St. Lucie County increased to this range in the late 1970s, but have since approached their previous lower levels.

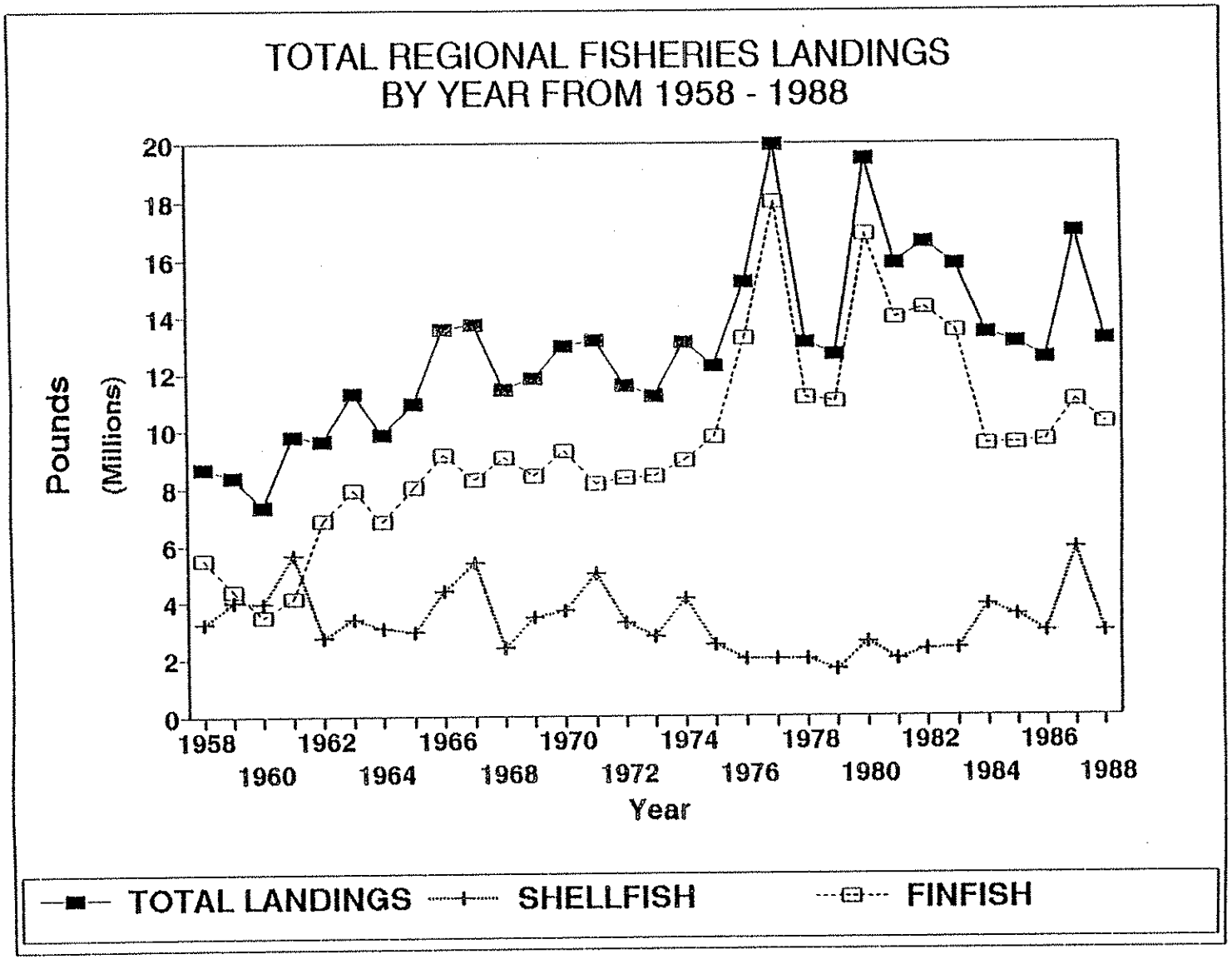
Figures 6-3 through 6-5 show the relative total, finfish, and shellfish landings contributions of each county for the entire period from 1958 through 1988 (top) and for the 1988 year (bottom). The average total fisheries contribution of each county in 1988 was almost identical to the average contribution for the 30-year period, indicating that there has been no major shift in the overall distribution of total fisheries during this period. Finfish landings (Figure 6-4) show a slight change in distribution among counties, but a dramatic shift is apparent for shellfish landings (Figure 6-5). Brevard County accounted for 67% of total shellfish landings for the 30-year period, but its landings were 82% of the regional total by 1988. The harvest for Indian River, St. Lucie, and Martin Counties had decreased 22% to 3%, indicating a major shift in the center

TABLE 6-1

ESTUARINE DEPENDENT COMMERCIAL FINFISH AND SHELLFISH OF THE INDIAN RIVER LAGOON REGION

FINFISH	SHELLFISH
Atlantic Sheepshead	Blue Crab
Black Drum	Hard Clam
Bluefish	Oyster
Croaker	
Cravalle Jack	
Flounders	
King Whiting	
Spanish mackerel	
Mangrove Snapper	
Mutton Snapper	
Menhaden	
Permit	
Pigfish	
Pompano	
Red Drum	
Silver Mullet	
Striped mullet	
Spot	
Spotted Seatrout	
Tripletail	
Yellowtail Snapper	

Sources: Rathjen and Bolhassen, 1988
Yingling, 1987

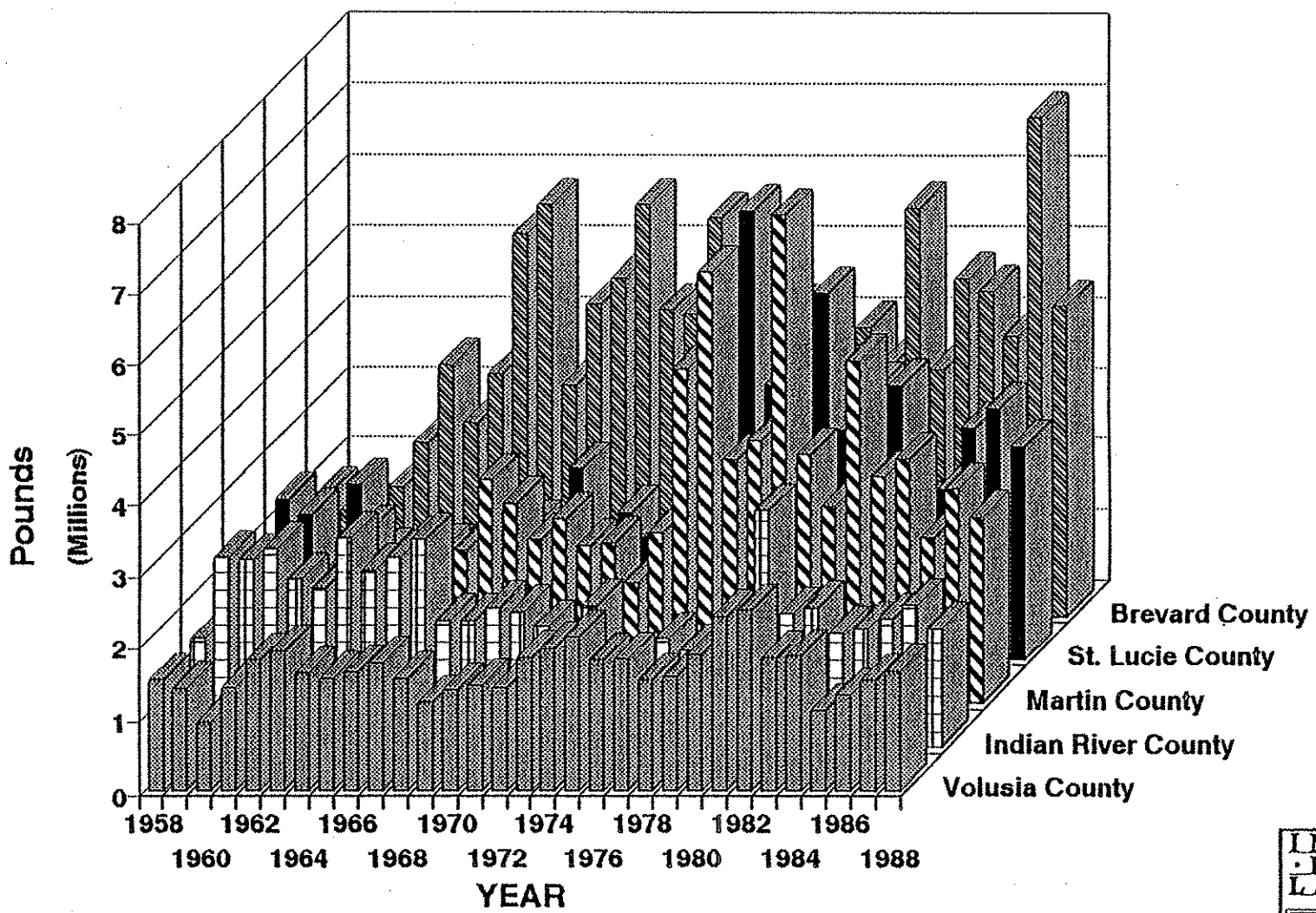


Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 6-1	TOTAL FISHERIES LANDINGS FOR THE INDIAN RIVER LAGOON REGION BY YEAR FOR THE PERIOD 1958 TO 1988

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

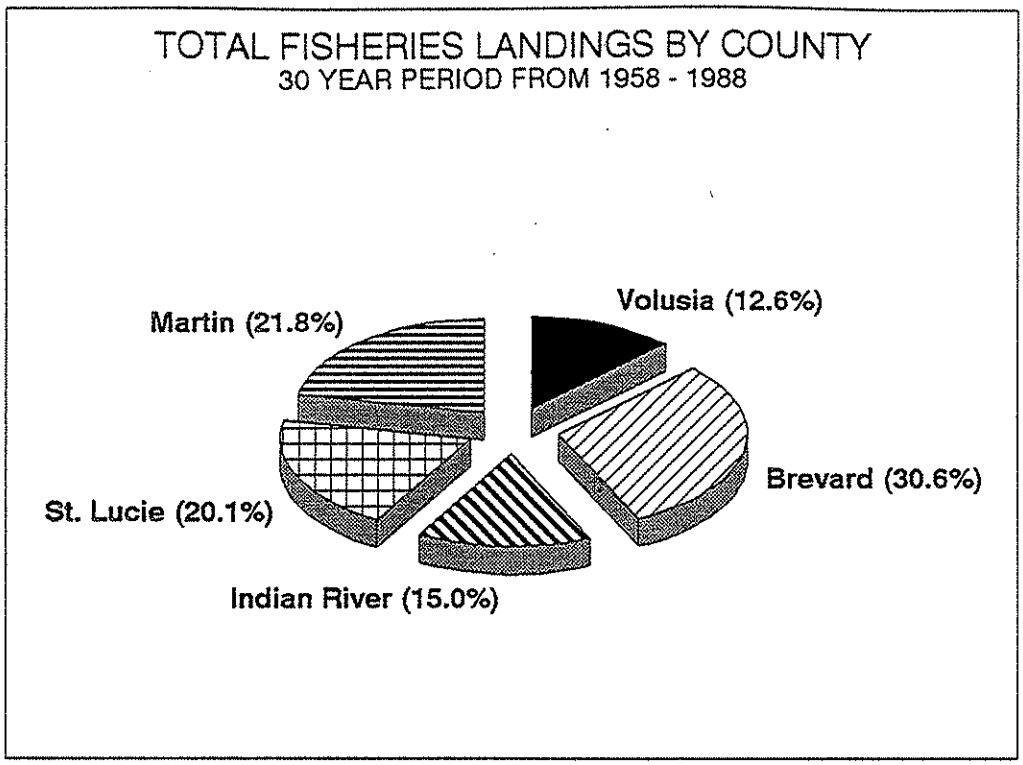
TOTAL FISHERIES LANDINGS BY YEAR
FOR THE PERIOD FROM 1958 - 1988



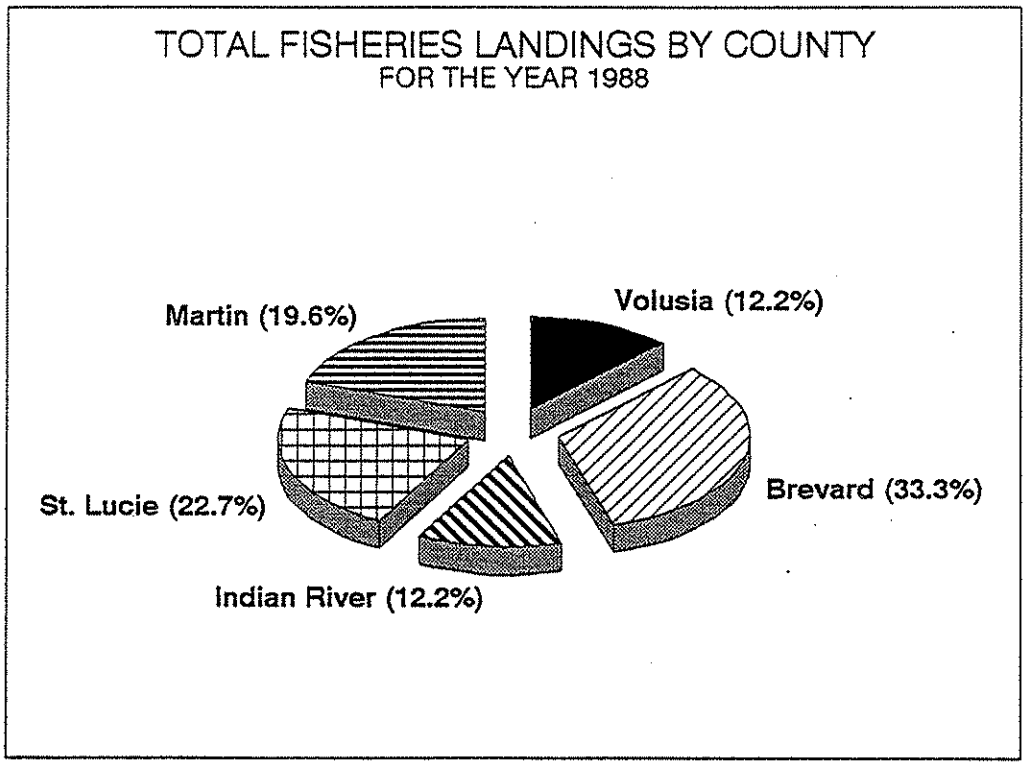
Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 6-2 TOTAL FISHERIES LANDINGS BY COUNTY BY YEAR FOR THE PERIOD 1958 TO 1988

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



a) ANNUAL AVERAGE TOTAL FROM THE 1958 THROUGH 1988 PERIOD



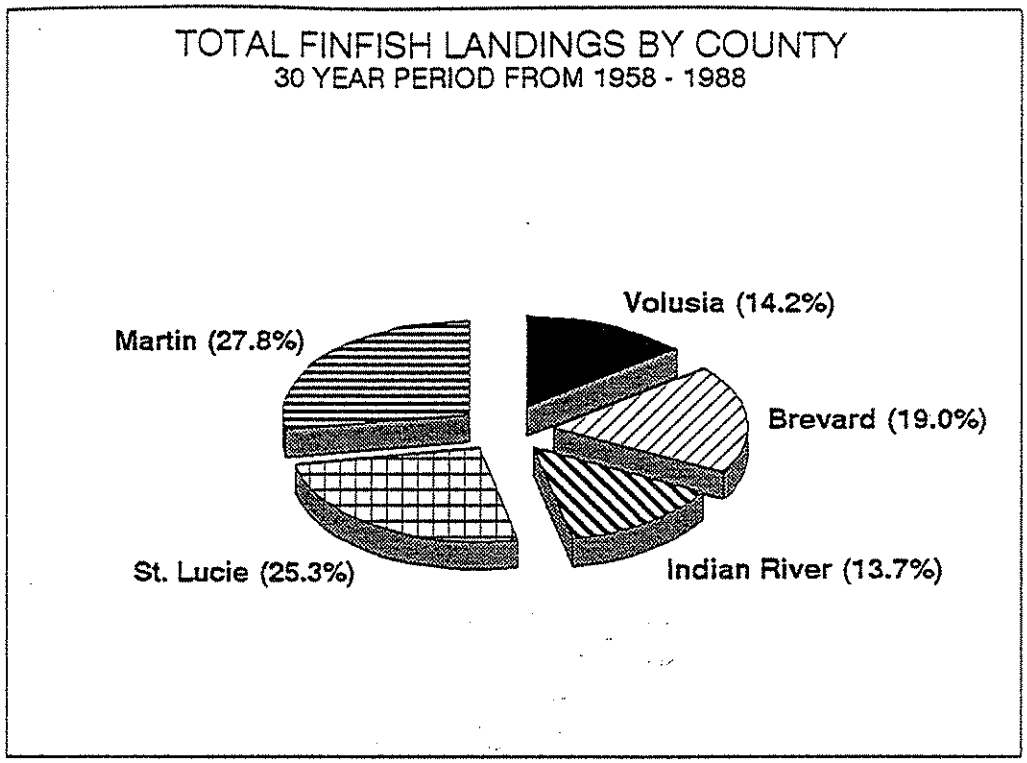
b) ANNUAL TOTAL FOR THE YEAR 1988

Sources:

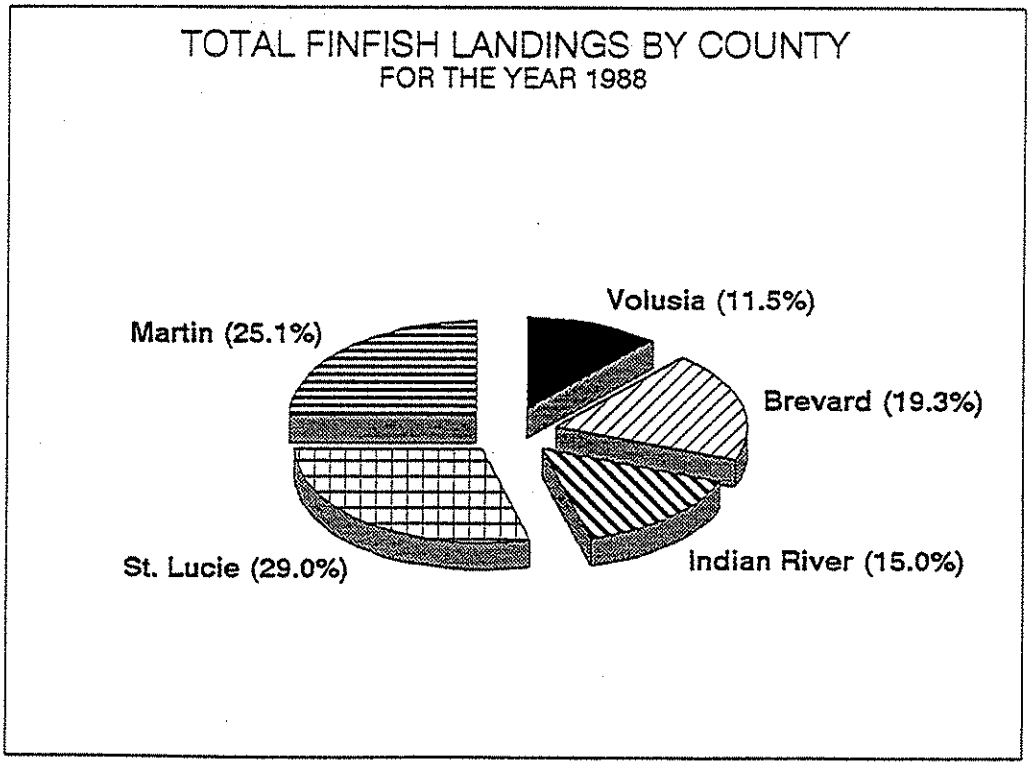
Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.:	FIGURE 6-3	COUNTY HISTORIC (1958-1988 CUMULATIVE) AND RECENT (1988) ANNUAL LANDINGS AS A PERCENTAGE OF THE REGIONAL TOTAL.
	DATE:		

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



a) ANNUAL AVERAGE TOTAL FROM THE 1958 THROUGH 1988 PERIOD



b) ANNUAL TOTAL FOR THE YEAR 1988

Sources:

Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.:	FIGURE 6-4	COUNTY HISTORIC (1958-1988 CUMULATIVE) AND RECENT (1988) ANNUAL FINFISH LANDINGS AS A PERCENTAGE OF THE REGIONAL TOTAL.
	DATE:		

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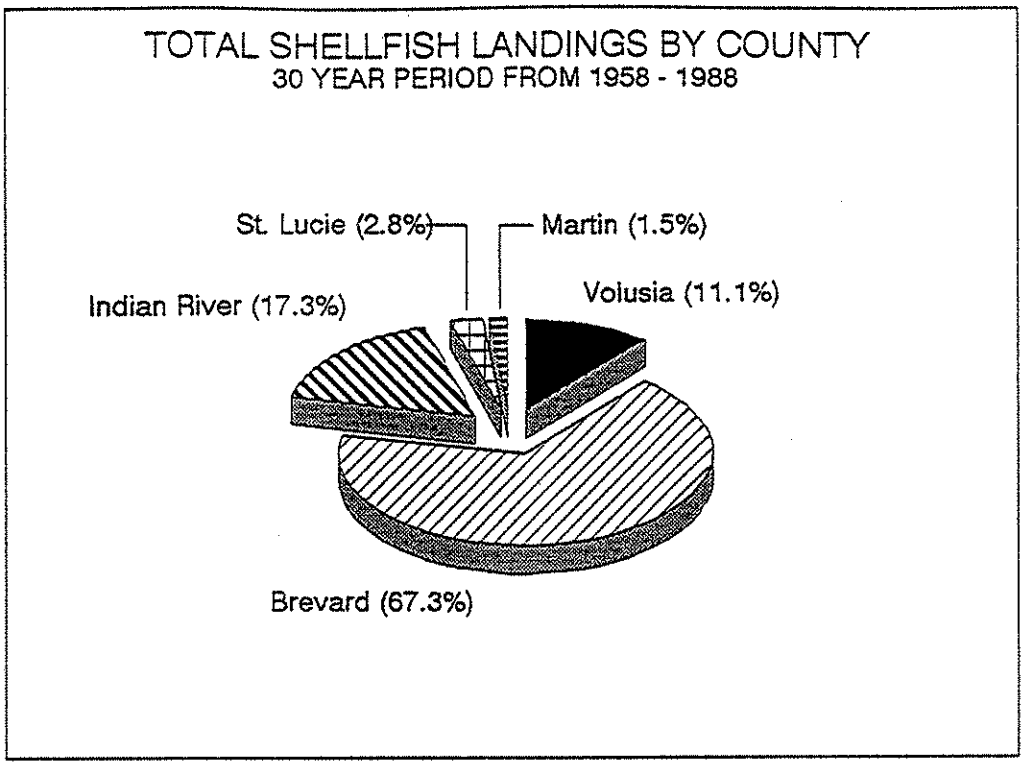
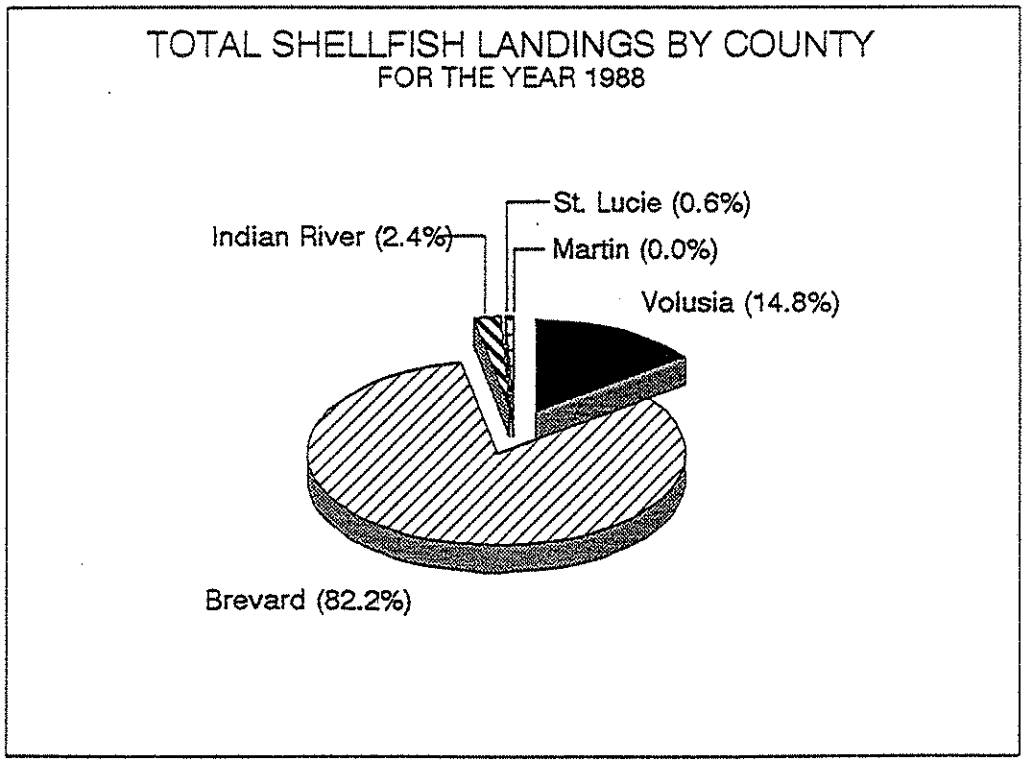


a) ANNUAL AVERAGE TOTAL FROM THE 1958 THROUGH 1988 PERIOD



b) ANNUAL TOTAL FOR THE YEAR 1988

Sources:

Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.:	FIGURE 6-5	COUNTY HISTORIC (1958-1988 CUMULATIVE) AND RECENT (1988) ANNUAL SHELLFISH LANDINGS AS A PERCENTAGE OF THE REGIONAL TOTAL.
	DATE:		

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of activity of the shellfish industry from the more southern counties (Martin, St. Lucie, Indian River) to Brevard County in the north.

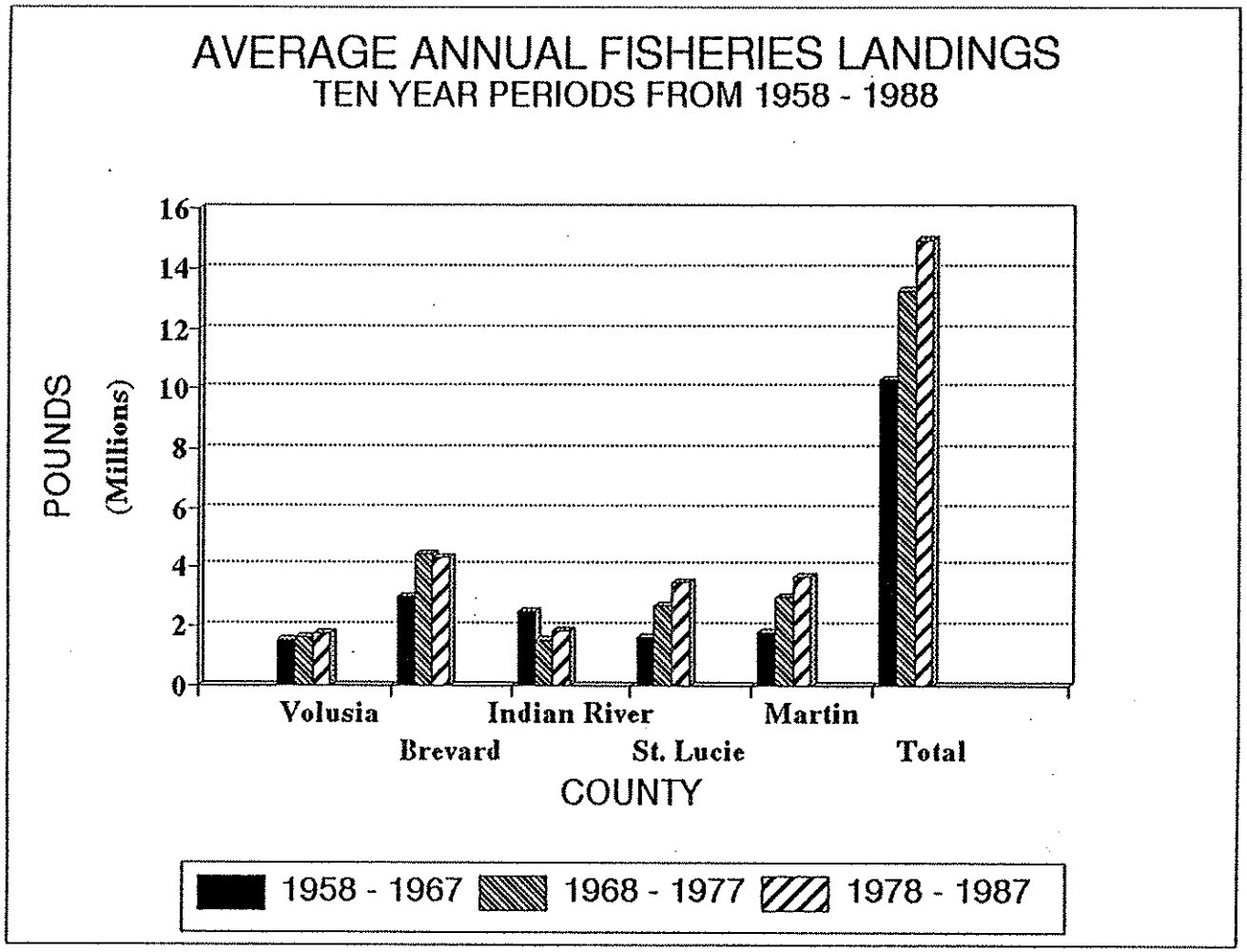
Total landings amounts do not always indicate the total fisheries picture. Figure 6-6 shows average total fisheries yields for three ten-year periods (1958-67, 1968-77, and 1978-87). Total yield for the region has shown a consistent upward trend from about 10 million pounds to about 15 million pounds, with most of the increase coming from Brevard, St. Lucie, and Martin Counties.

The two factors accounting for the increases appear to be the increased finfish harvests between 1976 and 1983 and the increased shellfish harvest from 1984 through 1988. This increase largely has been due to the increased hard clam harvests in Brevard County. Further examination of the trends in Figure 6-1 shows an apparent gradual decline in shellfish landings from about 1960 to 1974, with an approximately 50% decline from about 4 million pounds to 2 million pounds.

Figure 6-7 shows the total fisheries, finfish, and shellfish landings trends for each county from 1958 through 1988. The peak in landings during the late 1970s appears to be a function of greatly increased finfish harvests in St. Lucie and Martin Counties. The 1988 harvest represents an approximately 40% decrease from the peak harvest of 1977. However if this peak is ignored, the total fisheries landings have remained fairly constant at a rate between 8 million and 10 million pounds in the period from 1964 through 1988.

6.3.2 Shellfish

Commercial shellfish of the Lagoon include hard clams, oysters, blue crabs, and shrimp. Landings of total shellfish are shown for each county in the region in Figure 6-7. Landings of key shellfish species by county for the 30-year (1958-1988) period and for 1988 are shown in Figure 6-8. Brevard County has been the predominant shellfish producer with over 67% of the total harvest, with Volusia and Indian River Counties also significant producers (17% and 11% over the 31-year period). Blue crabs historically comprised almost all of the shellfish harvest until the early 1980s when hard clam landings increased to over 1 million pounds in Brevard County. Blue crabs still comprise virtually all of the shellfish harvest in St. Lucie and Martin Counties.



Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-6	TEN YEAR ANNUAL AVERAGE TOTAL FISHERIES LANDINGS FOR FIVE INDIAN RIVER LAGOON COUNTIES

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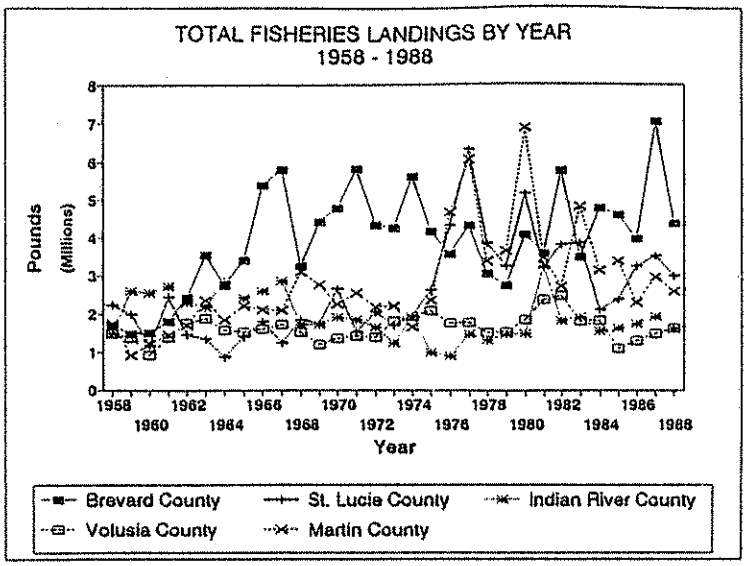
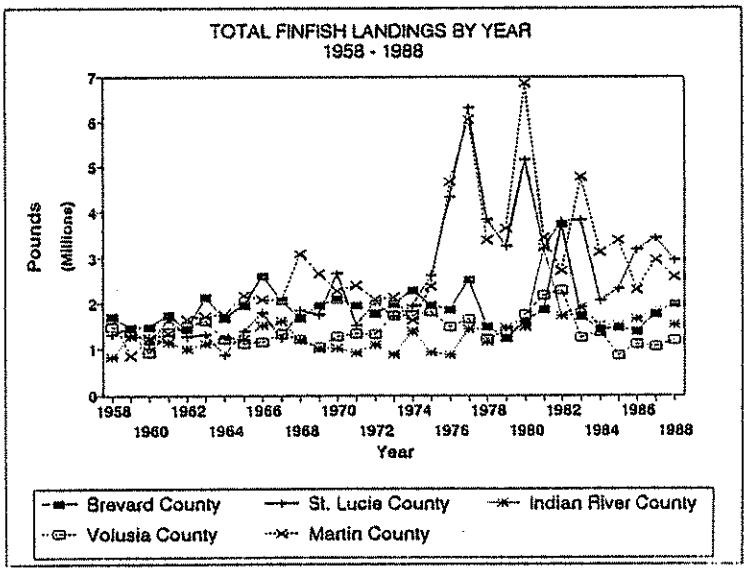
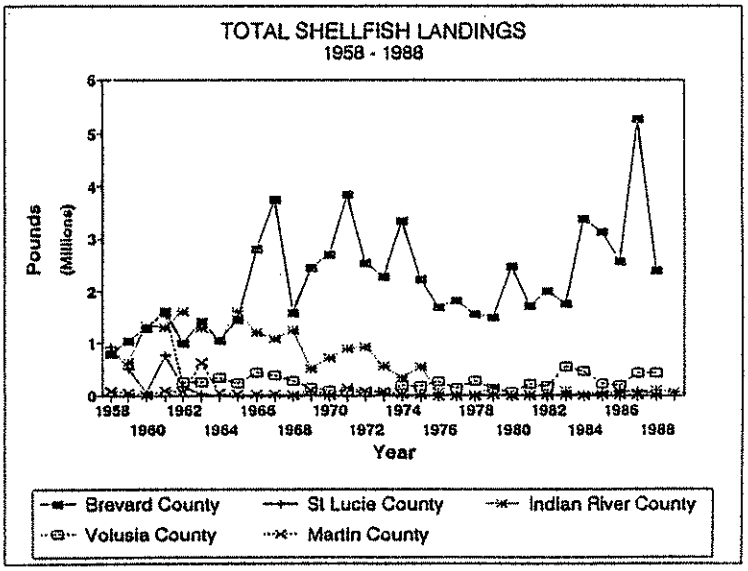


Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

a) TOTAL FISHERIES LANDINGS



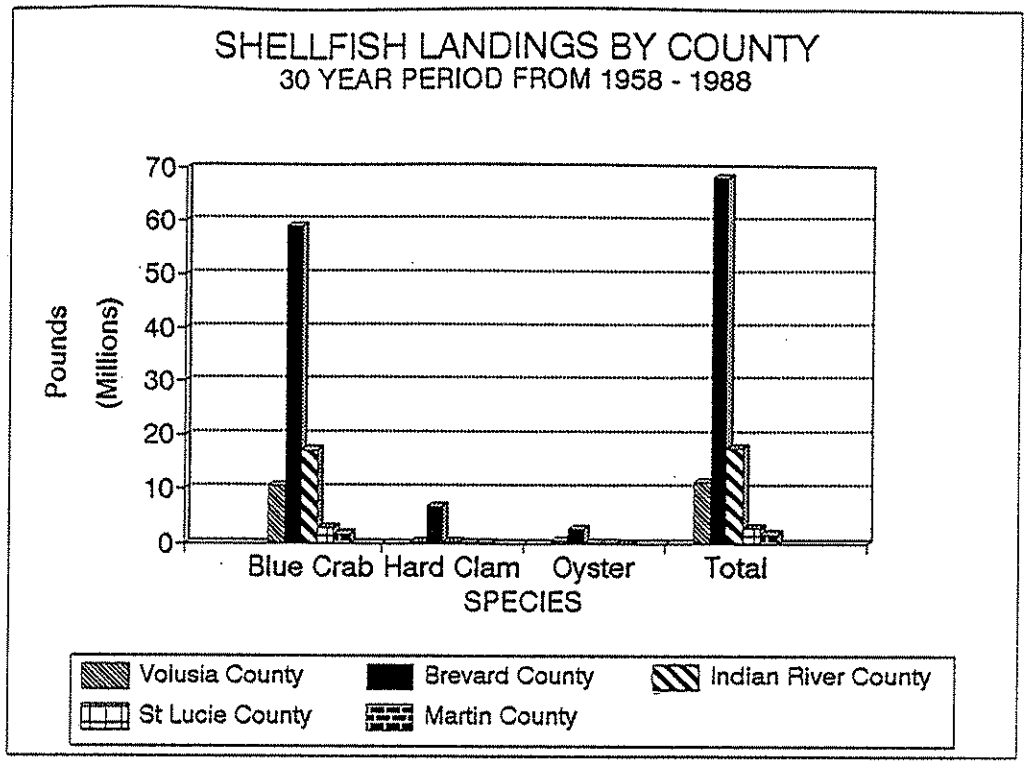
b) TOTAL FINFISH LANDINGS



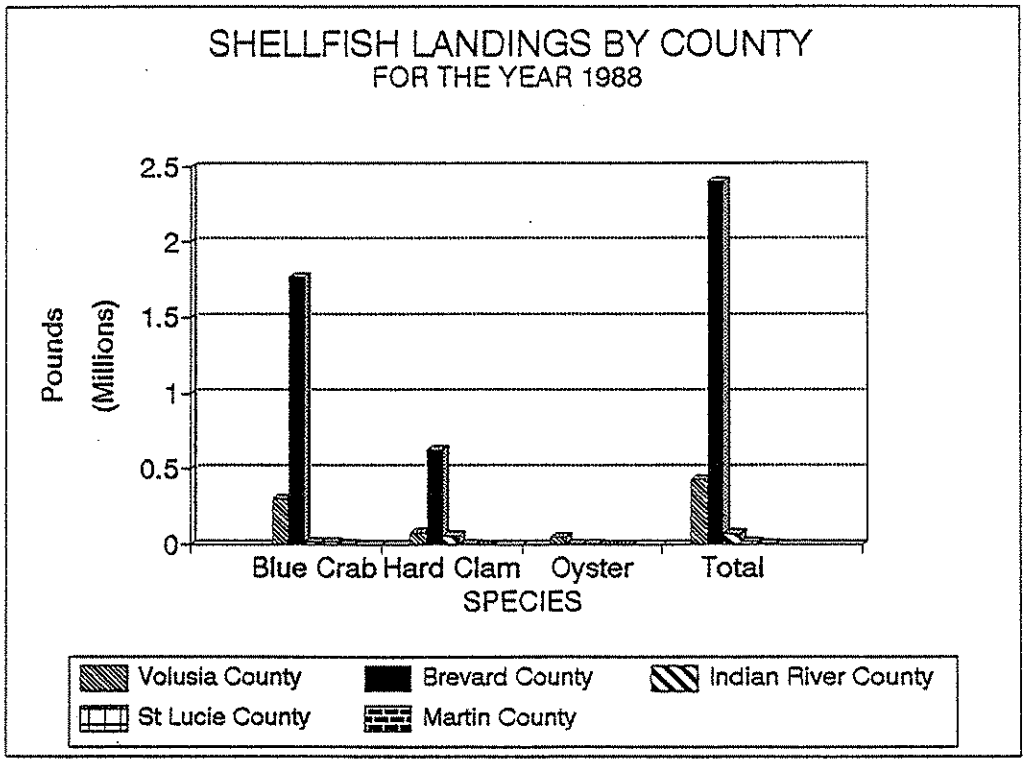
c) TOTAL SHELLFISH LANDINGS

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysis	DRAWING NO.: DATE:	FIGURE 6-7	YEARLY ANNUAL LANDINGS FOR FIVE INDIAN RIVER LAGOON COUNTIES

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



a) CUMULATIVE TOTAL FOR 1958 TO 1988



b) TOTAL FOR THE YEAR 1988

Sources:
Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-8	COMPARISON OF SHELLFISH LANDINGS FOR THE YEAR 1988 TO THE CUMULATIVE TOTAL OF THE 30 YEAR PERIOD FROM 1958 TO 1988

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Peak years for hard clam harvests were 1985 in Volusia County (43,630 pounds) and Brevard County (1,421,319 pounds) and 1987 in Indian River County. Hard clam harvests have generally showed a steady decrease since 1985 in Volusia County to a total harvest of 7,188 pounds in 1993 (FDNR, 1994). Harvests in Brevard and Indian River Counties decreased from their peak years through 1990 in Brevard County and 1991 in Indian River County to levels that were less than 33% of peak annual harvest. In both Brevard and Indian River Counties, harvests have since rebounded, with 885,631 pounds in Brevard County and 53,108 pounds in Indian River County in 1993.

The value of the hard clam harvest from the Indian River Lagoon in 1993 has been estimated as about $7.5 million (FDNR, 1994), approximately equal to annual levels between 1985 and 1987 when the total pounds harvested (1,517,297 pounds) was over 50% greater than in 1993 (945,927 pounds). This shows the substantial increase in hard clam prices during this period.

6.3.3 Key Commercial Fish Species

The increases in total finfish landings shown in Figure 6-1 are not consistent for all species however, and tend to mask changes and trends in fisheries utilization. Figure 6-9 shows landings trends for selected finfish species. One apparent trend from this data is the increase in the number of forage or lower level consumer (i.e. spot, croaker, menhaden, mullets) fish and oily-fleshed fish (Spanish mackerel, bluefish) landed since the mid 1970s. These species comprised 76% of the total landings in 1988 versus 72% in 1958. The percentage of other species fell from 28% to 24% in this period. This pattern may have both economic and ecological implications. The economic implication is generally one of reduced monetary value of the catch. Use of this group of species is generally some form of processing, for fish oil, cat food, processed fish products, or other use. As such the monetary value per pound is generally less for these species than for species such as spotted seatrout which have often commanded premium prices as fresh fish. For instance, Yingling (1987) reported average prices per pound in 1984 of $0.35 for spot vs $0.88 for spotted seatrout and $3.19 for pompano.

6.3.4 Trends in Commercial Fisheries

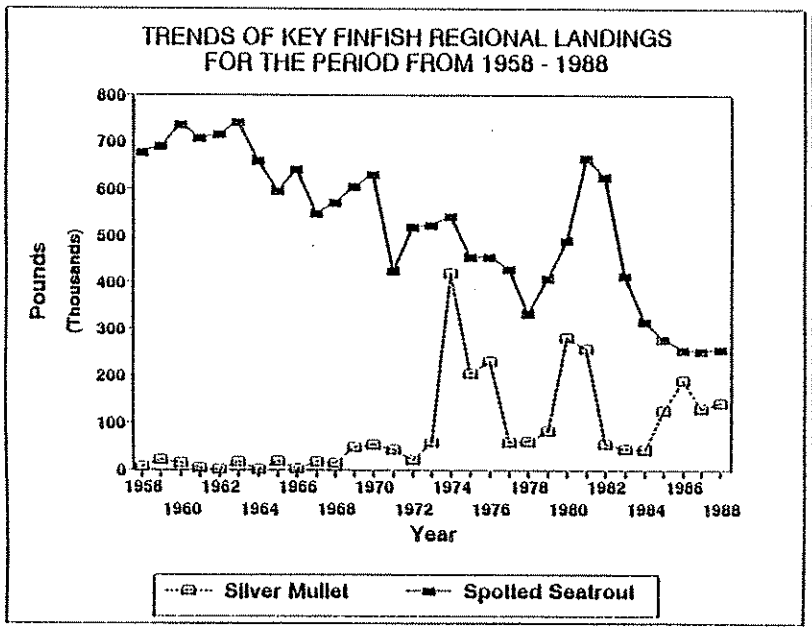
This trend from landing of high value fish to lower value fish may also indicate a decreasing availability of the desirable fishes. This would indicate a depletion of the fisheries resources for many of these species as well as a major drop in population levels. Figure 6-9 shows the average yearly landings for each year for several major species. Several species such as seatrout, red drum, and whiting have shown a pronounced decrease since 1958.

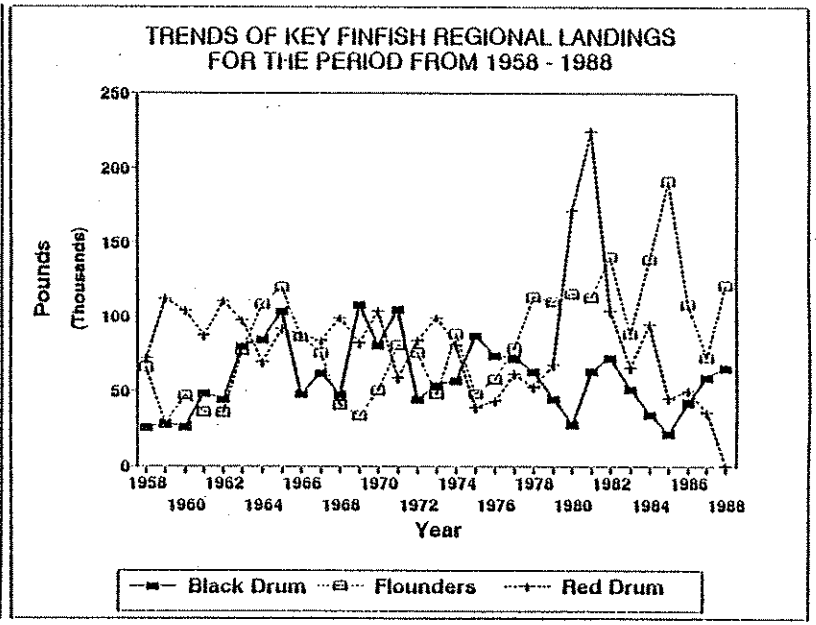
The increased harvest of species such as menhaden and the mullets may also have an effect on the overall ecology and productivity of the Lagoon. These species provide an important food or forage source for many of the predator species such as the spotted seatrout which have already shown declines in numbers. The forage fishes also tend to be plankton-eating species and as such may have an ecological role in preventing overpopulations of algae which can result in algal blooms in the Lagoon.

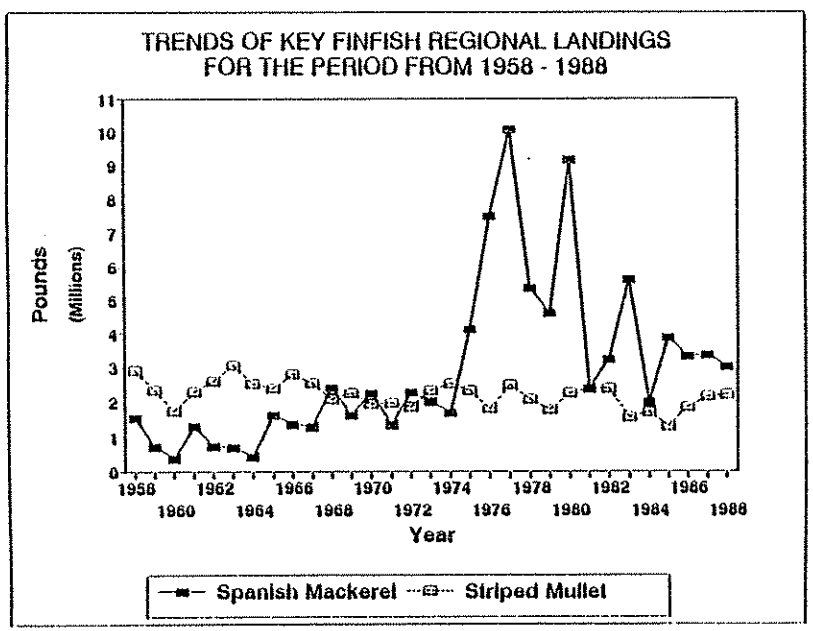
Another major trend involves the large increase in landings of many species in the late 1970s. For most species, more recent landings have shown a pronounced decrease from those peak levels, with recent low levels reached in the 1984 to 1986 period. Landings of most species have increased to some extent again since 1986.

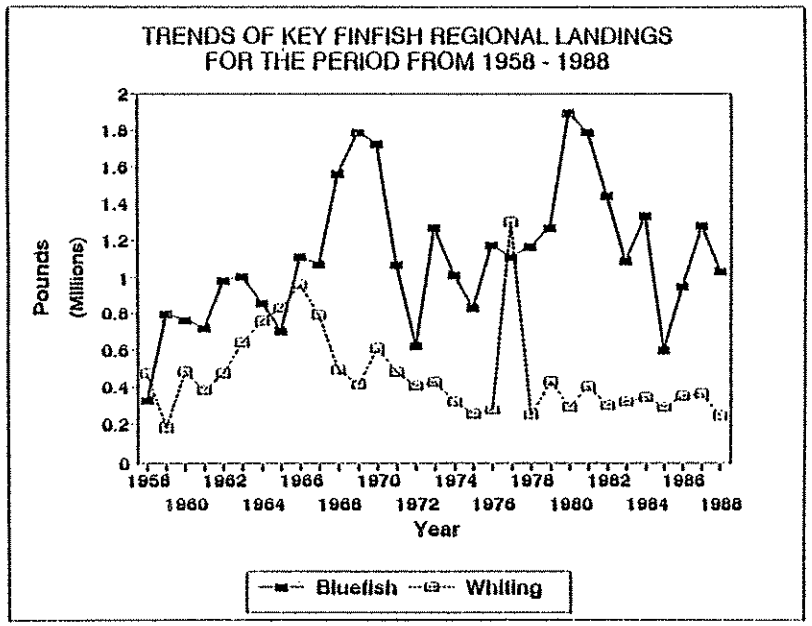
The primary exception to this recent increase in landings is the spotted seatrout which has continued at historically low levels through 1988. This trend is of particular concern for the Indian River Lagoon complex since this species is dependent on the Lagoon for all of its life cycle and is a key indicator of conditions within the Lagoon. Its depletion may be indicative of future trends of other species.

Important as these trends are as indicators of the health and status of the Indian River Lagoon, care should be exercised in the interpretation of these trends and their causes, since other factors independent of species populations may be involved. For example, the red drum was classified as a sport fish, and thus prohibited for commercial sale, in 1987. Therefore, the reported commercial catch in 1988 was 0 pounds. In another example, pigfish were dropped as a reported catch from the data summaries in 1985. These regulatory and reporting changes tend to skew long term averages and may be









Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

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

DRAWING NO.:

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FIGURE 6-9 LANDINGS TRENDS FOR KEY ESTUARINE-BASE FINFISH SPECIES FOR THE PERIOD FROM 1958 TO 1988

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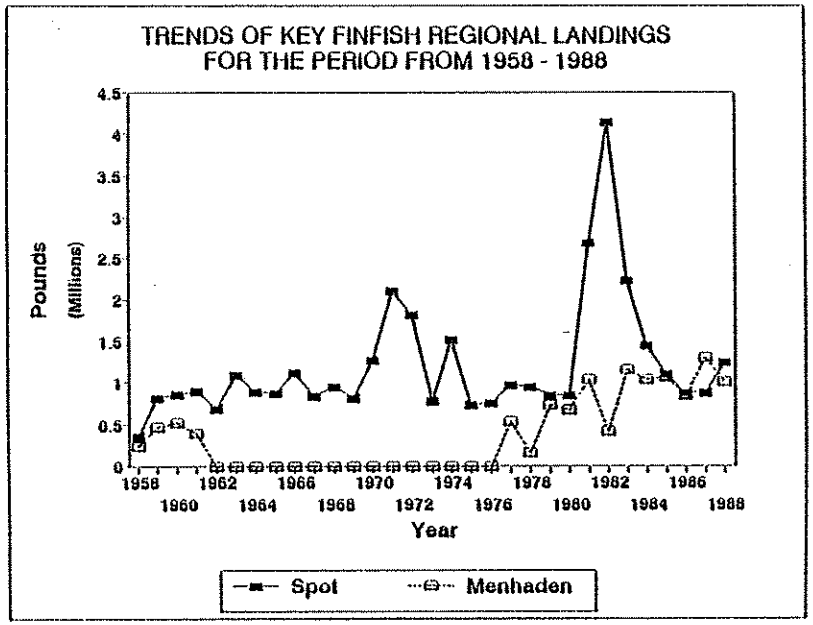
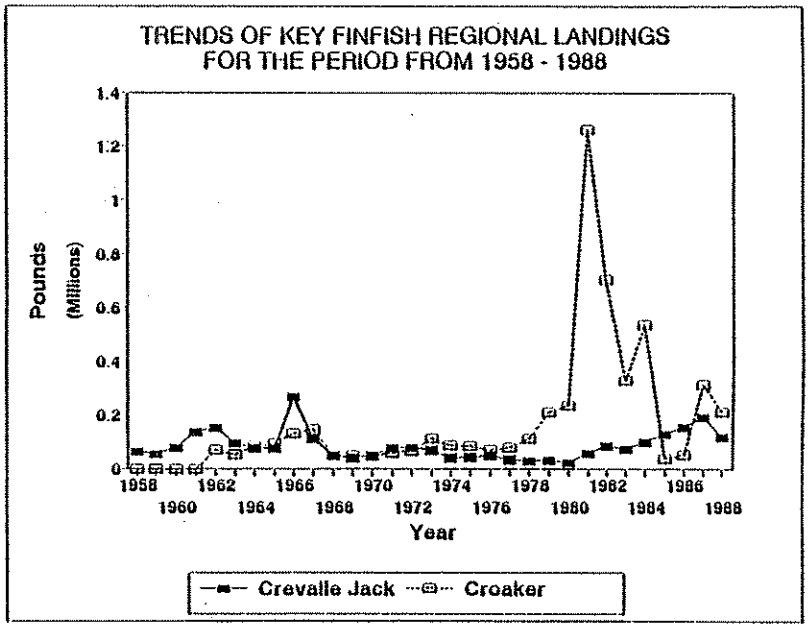
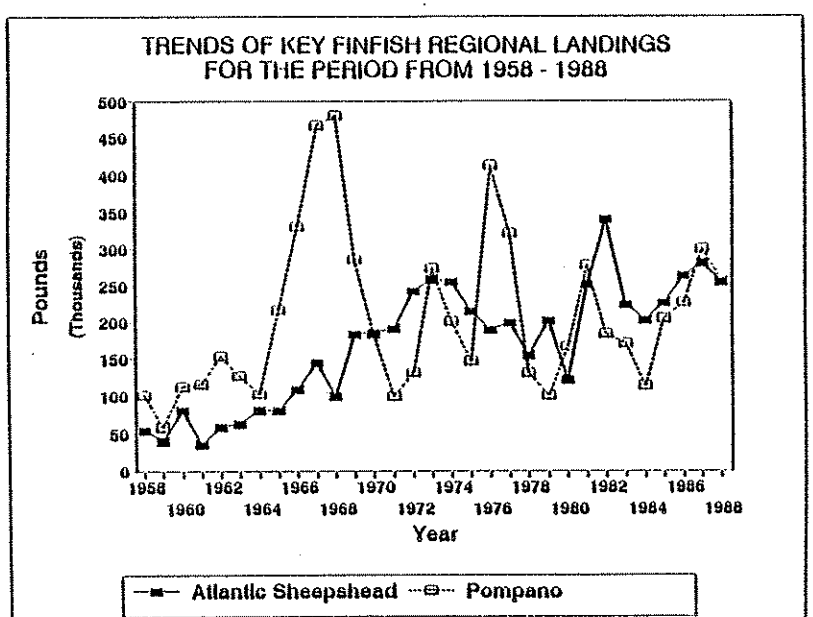
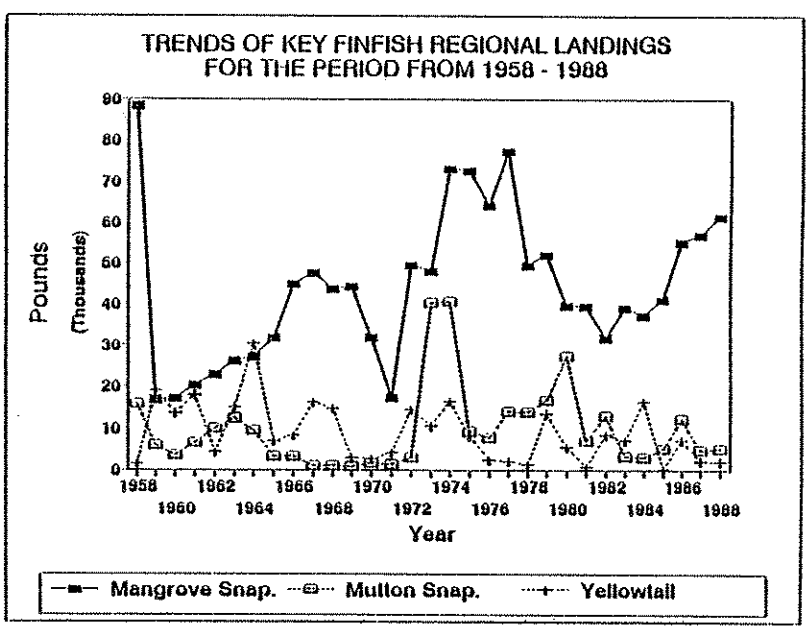








Sources: Florida Department of Natural Resources, various years
National Marine Fisheries Service, various years
Rathjen and Bolhassen, 1988.

• Woodward-Clyde Consultants
• Marshall McCully & Associates
• Natural Systems Analysis

DRAWING NO.:

DATE:

FIGURE 6-9 (CON'T) LANDINGS TRENDS FOR KEY ESTUARINE-BASE FINFISH SPECIES FOR THE PERIOD FROM 1958 TO 1988

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

misleading if additional data is not known. The menhaden catch may be another example of data which may be misleading. This data shows wide variations, with large catches for several years followed by several years with no catches. This may be a direct result of population changes, but it may also represent other factors. The menhaden industry is a somewhat specialized industry that has a few larger boats and factories which range along the Atlantic coast of North America (McClane, 1965). These boats can harvest large amounts of fish in short periods, but since there are a limited number of these boats, they may not fish each area in each year. This causes fluctuations in landings on a local basis. The industry is also subject to economic cycles which sometimes makes fishing unprofitable. Thus the reported catch in any year may also represent the status of the fishing pressure in an area rather than the actual population of fish.

6.4 RECREATIONAL FISHERIES

Data for recreational fisheries are even harder to quantify than for commercial landings. The recreational catch (3.2 million pounds) for the Lagoon region in the 1959 - 1962 period was estimated to be as high as almost 55% of the total commercial catch (Anderson and Gehringer, 1965). Anderson and Gehringer (1965) reported that spotted seatrout, pinfish, puffers, catfishes, king whiting, Atlantic sheapshead, bluefish, and croaker were the most abundant species caught by recreational anglers. Common snook and red drum are two of the most sought-after sportfish in the Lagoon today.

Bell, et al. (1982) have estimated that the overall economic value of recreational fisheries to a region can be as much as six times that from commercial fisheries. Adams (1985) reported a total of 52 charter boats and 8 party boats operating out of ports along the Indian River in 1983. The number of charter boats had increased to 61 by 1985 (Yingling, 1987) and is currently thought to be over 80. Yingling (1987) estimated that 52% of fishing days are done by boat and 48% by non-boat.

Yingling also analyzed the number of fishing trips made in 1984 based on the four-county (Brevard, Indian River, St. Lucie, Martin) population and FDNR's estimates of per capita fishing rates (1.30079 trips per person for boats and 1.3685 for non-boats). He determined the number of trips in 1984 to have been 761,666 saltwater boating trips

and 801,313 non-boat fishing trips. Using these fishing rate estimates and the 1970, 1990 and 2010 population estimates for the six-county Indian River Lagoon system area, the number and trends of recreational fishing trips within the region can be estimated for recent periods based upon the population of the Indian River Lagoon watershed (Table 6-2). By these estimates, the recreational fishing pressure in the region will have increased by 258% in the period from 1970 to 2010 and by 58% between 1990 and 2010. Bell (1993) calculates an increase of 100% in out-of-state tourist fishing pressure in the period from 1991 to 2010.

Milon and Thunberg (1993) have also evaluated recreation fisheries for the region, and have produced a much higher estimate of the number of fishing trips. The results of the two studies are not directly comparable because they do not cover identical areas and populations. The Yingling study covered only Brevard, Indian River, St. Lucie, and Martin Counties, while Milon and Thunberg's study included residents of all the Marine Fisheries Commission's Region 6, which also includes resident of Volusia, Lake, Osceola, Seminole and Orange Counties. Actual levels specifically for the Indian River Lagoon probably fall between these two estimates, but cannot be further quantified at this time.

Based on a larger population base and a higher estimate of the per capita fishing rates (6.3 trips per year), Milon and Thunberg have calculated a total of 3,138,228 total trips (fishing days) in Region 6 for 1992 as opposed to Yingling's estimate of 1,811,815 for the four-county area. Their estimate increases to 4,975,964 trips by 2010. This may mean that over 40% of the recreational fishing in the Lagoon is done by people who are not residents in the Lagoon watershed.

Milon and Thunberg estimate that 48% of trips involved boats, and over 65% of the total fishing effort was in in-shore waters along the shore or within the estuary or Lagoon complex (Milon and Thunberg, 1993). Surveys by the University of Florida (Milon and Thunberg, 1993) have indicated that sea trout and snook are the two fish species most often sought by recreational fishermen in the region, and red drum is also sought. Together, these three species, which occur predominately in the in-shore or Lagoon waters, are the targets of 48% of the anglers who expressed species preference. These statistics indicate the importance of the Indian River Lagoon as the center of recreational fishing effort for the region.

TABLE 6-2

ESTIMATE OF RECREATIONAL SALTWATER FISHING TRIPS BY RESIDENTS IN THE INDIAN RIVER LAGOON REGION FROM 1970 TO 2010

YEAR	TOTAL NUMBER		
	ESTIMATED POPULATION	ESTIMATED NUMBER OF FISHING TRIPS BY BOAT[1]	ESTIMATED NUMBER OF NON-BOAT FISHING TRIPS[2]
1970	301,978	392,810	413,257
1990	678,763	882,928	928,887
2010	1,082,853	1,408,564	1,481,884

Sources: Yingling (1987), U.S. Department of Commerce

1 = Population x 1.30079
2 = Population x 1.3685

An estimate of current total annual recreational fishing expenditures of $54 million is derived from these data (number of fishing days) and from an average daily expenditure estimate of $29.97 (Yingling, 1985), rising to $86 million in 2010 (Table 6-3) based on actual residents of the region. The values in Table 6-3 are reported in 1984 dollars for consistency in comparison with Yingling's 1984 estimate which was based on a four-county total population base rather than the population of the watershed alone. Milon and Thunberg's estimate for 1992, based on the entire Region 6, is over $346 million based on average daily expenditure of $114.81.

Bell, et al. (1982) and Yingling (1985) estimated that 61.45% of these fishing trips are within brackish coastal waters or within 3 miles of shore, where fisheries stocks are largely dependent on estuaries. Based on this estimate, the total recreational fishing value of the Indian River Lagoon system is roughly estimated at a minimum of $33.4 million for the year 1990. Additional revenue generated by Florida residents outside of the watershed may range as high as $211 million.

6.5 BOATING AND MARINE SERVICES

The number of registered recreational boats in the four-county (Brevard, Indian River, St. Lucie, Martin) area increased from 28,859 in 1978-79 to 38,067 in 1984-85 (Adams, 1985: Yingling, 1987). Marine support services for these boats includes full-service marinas, boat storage facilities, boat sales and rentals, repair facilities, tackle and bait stores, boating supply stores, marine construction and maintenance services, yacht clubs and resorts. Table 6-4 (from Yingling, 1987) lists the number of registered boats and boat slips from the four-county region in 1984. Table 6-5 lists the type and number of marine support facilities along the Indian River Lagoon complex from New Smyrna Beach to Stuart in 1984 (from Yingling, 1987) and in 1992 (Argus Business, 1993).

Marine service facilities are important not only in terms of their economic value and support of boating. They also can have major effects on water quality of the Lagoon. Potential direct effects can include:

- Spills and leakage of oils and fuels

TABLE 6-3

ESTIMATE OF RECREATIONAL SALTWATER FISHING EXPENDITURES BY RESIDENTS IN THE INDIAN RIVER LAGOON REGION FROM 1970 TO 2010

YEAR	ESTIMATED RECREATION FISHING EXPENDITURES - $[1]		
	EXPENDITURES FROM BOAT-BASED FISHING TRIPS	EXPENDITURES FROM NON-BOAT FISHING TRIPS	TOTAL RECREATIONAL FISHING EXPENDITURES
1970	11,772,516	12,385,312	24,157,828
1990	26,461,352	27,838,743	54,300,095
2010	42,214,663	44,352,788	86,567,451

Sources: Yingling (1987), Bell, et al. (1982)

1 = 1984 dollars

TABLE 6-4

PLEASURE AND COMMERCIAL VESSEL REGISTRATIONS AND BOAT SLIP INVENTORY IN THE INDIAN RIVER LAGOON REGION FOR 1984-85 SEASON

COUNTY	REGISTERED BOATS		MULTI-SLIP STORAGE	
	COMMERCIAL VESSELS	PLEASURE CRAFT	WET STORAGE SLIPS	DRY STORAGE SLIPS
Volusia				
Brevard	1,538	19,745	2,000	1,223
Indian River	482	5,553	641	490
St. Lucie	414	5,048	777	684
Martin	483	7,741	1,234	825
Palm Beach				
Indian River Regional Total	2,917	38,067	4,652	322

Source: Yingling, 1987

TABLE 6-5

REPORTED MARINE SUPPORT FACILITIES IN THE INDIAN RIVER LAGOON REGION FOR 1984 AND 1992 SEASONS

MARINE SUPPORT FACILITIES		
TYPE OF FACILITIES	NUMBER OF FACILITIES	
	1984	1992
Marinas/Boat Yards		
No Repairs	16	28
Engine Repair Only	12	13
Engine/Hull Repair	28	43
Piers/Fish Camps/Bait/Tackle/ Marine Resorts[1]	14	102
Yacht/Boat Clubs	14	11
Charter Boats	61	83
Launch Facilities		
Public Owned Ramps	58	...
Commercial Ramps	11	...
Boat Storage		
Wet Slips	2,880	...
Dry Rack	2,583	...
Dockage		
Linear Feet	9,746	...
Head/Party Boats	8	18
Facilities Offering		
Boat Sales	34	126
Boat Rentals	7	24

Sources: Yingling, 1987
Argus Business, 1993
BellSouth Yellow Pages, 1993

1 = Includes all pay piers and piers with facilities or bait shops and all saltwater bait/tackle stores.

... = no data update for 1992.

- Introduction of potentially toxic materials such as copper used in anti-fouling boat hull paints

- Alteration of habitat due to dredging, filling, and bulkhead construction

- Introduction of nutrients and bacterial contaminants from marine stormwater drainage and from live-aboard boaters and Marine Sanitation Devices (MSDs).

6.6 DEEPWATER PORT FACILITIES

The two deepwater port facilities in the Indian River Lagoon region are Port Canaveral in Brevard County and Ft. Pierce in St. Lucie County. In 1983 and 1984, these ports ranked sixth and tenth respectively of Florida's deepwater ports. In 1984, these ports respectively handled $357 million and $12 million of imports and exports, accounting for only 2.7% of the Florida total (Yingling, 1987).

The main export from Ft. Pierce has been fresh citrus, with a peak export in 1984 of 2.4 million boxes, when it was the second largest fruit exporting port in the state (Adams, 1985). Exports declined in the mid-1980s due to lower fruit production, but recent increases in production should be reflected in increased exports. Numerous imports of foreign fruits and vegetables also occur through Ft. Pierce. Chemicals and fertilizers are the other main products shipped through Ft. Pierce.

Ft. Pierce is the only deepwater port facility actually located within the Indian River Lagoon. Studies are currently underway concerning re-dredging and expansion of the channel at Ft. Pierce Inlet to expand the capabilities of the port.

Port Canaveral has only a minor connection to Indian River Lagoon through lock facilities at the west end. Major products moved through this port include petroleum products, dry cement, frozen citrus concentrate, fresh citrus, newsprint, and paper products. The cruise ship industry has grown greatly at this port since the early 1980s.

Most shipping traffic exits the port directly to the Atlantic Ocean without entering the Lagoon. However, some traffic does exit through the locks to the Lagoon complex. Coastal barges carry Bunker C grade fuel oil from the terminal facilities through the Canaveral Barge Canal and north in the Indian River Lagoon to the Florida Power and Light (FPL) power plant near Port St. John (Day, 1993).

7.0
CONCLUSIONS AND FINDINGS

7.1 HISTORICAL SETTING

Indian River Lagoon was formed as a result of forces associated with rising and falling sea levels acting on the shoreline over a period of over 100,000 years. This process involved the deposition of coastal sediments in linear features running from north to south and the re-working of sediments into dune ridges and valleys by wave and wind action. Inlets have formed, closed, and reformed at many locations along the complex, resulting in a highly dynamic and variable nature of the Lagoon and adjacent land areas. Although this process is still active today as a result of storms and long-term changes in sea level, artificial stabilization of inlets and the barrier islands have probably reduced the variability within the Lagoon, at least on a short-term (i.e 100 years) basis.

Man first appeared along the shores of the Lagoon about 15,000 years ago, and the Ais and Timucuan Indians maintained a sparse population with a nomadic life style throughout the region until the arrival of the Spanish in Florida in 1513. European settlement of the Indian River Lagoon region essentially began around 1565 with the Establishment of Santa Lucia, now Ft. Pierce. Permanent developments in the region began to occur around 1830 when the regional population doubled within 10 years to 733 people.

The 1800s saw the establishment of agriculture in the region with the first citrus groves along the northern Indian River Lagoon and on Merritt Island. Disease, mosquitoes, lack of transportation, and the second Seminole War inhibited development of the region and caused the population to drop to less than 100 people. The Homestead Act of 1865 and initiation of the Intracoastal Waterway in 1882 provided the impetus for permanent development of the region. Steamboat service on the Indian River Lagoon was initiated in 1885 and continued to 1900 between Jupiter and the railroad terminus at Titusville. Regional population had grown to over 15,000 by 1920.

Completion of the Florida East Coast Railroad line to Palm Beach in 1892 was a major step in altering the landscape of the region. The railroad built the first bridges over many of the tributary streams and rivers and introduced secondary development. The railroad provided access to markets for agricultural products, and large amounts of native flatwoods forest were cleared and drained for citrus and cattle production. The 1916 Drainage Acts of Florida established special taxing districts and promoted construction of canals to drain low-lying lands in the region. Control of the enormous mosquito population began around 1927 with ditching of saltwater wetlands to drain the breeding areas.

Permanent bridges to the barrier island were first constructed after the turn of the century, with many bridges constructed or replaced in later years. These bridges allowed development of the barrier island chain to proceed rapidly in the period from 1945 to 1970, when over 300,000 were living in the Indian River Lagoon watershed. Almost 90% of this growth occurred between 1950 and 1970 following the advent of the space program at Cape Canaveral and the establishment of Kennedy Space Center and Patrick Air Force Base. The increased population resulted in many additional impacts on the Lagoon.

By 1970 more than 50 wastewater treatment plants were discharging into the Lagoon and its tributaries. Over 70% of the natural mangrove forests and salt marshes along the Lagoon had been ditched or diked for mosquito control, thus reducing their natural water purification and food chain support functions. Replacement of wooden bridges across the Lagoon by permanently filled causeways between 1940 and 1970 resulted in losses of fish and shellfish habitat in the Lagoon and changes in circulation patterns that affected the Lagoons water quality. Pesticide impacts had reduced the populations of many species of birds (i.e bald eagle, brown pelican) to dangerously low levels, and the dusky seaside sparrow had nearly been driven to extinction by the impounding of the salt marshes.

New environmental regulations such as the Clean Water Act of 1972 have helped to correct some of the problems caused by increased use of the Lagoon and its watershed over the last 200 years. Regional watershed and drainage management programs such as SWIM and the Indian River Lagoon Act have helped to slow the rate of increase of

discharge of wastewater and stormwater to the Lagoon. Loss of wetlands habitat along the Lagoon has been decreased by new mosquito impoundment management programs and dredge and fill regulations. In particular, Chapters 253, 373, and 403 of the Florida Statutes reflect the leadership of the Florida legislature in addressing water and wetlands impacts. These have slowed or reversed many of the types of impacts that occurred between 1950 and 1970. However, population of the counties (including portions of the counties not within the Indian River Lagoon watershed) along the Lagoon still has increased from 303,858 in 1970 to 678,763 in 1990. This rate of increase will continue to cause major changes in uses in the Lagoon watershed and will continue to challenge the ability of the Lagoon system to assimilate these changes.

7.2 EXISTING AND FUTURE POPULATION

The population of the Indian River Lagoon watershed is projected to increase from 302,000 in 1970 to 1,082,000 in 2010, based on data from the Bureau of Census counts and BEBR county projections data. All of the segments are projected to have growth rates below the regional average of 60% from 1990 to 2010 except for Segment 4, the South Indian River Lagoon segment.

Segment 4 (South Indian River Lagoon) from Jupiter Inlet north to the north end of St. Lucie County is projected to have a population increase of 94% between 1990 and 2010. This increase is expected to occur around the existing urban centers such as Ft. Pierce, Stuart, and especially Port St. Lucie. This is the largest Segment in terms of land area, and the overall population density is expected to remain below the regional average. However, much of the population will be concentrated along the Lagoon.

Segments 1A (Mosquito Lagoon), 2 (North Central Indian River) and 3 (South Central Indian River) are projected to have population increases between 40% and 60% by 2010. Segments 1B (Banana River) and 1C (North Indian River) are projected to have much lower increases, close to 20%, during this period. The lower rate in these two segments is a result of the large proportion of land in federal ownership (Kennedy Space Center, Merritt Island National Wildlife Refuge, and Canaveral National Seashore) and the existing highly saturated density in the remaining urban areas.

Segments 1B (Banana River basin) and 2 (North Central Indian River basin) in central Brevard County around Melbourne, Palm Bay, and Cocoa Beach will remain as the most densely populated areas with over 1,000 people per square mile. Population density is projected to increase from between 22% and 94% in the remaining segments to levels from 430 to 840 people per square mile. By the year 2010, the least densely populated segment (Segment 4) will have a density (434 psm) about equal to that of Segment 1C - North Indian River (Melbourne, Cocoa, Rockledge, Titusville) in 1990. The most densely populated areas of the south Banana River basin may have densities of over 2,400 psm by 2010.

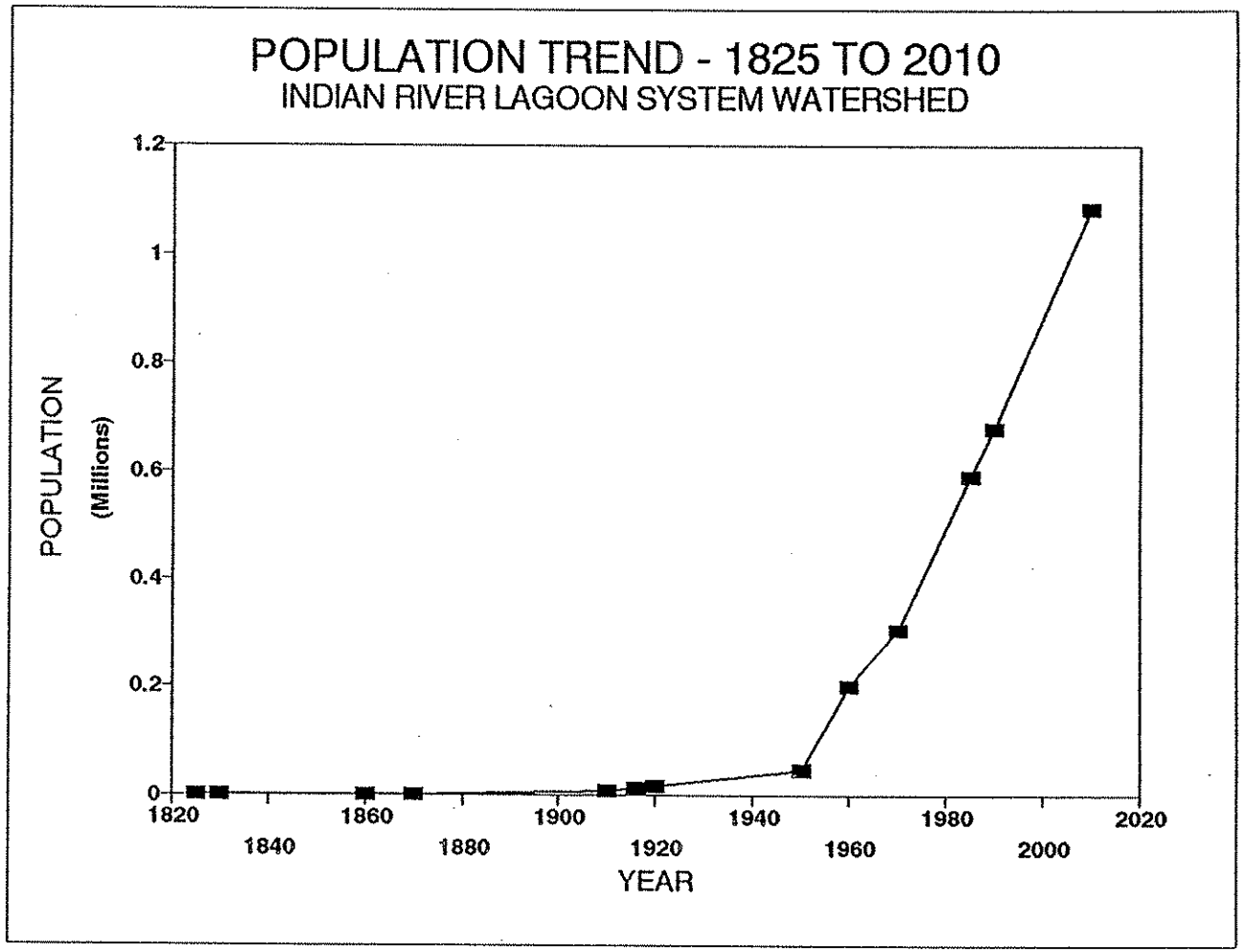
The population of the Indian River Lagoon watershed, based on historical population information and projected future change, is still expanding at a rapid rate and is projected to continue growing at a high rate through 2010, as shown in Figure 7-1.

7.3 EXISTING AND FUTURE LAND USE

As a region, existing land use (land and water areas) is approximately 10% residential, 4% industrial or commercial, 33% agricultural, and 36% natural or open land. This is projected to change to 32% residential, 15% industrial and commercial, 30% agricultural, and 23% natural or open land by 2010.

Agricultural land is expected to decrease only slightly (6% decrease), but natural land area is expected to decrease by over 35% by 2010. Commercial, industrial, and residential lands are projected to increase by over 230% in the region.

Segment 1A (Mosquito Lagoon) is expected to remain very similar to its present state with only a 1% increase in residential land use and a slight increase in open land. Segment 1B (Banana River) also is expected to remain relatively unchanged in terms of land use, although much of the open land in Segments 1B and 1C has been reclassified as institutional land in the future condition (on the basis of federal ownership). Segment 1C is projected to have a 190% increase in residential land use from 6% to 18% of total area.



• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 7-1	POPULATION TRENDS FOR THE INDIAN RIVER LAGOON SYSTEM WATERSHED FROM 1830 TO 2010

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

Residential land use is projected to increase by 131% in Segment 2, 216% in Segment 4, and 481% in Segment 3, based on the counties' growth projections. Agricultural land is projected to remain essentially unchanged except in Segment 3, where it is projected to drop by 57% due to the large increase in residential land use.

The future land use numbers are based on the individual county Growth Management Plan projections of future land use. These plans have used different assumptions and zoning methods, so that there may be great variation in projected rates among counties. This also results in a fairly low degree of confidence in the reliability of these estimates. Most of the counties have included very few lands in the open or natural category and have projected large increases in residential land uses. However, when compared to the population projections, it appears that not all of the anticipated residential areas will be filled by 2010. For example, residential land use in Segment 3 is projected to increase by 481%, yet the population is projected to increase by only 57%. Thus the land use projections should be regarded as projections of maximum possible increase rather than most probable increase. Based on the projections allowable under the local government comprehensive plans, significant increases in non-point source loading to the Lagoon are expected, and significant decreases in open space and natural habitat will occur.

7.4 ECONOMIC USES

Non-farm natural resources-based employment (including fisheries) in the counties comprising the Indian River Lagoon region represented only about 3% of total employment in 1991. The highest percentage (11%) was in St. Lucie County, where citrus related employment probably was a major factor.

The Indian River Citrus Region is one of the major citrus producing areas of the state and of the world, accounting for an estimated 7% of world production of fresh fruit in 1991. Citrus production was first documented in 1866 at 1.26 million boxes and rose to a peak of 283 million boxes in 1980. Freezes and conversion of citrus groves to urban uses has caused some decline in production since then to 205 million boxes in 1991.

Between 1987 and 1991, approximately 12,000 additional acres of citrus land came into production in the region, representing over 50% of the statewide growth in acreage.

Much of the quality of the Indian River Citrus Region has been attributed to the ameliorating effect of the Indian River Lagoon on weather conditions.

7.5 FISHERIES AND BOATING USES

Although harvesting of fish and shellfish by the human population of the region has been shown to extend at least 8,000 years back in time to the Ais and Timucuan Indians, the first significant commercial fisheries did not develop until the 1890s. Fishery landings have been estimated to have been about 2.5 million pounds in 1895, and had grown to almost 9 million pounds when catch records were first recorded. In 1991, the fisheries landings from this region constituted over 16% of Florida's total landings.

Landings records from 1958 to 1988 show a moderately increasing trend in total landings from about 9 million pounds in 1958 to 13 million pounds in 1988. Most of the increase is from finfish landings which showed a change from about 6 million pounds to 10 million pounds. Significantly higher finfish landings from 1975 to 1982 were due to higher catches reported from Martin and St. Lucie Counties.

Shellfish landings showed a steady decline from about 4 million pounds to 2 million pounds from 1960 to 1974. This decline appears to have consisted mainly of blue crab and oyster harvests, and the decline was largely due to reduced landings in Indian River County. A recovery to about 3 million pounds between 1982 and 1988 was due to increased hard clam harvesting in Brevard County.

Some shift in species composition of reported finfish landings appears to have taken place, with a higher proportion of lower priced species being taken in more recent periods. One species, the spotted seatrout, has shown a steady and significant decline in landings of over 50% from 1962 to 1988. This species is almost entirely dependent upon the Lagoon throughout its life cycle, so its decline may be indicative of conditions within the Lagoon.

Overall, the commercial fisheries landings appear to shown a relatively stable pattern other than the high harvest period in the 1970s, indicating that the annual total landings range of 8 to 10 million pounds which has predominated for the past 30 years may

represent a long-term sustainable harvest level for the Lagoon complex. Within this pattern, there have been changes in specific shellfish and finfish resources. The most important of these trends are the decline in the spotted seatrout, declines in blue crab and oyster harvests which are most apparent in Indian River County, and an increase in the hard clam harvests. Hard clam harvests have also shown some drop from peak levels and the long term trend for this resource is unclear.

These observations are similar to those that have been reported previously (Anderson and Gehringer, 1965; Snelson, 1980: Rathjen and Bolhassen, 1988), although patterns involving specific areas of the Lagoon, such as the Indian River County portion, may be somewhat clearer.

Recreational fishing and boating represent important economic and cultural assets for the region. Annual recreational fishing expenditures of residents in the region are estimated to increase from $24 million in 1970 to at least $86 million in 2010, and over 50% of the total is estimated to be derived from the Lagoon and nearby coastal waters. Expenditures for tourists and Florida residents outside of the region may be as high as four times these figures.

Boating also represents a significant industry in the region with a rapidly expanding number of boats and support facilities. These facilities can have adverse effects on water quality and resources of the Lagoon. The expansion of this industry will increase the magnitude of any problems.

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