FINAL TECHNICAL REPORT

HISTORICAL IMAGERY INVENTORY AND SEAGRASS ASSESSMENT INDIAN RIVER LAGOON

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM MELBOURNE, FLORIDA

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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

1.1 BACKGROUND AND OBJECTIVES

This report is the fifth volume of the Technical Report series prepared as support for the Characterization Report for the Indian River Lagoon National Estuary Program. The purposes of this volume are: 1) to summarize the types and sources of historical imagery, in particular aerial photography, available for the Indian River Lagoon region, and 2) to describe the apparent status and trends of seagrass beds in the Indian River Lagoon system as derived from an analysis of available historical imagery and mapping information.

Seagrass and other submerged aquatic vegetation (SAV) beds have been identified as being of great importance to the ecological health of estuaries. These beds form the base of important food webs and provide cover and habitat for many species of fish and wildlife. Studies of several other estuaries such as Tampa Bay (Ries, 1993), Sarasota Bay (Tomasko, 1993), and Chesapeake Bay (Batiuk, et al., 1991) have shown that large decreases of SAV have occurred and continue to occur. Much of this decrease has been attributed to the effects of human habitation and anthropogenic (human-caused) effects on water quality and marine substrates (Hurley, 1991; Dennison, et al., 1993).

Since SAV has been described as perhaps the most important habitat in the Indian River Lagoon system, maintaining and enhancing it is a primary goal of both the IRLNEP and the Surface Water Improvement Management Program (SWIM) (Morris and Tomasko, 1993). The SAV Initiative (SAVI) was launched by SWIM and IRLNEP in 1992 to attain this goal. The basic premises of the SAVI are that SAV distribution is primarily controlled by light penetration and the availability of adequate photosynthetically active light at the bottom of the estuary, and that changes in SAV abundance are largely controlled by changes in available light. Light penetration in turn is affected by several parameters of water quality such as color, suspended and dissolved solids, and phytoplankton chlorophyll levels in the water column.

One approach to enhancing the productivity and ecological health of the Indian River Lagoon system is enhancing the distribution of SAV beds by maintaining the best possible water clarity and controlling water quality characteristics that in turn control water clarity. The SAVI has identified a water depth of 6.7 feet (ft) [2 meters (m)] at which seagrasses should be capable of surviving in the Indian River Lagoon if water quality has not deteriorated below historic standards.

Before developing management strategies, it is necessary to evaluate whether this standard is reasonable for this Lagoon, based on current and past distribution of SAV in the system. It is also necessary to evaluate the extent to which SAV distribution has changed over time, and to identify the current status and trends of the SAV distribution. Several results of this evaluation are: 1) the identification of the amount of change that has occurred over time, 2) locations in which the greatest and least changes have occurred, 3) comparison of the extent of change to changes in depth distribution to determine if water clarity change is a probable cause of the SAV change, and 4) an approximation of the degree to which present levels differ from historical levels and the degree to which SAV abundance may be increased in each portion of the system if water quality limitations are removed.

The evaluation of these changes over time and the determination of trends requires examination of SAV distribution over the longest possible period. This is done by means of examining historical aerial photographs and maps and comparing distribution at different points in time. The results of this study provide an approximation of these changes. However, much additional detailed analysis may be required, and this report also is intended to provide future researchers with information on the availability of the historical imagery resources that might be used. Data and references used in this report represent material available as of June, 1993 when analyses were initiated.

Chapters 2 through 4 of this volume review the types of historical imagery that are applicable to studies of seagrasses and other resources of the Indian River Lagoon system. They also present in a series of tables an inventory of available aerial photography from various sources, as well as an evaluation of the utility of several of the image sets for mapping of seagrasses. Chapter 5 summarizes SAV mapping studies that have been performed in the past, and that are used as data sources for this integration of available information.

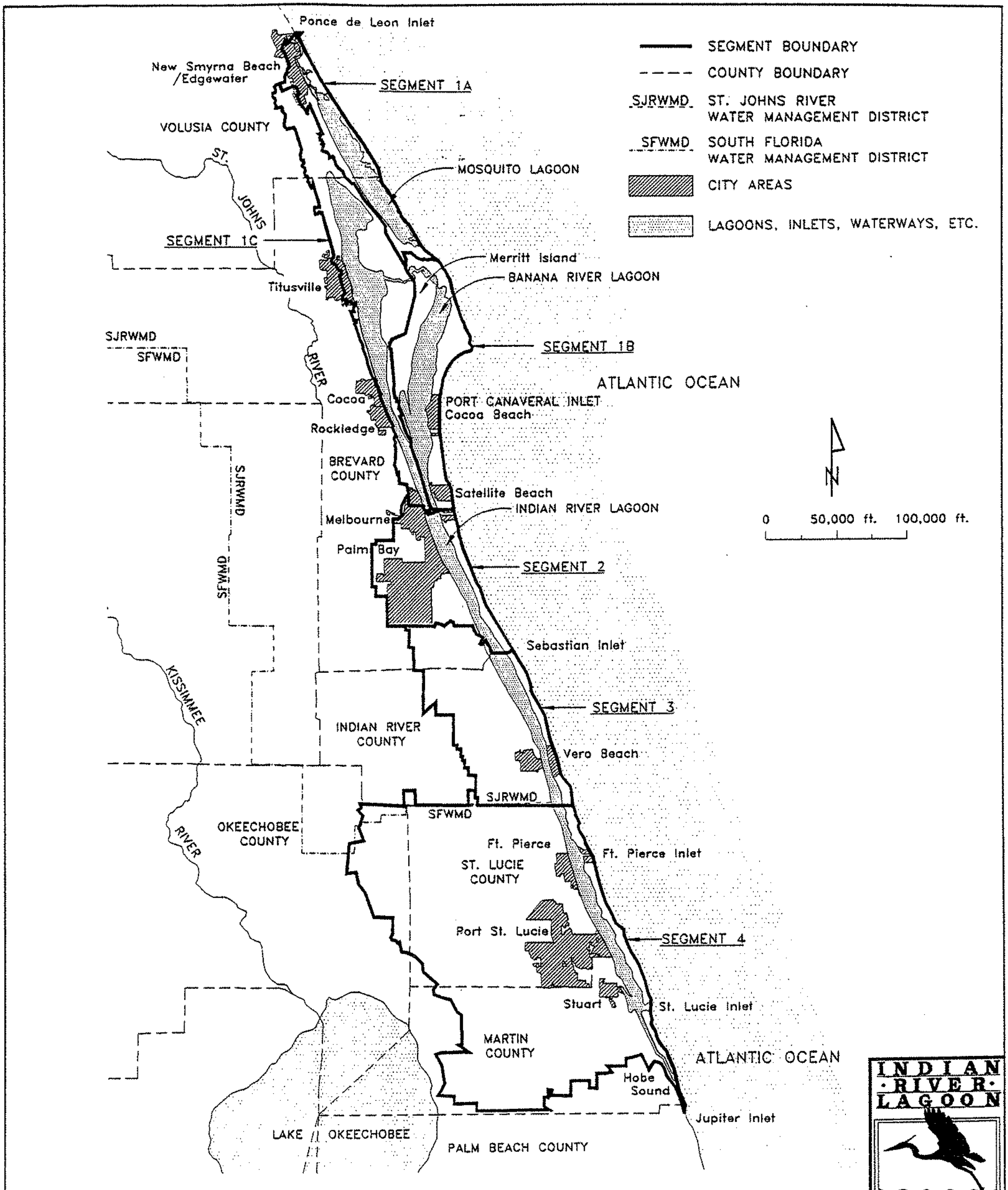
In Chapters 6 through 8, the available imagery and past mapping studies have been used to develop an integrated evaluation of the distribution of SAV throughout the system and to evaluate the trends in distribution and in depth of occurrence in various segments of the Lagoon.

1.2 OVERVIEW OF THE INDIAN RIVER LAGOON SYSTEM

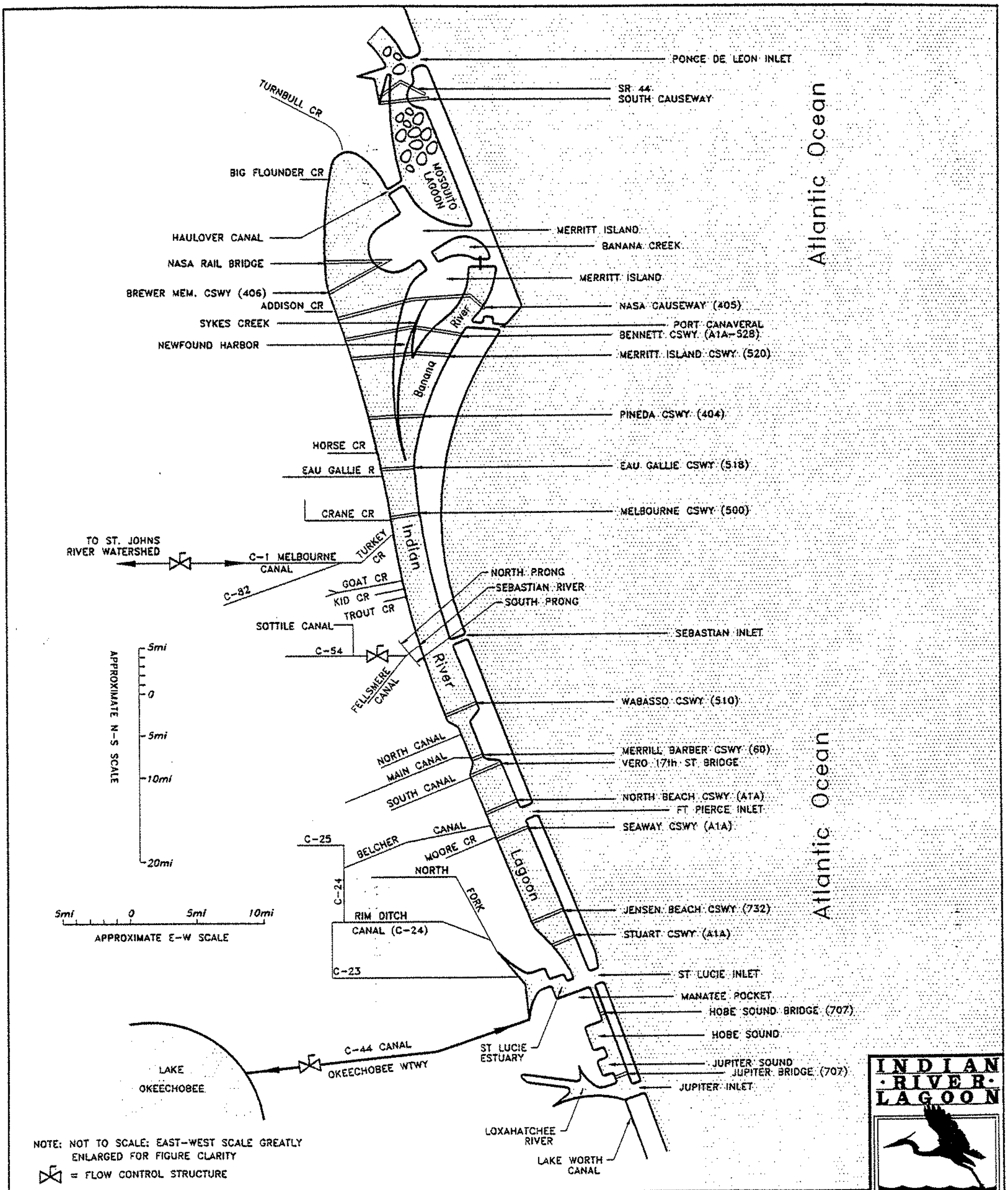
The Indian River Lagoon system is composed of Mosquito Lagoon south of Ponce Inlet, Banana River, and all of Indian River Lagoon from its north end at Turnbull Creek to its south end at Jupiter Inlet. This includes Hobe Sound and Jupiter Sound. Figure 1-1 shows the major landmarks and features along the system.

For this study, the system has been segmented into six segments as shown in Figure 1-2. The segment boundaries were modified from divisions presented by Glatzel and Da Costa (1986), based on hydrologic, infrastructure, and geomorphological characteristics. A more detailed discussion of the segmentation is presented in the "Physical Resources Technical Report" volume. For a more detailed inventory of seagrass distribution, the water bodies have been further broken into subsegments (Figures 1-3A, B and C). Subsegments M1 through M9 are subsegments of Segment 1A which covers Mosquito Lagoon. Subsegments B1 to B7 of Segment 1B cover Banana River, and Subsegments I1 to I 40 cover the four segments (1C, 2, 3, 4) of the Indian River Lagoon. All segment and subsegment numbers are listed from north to south.

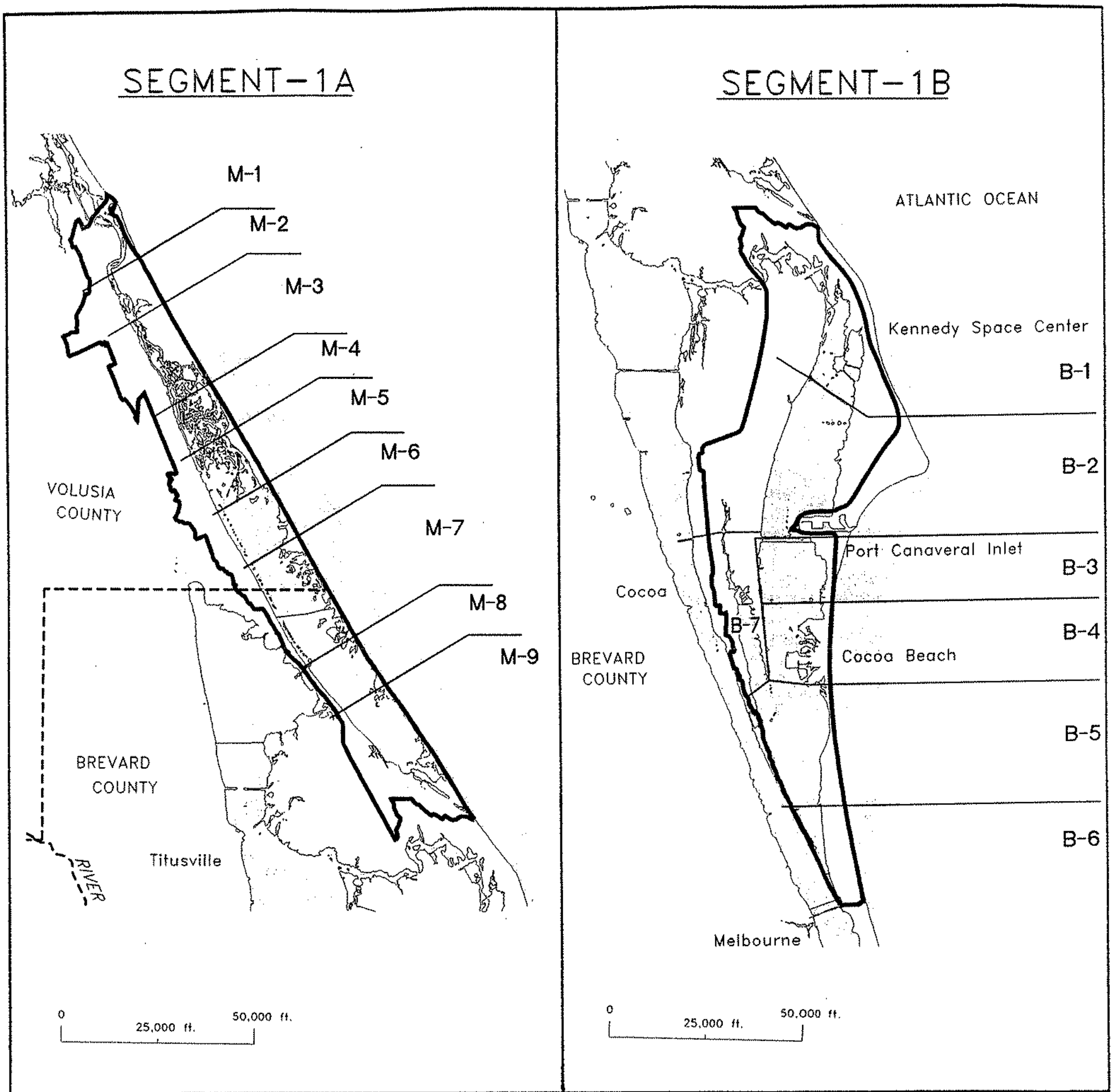
These subsegments were initially derived from subsegment boundaries used in earlier studies, particularly those of Thompson (1976). These initial units were selected in order to utilize acreage values and other information directly from the earlier studies. Additional subsegment boundaries were added to break portions of the Lagoon system into more easily analyzed units, and also to provide consistency among previous studies (i.e., to split and remove areas of overlap between studies). As much as possible, subsegment boundaries utilize causeways, points, and other features which may affect the circulation in the Lagoon and relate to different water quality characteristics among subsegments.



•Woodward–Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: INDIAN10.DWG DATE: 7-5-94	FIGURE 1–1 MAP OF INDIAN RIVER LAGOON SYSTEM AND WATERSHED SHOWING SEGMENTS	INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



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



LEGEND:

- – – – = COUNTY BOUNDARIES
- ▬▬▬ = SEGMENT BOUNDARIES
- –··–··– = WMD BOUNDARY

LEFT SEGMENT 1A - MOSQUITO LAGOON
RIGHT SEGMENT 1B - BANANA RIVER

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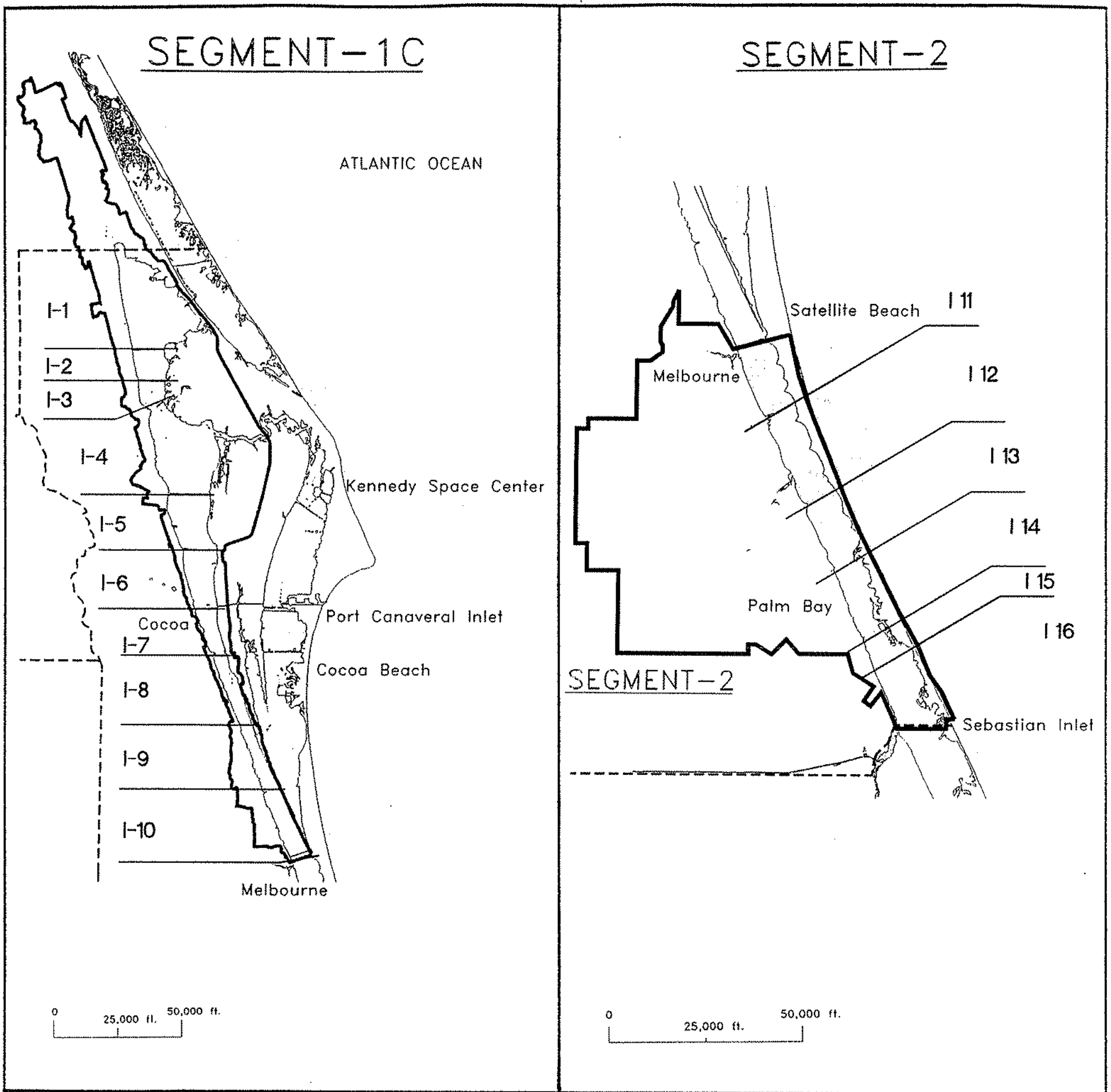
FIGURE 1-3A SUBSEGMENTS USED FOR HISTORICAL ANALYSIS OF INDIAN RIVER LAGOON SEAGRASSES



LEGEND:

- - - - = COUNTY BOUNDARIES
—— = SEGMENT BOUNDARIES
— · — = WMD BOUNDARY

LEFT SEGMENT 1C - NORTH INDIAN RIVER LAGOON
RIGHT SEGMENT 2 - NORTH CENTRAL INDIAN RIVER LAGOON

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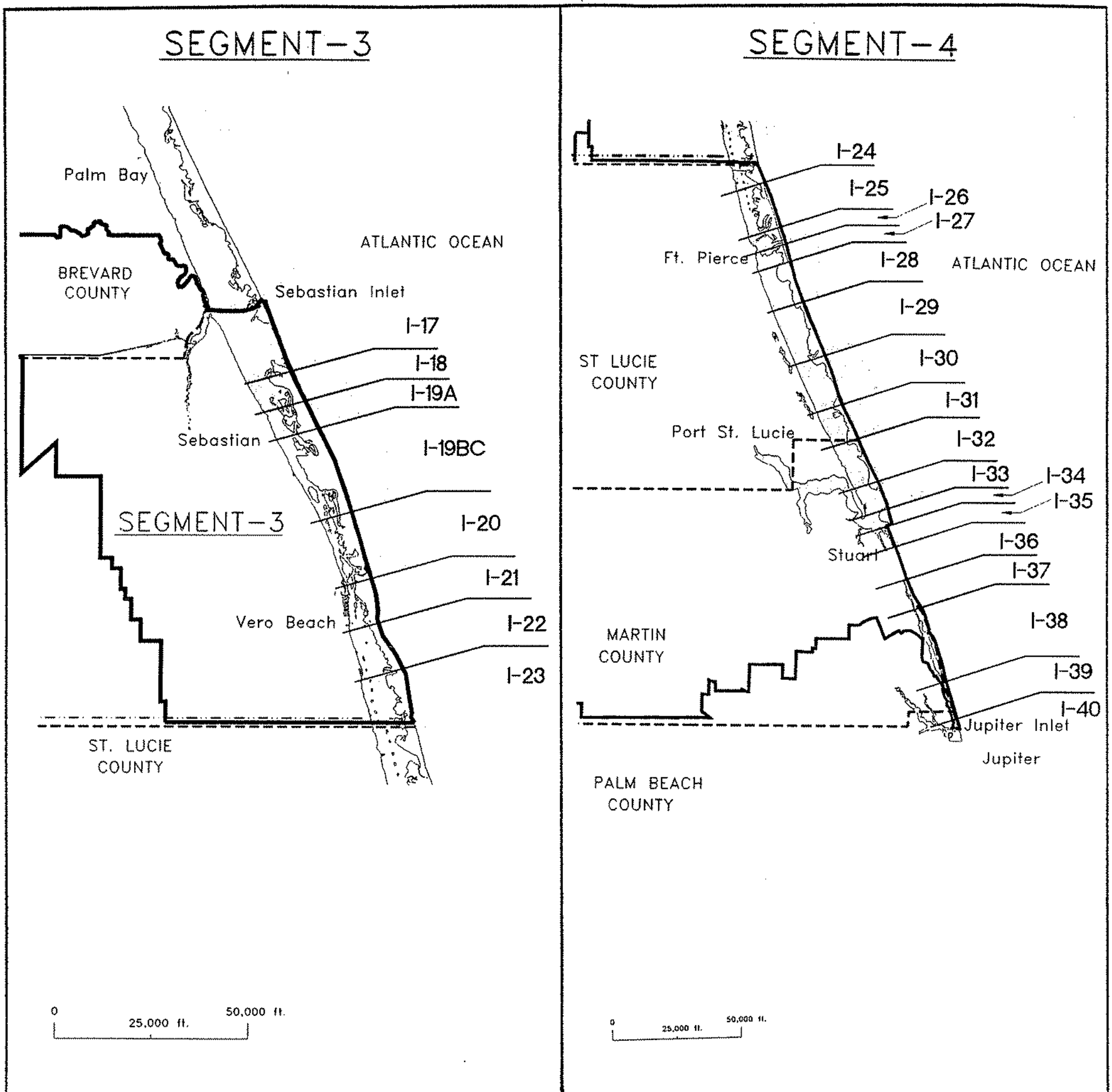
FIGURE 1-3B SUBSEGMENTS USED FOR HISTORICAL ANALYSIS OF INDIAN RIVER LAGOON SEAGRASSES



LEGEND:
- – – – = COUNTY BOUNDARIES
- ▬▬▬ = SEGMENT BOUNDARIES
- –··–··– = WMD BOUNDARY

LEFT	**SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON**
RIGHT	**SEGMENT 4 - SOUTH INDIAN RIVER LAGOON**

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FIGURE 1-3C

SUBSEGMENTS USED FOR HISTORICAL ANALYSIS OF INDIAN RIVER LAGOON SEAGRASSES

2.0
REVIEW OF IMAGERY DATA TYPES

2.1 USES OF IMAGERY

Remote sensing imagery and, in particular aerial photography, is a necessary tool for evaluating many resources that affect the status of the Indian River Lagoon system. Much of this resource information would be very difficult or impossible to obtain without the availability of this imagery. Photographic imagery also represents a valuable database describing conditions in past times. In many cases it is necessary to study conditions in the past, and historical imagery often offers the only remaining evidence.

Many of the resources or studies that interest today's resource managers were not envisioned in the past as being important. Financial and personnel resources also may not have been available to act upon desired studies on a real time basis. It is only through the existence of such photographs that it is possible today to study these resources of the past. In some cases managers had the foresight to acquire and save inexpensive photographic records in lieu of more expensive studies. These records form an important part of today's database for the Indian River Lagoon system. For this reason, it is important that acquisition of aerial photographs and other types of remote imagery be continued to document current conditions, so that these may be studied in the future as needs arise.

One of the main benefits of this historical record is the ability to document trends and changes over time. These changes are critical for evaluating the status of the Indian River Lagoon system and in developing correlations that provide evidence of causes and effects within a basin. Major uses of aerial photographs in the Indian River Lagoon system are described in the following sections.

Land Use and Land Cover Analysis

Land use analysis represents the major use of remote sensing imagery. Aerial photos have been the source of primary data for virtually all land use studies and, depending on the scale and quality of imagery, can yield accurate information for areas smaller than 0.25 acres (ac).

Land use studies have been produced by all levels of government and many private and institutional researchers. The U.S. Geological Survey (USGS) (Anderson, et al., 1972) has produced the Land Use and Data Analysis (LUDA) map set for the entire United States. The Indian River Lagoon system region was mapped by the USGS LUDA project from 1972 to 1974 aerial photography. The State of Florida (Florida Department of State Planning, 1976) has developed the Florida Land Use and Cover Classification System (FLUCCS), which is very similar to the LUDA classification scheme. Both the St. Johns River Water Management District and the South Florida Water Management District maintain FLUCCS-based land use map layers on their GIS databases for the period between 1986 and 1990. St. Johns River Water Management District also maintains a land use layer based on 1974 aerial photographs.

Land use maps from aerial photographs provide the raw data for many additional uses, including routing for roads, power line corridors, and other linear features; site selection and planning of land developments and parks; tax assessment; and growth management. One of the most important uses of land use maps for resource managers in the Indian River Lagoon system is as the basis for developing modeling of surface water and associated pollutant run-off loads into the Lagoon. The determination of existing and future projected pollutant loadings for the Lagoon, described in the companion technical report "Assessment of Water Quality, and Point and Non-point Loadings" has been based on land use determinations derived from aerial photographs.

Soils Classification

The U.S. Soil Conservation Service (SCS) is one of the primary users of aerial photography. It has used black and white aerial photographs as the base for developing soils maps of each of the counties in the Indian River Lagoon drainage system Although specific information is based on site-specific soil samples, boundaries between soil series are delineated on the aerial photographs, and the photographs are used as the basis for the maps in the county soil surveys.

Agricultural Production

The Agriculture Stabilization and Conservation Service (ASCS), the Florida Department of Agriculture and Consumer Affairs, and SCS also use aerial photographs for calculating acres of agricultural production for various crops. These data are then used in producing annual summaries of citrus and vegetable production for each county. Aerial photographs are also used to determine and verify crop subsidy payments and crop damage assessments, as well as to determine the status of agricultural management practices such as irrigation methods.

Because of the extent to which SCS and ASCS use aerial photos, their county offices are some of the best local sources of aerial photographs. Photographs are updated at three to six year intervals at scales ranging from 1" = 440' (older series) to 1" = 2,000' (generally post-1970 series). Photographs are generally black and white, although color Infra-red has been used in some counties since about 1984. The season of photography is generally between October and May.

SAV and Wetlands Distribution

One measure of the ecological health of the Indian River Lagoon is the extent of the distribution of SAV. Aerial photographs can give information on the presence of SAV and the density or abundance of seagrasses and other SAV. Changes in abundance and distribution over time may be indicative of changes in water quality or other factors that affect the condition of the Lagoon. Thus, seagrass distribution might be used for identifying potential areas of impact or sources of water quality deterioration in the absence of site-specific water quality monitoring. Aerial photographs have been used in this manner for emergent wetland communities throughout the state of Florida.

Wetlands and SAV provide valuable habitats for many fish and wildlife species, including food and sport fishes and endangered wildlife. The abundance of these habitats affects the abundance of the fish and wildlife of the Lagoon. Aerial photographs can be used to monitor the quality and abundance of these habitats and determine changes and trends occurring over time. These photos are also used by agencies such as the Florida Department of Environmental Protection (FDEP) to identify illegal activities in surface waters and associated wetlands and to monitor the status of permit compliance.

Mosquito Impoundments

Marshes impounded for mosquito control have altered the condition and ecological functions of most of the tidal wetlands surrounding the Indian River Lagoon (discussed in the "Biological Resources" report). Numerous changes in the management and function of these impoundments are being implemented by various agencies to reverse damages caused by impounding these wetlands. Aerial photographs can be used to determine the changes in vegetation and habitats within these impoundments and monitor the success of these efforts. Aerial photographs also provide the only reliable records of vegetation as it existed in these areas prior to impoundment.

Manatee Distribution/Population Studies

The U.S. Fish & Wildlife Service (FWS), FDEP, and other organizations use low altitude oblique aerial photographs to locate manatees within the Indian River Lagoon system. Aerial photos are used to supplement aerial surveys and allow counting of large concentrations of manatees. These data have been used to evaluate population size and movement and identify locations that are most often used. Resulting information has allowed refinement of manatee protection zones within the Lagoon. Large-scale photos (1"=200' or greater) are generally necessary to locate the manatees.

Water Quality/Circulation Monitoring

Remote sensing imagery has been used in some cases to evaluate water quality and identify sources of pollution, although its use for this purpose in the Indian River Lagoon system has not been documented. Aerial photographs have limited value for this use. Color, and to some degree black and white, photographs may be used to identify high turbidity areas and also areas with high color from tannic acids. Color infra-red photography also has had some application in identifying areas of septic tank seepage by revealing saturated soil areas.

In addition to color infra-red film, the primary tool for water quality applications has been the satellite-based multispectral scanning (MSS) technology. MSS and other scanning tools (i.e. thematic mapper) have been applied to measuring temperature differences in surface waters for delineating thermal plumes (Schweitzer, 1982), and also may have applications for other parameters such as suspended solids, chlorophyll *a*, nitrates, and dissolved organic carbon (Schweitzer, 1982).

Geomorphology Studies

Aerial photography is valuable in identifying drainage patterns, watershed boundaries, and areas with eroding soils. Springs and seepage areas may also be identified from aerial photos or MSS data. Various geological landforms such as relic dune systems and coastal ridges are also apparent on aerial photographs. Changes in shorelines can be effectively monitored over time through the use of remote imagery.

2.2 TYPES OF IMAGERY

2.2.1 Vertical Aerial Photographs

Vertical aerial photos are available in various scales and types. Scale refers to the ratio of the distance on the photo to the actual ground distance represented by the photograph. Large scale photos have fewer feet per inch of photograph distance than small scale photographs. Scales generally range from 1" = 400' to 1" = 50,000'. For the Indian River Lagoon region, larger scale photographs are generally available from county and city governments, water management districts, and the SCS, while small scale photographs are generally provided by other state and federal agencies such as the Florida Department of Transportation (FDOT) and USGS.

Vertical aerial photographs are taken from locations directly above the location in the center of the photograph. Photos are normally taken sequentially along flightlines with automatic cameras in special mounts. Because the straight-line distance from the lens to the ground surface is different at the edges of the photo from that at the center or focal point, there is always some distortion in scale within aerial photos. There may also be distortion and scale differences among different photographs in the same flight line because of differences in the altitude of the aircraft and in the angle of the aircraft in relation to the land surface.

Scale of aerial photographs is a function of focal length of the camera lens and of altitude of the plane. Longer focal lengths and lower altitudes result in larger scale photos and greater detail and resolution of the photographs. However, because the variation in lens to ground distance between the center and the edge of the photograph is proportionally larger at lower altitudes, these larger scale photographs usually have greater distortion than smaller scale photographs that are taken from higher elevations. This tradeoff must be recognized when selecting the optimal scale to be used for specific purposes.

Various techniques exist for correcting scale distortion (rectifying) in photographs. In order to accurately map locations and determine distances between locations, photographs must be rectified. Ground control points must be established at known locations and adjustment of photographs is based on these known distances. Recent advances in computer input and enhancement of photographic images have reduced the level of specialized equipment necessary, but rectification remains a major problem in the use of aerial photographs for measuring and mapping features.

2.2.2 Oblique Aerial Photographs

Oblique aerial photographs are those that are taken at an angle from a location that is not directly above the center of the image area. Because of the resulting distortion within the photograph, oblique photographs are extremely difficult to rectify and usually can not be used for area measurement or for accurate mapping. There is a greater degree of obscuring of information by foreground features, and resolution is less due to greater light diffraction caused by the greater angle. However, oblique photographs often can present a different view of areas and can emphasize features such as height differences of vegetation or other objects, that are not as apparent in vertical aerial photographs.

2.2.3 Types of Film

Aerial photographic film types include black and white, true color, and infra-red (IR). These film types differ in value for different applications, and selection of film type is an important step in obtaining imagery for different project uses. Unfortunately, for assessing conditions in the past, one must use whatever photographs are already available. For historical purposes, existing photographs must be relied upon and selection of available imagery may be limited.

Black and white film is the oldest medium, and is the only film type readily available for the region prior to about 1972. Black and white film has high resolution and good differentiation between man-made objects, but has limitations in differentiating between natural features such as different vegetation types and between open water and vegetated wetlands. Black and white film has moderately good water penetrating capability, but does not always distinguish between types of water discoloration or between water color or substrate differences.

True color film shows colors as they are apparent to the human eye. Thus, many features can be most readily identified without specialized training. Color photography offers better ability to differentiate between different vegetation types, and between different types of water discoloration and bottom type. True color aerial photography first became available during the 1950s, but generally was not used until the 1970s. Because of the extra cost, poorer penetration in hazy conditions, and lower resolution than black and white photography, it has not been extensively used. It has largely been replaced by infra-red film because of that film's greater resolution in several respects.

False-color infrared-film has generally been available since the mid-1980s. This film type presents colors in terms of their spectral reflectance to infra-red radiation rather than to visible light as seen by the human eye. Infra-red film offers greater differentiation between different vegetation types because of differential absorbance by plant pigments. It offers better land-water boundary differentiation than other film types when those boundaries are obscured by vegetation. Infra-red is also capable of differentiating moisture differences in soils and vegetation and thus can detect wetland boundaries and drainage patterns. This trait also gives it the capability of detecting some septic tank seepage patterns. However, false-color IR has poor water penetration capability in comparison to black and white and color film (Carter, 1982). Thus it is less sensitive for identifying submerged aquatic vegetation unless water clarity is high. Black and white IR film also exists, but this film type has very limited capability in relation to the other film types, being used mainly for monitoring water temperature and thermal plumes. Thus it is of limited use and no significant sources of this type of film have been identified for the Indian River Lagoon region.

2.2.4 Other Remote Sensing Imagery

The primary non-photographic remote sensing application is multispectral scanning (MSS) technology. Instead of photographic film, this system uses radiation detectors that selectively pick up electromagnetic radiation in selected wavelengths or bands. Sensor readings are converted into digital signals that are read by computer and converted into images that can be displayed on CRT screens or on photographic paper. The most important sources of MSS data are the LANDSAT, EARTHSAT, and SPOT Satellites.

Through the use of multiple sensors, different specific bands of radiation can be monitored. Each band of wavelengths has specific spectral qualities of reflectance and absorbance. Different bands react differently to the presence of water, plant chlorophyll, and other factors. Using computer technology, signals from various bands can be combined in various combinations to provide maximum sensitivities to selected factors. For example, LANDSAT carries four spectral bands (MSS-4, green; MSS-5, lower red; MSS-6 upper red-lower infrared; and MSS-7, infrared). The green band [0.5 to 0.6 microns (μ)] provides maximum differentiation and penetration in water, which makes it useful for detecting sediment plumes, underwater features, and contaminants. As with IR photographs, the infrared band 7 (0.8 to 1.1 μ) offers the best land/water boundary definition.

The LANDSAT images offer resolutions up to 40 meters (m). Images are arranged in"scenes" which cover 115 x 115-mi area and are available on digital tapes, positive and negative films, and paper prints. One of the advantages of LANDSAT data is the frequency of observations. Satellite coverage has been repeated at intervals as often as 18 days.

Starting with the LANDSAT D satellite, an advanced MSS system known as the Thematic Mapper (TM) (Colwell, 1983) provides enhanced multi-spectral data. This system uses a total of seven spectral bands from the visible (0.45 to 0.69 μ) to the thermal infrared (10.4 to 12.5 μ) with resolution to 30 m. The greater range of bands allows greater differentiation between spectral signatures and greater resolution in differentiating between different features.

Numerous other remote sensing technologies have been developed and are being utilized more commonly. These include the thermal IR mapper, side scanning radar, and laser-induced fluorescence scanning. The thermal IR can detect temperature differences within water bodies and thus is useful for tracking thermal effluent and current patterns. Radar is primarily useful for mapping solid features, but has some applicability in differentiating among submerged substrate types. The laser-induced fluorosensor has been shown to have some capacity for detecting chlorophyll *a* and possibly dissolved organic carbon (DOC) in water bodies. Although each of these has some potential use in studies in the Indian River Lagoon system, their availability and utility are still generally limited.

3.0 SOURCES AND IDENTIFICATION OF AVAILABLE IMAGERY

3.1 FEDERAL GOVERNMENT

3.1.1 National Cartographic Information Center

Remote sensing imagery is available through several sources in the federal government. The primary source for imagery is the National Cartographic Information Center (NCIC).

Aerial photography available for the Indian River region has been identified using the Aerial Photography Summary Record System (APSRS). APSRS is an information system for determining the availability of aerial photography meeting specified criteria over a given geographic area. The National Cartographic Information Center (NCIC) is the information branch of the U.S. Geological Survey's National Mapping program. In order to organize and distribute information about U.S. aerial photography coverage, and to help eliminate aerial mapping duplication by tracking individual aerial projects, NCIC developed APSRS. Originally, the principal products of APSRS were state-base graphic indexes that showed the coverage of conventional aerial photography projects over each State. Currently, APSRS is available on CD-ROM, and contains approximately 2.4 million records referencing data that describes the holdings of nearly 600 contributors from Federal, State, and local government agencies, universities and private industry. The APSRS CD-ROM is re-issued with updated information approximately every 6 months; the August 1992 version was used for this report to identify aerials available for the Indian River Lagoon region.

Aerial photos in the APSRS inventory covering the Indian River Lagoon region were identified using the APSRS grid of latitude-longitude lines. Each sixteenth of a grid area represents a 7.5 minute portion of the earth, and can be queried in APSRS by entering the latitude and longitude of the southeast corner of the corresponding 7.5 minute USGS topographic quadrangle map. The Indian River Lagoon system extends through five counties and thirty-two 7.5 minute topographic quadrangles. In order to streamline the inventory process, the APSRS search was divided into six areas by county, except that the largest county (Brevard) was subdivided so that the searched areas would be approximately equal. The counties searched from north to south include Volusia, Brevard North, Brevard South, Indian River, St. Lucie, and Martin. Within each county area, the search was bounded by the southeastern most quad and the northwestern most quad. In this manner the search was streamlined by limiting it to the western most quad that includes the Lagoon, rather than the western boundary of each county. The search was subdivided by time periods as follows:

- 1920 to 1940
- 1941 to 1950
- 1951 to 1960
- 1961 to 1970
- 1971 to 1980
- 1981 to 1993

The search was further subdivided by film type for each area, so that the inventory for each area is presented in the following order:

- color
- color infrared
- black and white
- black and white infrared

The APSRS inventory obtained in this manner consists of a listing of all imagery available for the specified area in two separate formats: a brief format and a long format. The brief format consists of one line for each aerial photograph, and provides the following information for each photograph:

- agency source
- date
- project number
- scale
- film type

Groups of individual photographs that form a complete project can be quickly identified in the brief format by identifying the agency sources, which are the same throughout the project, and the project numbers, which have the same format throughout the project.

A summary of the number of individual aerials available for each county by film type is presented in Tables 3-1 to 3-5. A brief format or a long format inventory can also be obtained through APSRS on electronic disks. The full view, or long format, includes the following information for each aerial:

- agency
- latitude
- longitude
- state/county
- date of coverage
- project code
- scale
- focal length
- film type
- sensor class
- cloud cover
- quadrangle coverage
- remarks

At the beginning of each search, the search information (latitude, longitude, date of coverage) is provided, and serves to orient the reader as to the parameters of the search.

3.1.2 Agriculture Stabilization and Conservation Service/Stabilization Conservation Service

Although the NCIC serves as a central clearing house for identifying and obtaining imagery maintained by the federal government, it is not the only source of information and much of the photography in the APSRS inventory can be obtained through other avenues.

TABLE 3-1

SUMMARY OF AERIAL PHOTOGRAPHIC COVER OF VOLUSIA COUNTY IN APSRS

DATE	FILM TYPE	TOTAL NO. OF AERIALS	NO. OF AERIALS BY FILM TYPE
1921 to 1940	---	0	---
1941 to 1950	B & W	67	67
1951 to 1960	B & W	26	26
1961 to 1970	Color Color IR B & W B & W IR	122	33 7 27 55
1971 to 1980	Color Color IR B & W B & W IR	131	17 38 55 21
1981 to 1993	Color Color IR B & W	223	37 126 60

TABLE 3-2

SUMMARY OF AERIAL PHOTOGRAPHIC COVER OF BREVARD COUNTY IN APSRS

DATE	FILM TYPE	TOTAL NO. OF AERIALS	NO. OF AERIALS BY FILM TYPE
1921 to 1940	---	0	---
1941 to 1950	B & W	80	80
1951 to 1960	B & W	30	30
1961 to 1970	Color Color IR B & W B & W IR	371	142 63 62 104
1971 to 1980	Color Color IR B & W B & W IR	129	8 39 71 11
1981 to 1993	Color Color IR B & W	273	46 171 56

TABLE 3-3

SUMMARY OF AERIAL PHOTOGRAPHIC COVER OF INDIAN RIVER COUNTY IN APSRS

DATE	FILM TYPE	TOTAL NO. OF AERIALS	NO. OF AERIALS BY FILM TYPE
1921 to 1940	---	0	---
1941 to 1950	B & W	80	80
1951 to 1960	B & W	30	30
1961 to 1970	Color Color IR B & W B & W IR	371	142 63 62 104
1971 to 1980	Color Color IR B & W B & W IR	129	8 39 71 11
	Color Color IR B & W B & W IR		8 39 71 11
1981 to 1993	Color Color IR B & W	273	46 171 56

TABLE 3-4

SUMMARY OF AERIAL PHOTOGRAPHIC COVER OF ST. LUCIE COUNTY IN APSRS

DATE	FILM TYPE	TOTAL NO. OF AERIALS	NO. OF AERIALS BY FILM TYPE
1921 to 1940	---	0	---
1941 to 1950	B & W	80	80
1951 to 1960	B & W	30	30
1961 to 1970	Color Color IR B & W B & W IR	371	142 63 62 104
1971 to 1980	Color Color IR B & W B & W IR	129	8 39 71 11
1981 to 1993	Color Color IR B & W	273	46 171 56

TABLE 3-5

SUMMARY OF AERIAL PHOTOGRAPHIC COVER OF MARTIN COUNTY IN APSRS

DATE	FILM TYPE	TOTAL NO. OF AERIALS	NO. OF AERIALS BY FILM TYPE
1921 to 1940	---	0	---
1941 to 1950	B & W	6	6
1951 to 1960	B & W	49	49
1961 to 1970	Color Color IR B & W B & W IR	327	144 74 37 72
1971 to 1980	Color Color IR B & W	135	49 54 32
1981 to 1993	Color Color IR B & W	72	22 20 30

Photography produced by the SCS and ASCS is currently stored in the ASCS Archives in Salt Lake City. Table 3-6 lists the years and counties for which photography is available for purchase through this office. Copies of some of these photos are also available through local county SCS and ASCS offices, but most local offices do not have full sets of all photos. Photo series available through ASCS and SCS are generally contracted by county. Each county is usually photographed at intervals of three to six years, depending on the rate of land use change within the county or on special needs such as revised soil surveys or perturbations to agricultural systems. Most SCS and ASCS photographs are black and white, although some color IR photos are available for the 1980s and 1990s.

3.1.3 National Archives

The National Archives in Washington D.C. maintains an archive of aerial photographs. Many of these photographs are not included in the APSRS inventory system. The APSRS system contains material from 1940, when systematic large-scale coverage programs were started. The material in the national Archives largely pre-dates this period and/or is very limited and specific in areal coverage or use. Material from the National Archives are ordered from the National Archives and consists only of copies. Many negatives are lacking, so the copies are of varied quality. There is no means of readily inventorying available materials by mail, and original source materials may only be examined at the archives by appointment. This limits usefulness and requires much research and a long turn-around time for obtaining materials.

3.1.4 National Aeronautics and Space Administration

Much aerial photography and remote sensing imagery has been produced by the National Aeronautics and Space Administration (NASA). Available photography can be identified and accessed through APSRS and NCIC, which serves as the distribution agency for NASA photography. NASA photography includes pictures taken from manned spacecraft as well as photography from airplanes. One of the most important sources of aerial photography has been the National High Altitude Program (NHAP) conducted by NASA and cooperating agencies (Carter, 1982; Johnson, 1982). This program has produced color IR and other photography for most of the United States taken from high altitudes between 1983 and 1990.

TABLE 3-6

BLACK AND WHITE AERIAL PHOTOGRAPH AVAILABILITY, ASCS, SALT LAKE CITY

COUNTY (N TO S)	1951	1952	1957	1958	1970	1972	1973	1979	1980	1981	1984	1989
Volusia	●			●		●	●			●	●	●
Brevard	●			●	●			●			●	
Indian River	●		●		●				●	●	●	
St. Lucie		●		●	●					●	●	
Martin		●		●	●					●	●	

Scale: 1950s and 60s flown at 20,000 ft
1970s flown at 40,000 ft
Early 1980s flown at 60,000 ft

NASA photographs are included in the APSRS search results in Tables 3-1 through 3-5. Copies of some of the NASA aerial photography covering the Indian River Lagoon region are maintained by the Kennedy Space Center (KSC) through its environmental consultant, Bionetics Corp. The Ground Engineering Office at KSC also may be a source of additional photography (Edward E. Clark Engineers, 1991).

3.1.5 Other Federal Agencies

Several other federal agencies and offices obtain and use aerial photography for specific uses. This photography generally covers small areas and is variable in film type, scale, and periods of time covered. Examples of agencies which may have photography available are the U.S. Army Corps of Engineers (COE), U.S. Fish and Wildlife Service (FWS), and U.S. Coast Guard (USCG). Regional offices of these agencies may be potential sources of aerial photography, although photographs are rarely, if ever, allowed to leave the offices.

The COE is probably the main source of photography of these other agencies. Most COE photography applicable to the Indian River Lagoon region is accessible through the Jacksonville District Office in Jacksonville. Table 3-7 lists shows a list of aerial photographs provided by the Jacksonville COE District in Jacksonville. Additional materials may be available in other regional offices, but availability will vary over time.

3.1.6 Earth Observation Satellite Company

The Earth Observation Satellite Company (EOSAT) is the private organization that has been licensed by the federal government to process and sell remote sensing imagery from the Landsat Earth Satellite Data System satellites. The company can be contacted at 4300 Forbes Boulevard, Lanham, Maryland 20706 (301-552-0537) for information on products and services. EOSAT also is a source for SPOT imagery from European Space Agency satellites.

3.2 STATE AGENCIES

The second step in identifying aerial photography available for the Indian River Lagoon was to contact state and local sources to determine if additional imagery is available and if any

TABLE 3-7

BLACK AND WHITE AERIAL PHOTOGRAPHY AVAILABILITY, U.S. ARMY CORPS OF ENGINEERS, JACKSONVILLE

LOCATION	DATE	SCALE	QUALITY
Entire IRLNEP area	1984-85	1:96,000	good, not stereo
Entire IRLNEP area	1980-81	1:96,000	good, some stereo
Entire IRLNEP area	1974-75	1:12,000	marginal (degrading)

The above aerials are from large COE projects. A county-by-county search for smaller projects resulted in:

LOCATION	DATE	PROJECT	SCALE/COMMENTS
Volusia	05/28/77	Beach Erosion	1" = 250'
Brevard	06/27/78 10/19/72 05/05/73		
Indian River	Unknown		(some color aerials are available)
St. Lucie	1958 05/05/65 08/18/85	St. Lucie Canal Right-of-Way	various; 1:5,000 stereo; 1"=800'
Martin	05/10/92	Shoreline Protection	stereo

Note: An Intracoastal Waterway East Coast Project was done in 1947, and these aerials are also available through Jacksonville Corps of Engineers.

of the identified federal imagery is available locally for sale or loan. Sources contacted include county and state SCS offices, FDOT, county and city governments, and local aerial photography firms.

Numerous other state of Florida supported agencies also have aerial photographs and historical imagery available. As with individual federal agencies and offices, most of this material will not be released from the office. In some cases, copies may be obtained from the agency, usually under special arrangements. The primary sources of this information are FDOT the water management districts, Florida Department of Environmental Protection (FDEP), and the state universities.

3.2.1 Florida Department of Transportation

FDOT maintains the most extensive coverage of the state. FDOT aerial photographs are black and white and small scale (about 1" = 2,000). Table 3-8 shows that FDOT maintains coverage on about a four-year cycle for all of the counties in the Indian River Lagoon region. These are available for purchase or viewing from the Florida Department of Transportation headquarters in Tallahassee.

3.2.2 Water Management Districts

Substantial aerial photographic resources are present at the St. Johns River Water Management District and the South Florida Water Management District. However, both of these agencies are very large, and resources are spread over many departments with no centralized inventories. Coverage includes both regional coverage collected for land use mapping and regional watershed projects, and smaller, project-specific coverage.

3.2.3 Florida Department of Environmental Protection

Various offices of FDEP have aerial photographs covering parts of the Indian River region. Offices and departments that were previously in the Department of Natural Resources usually maintain the best coverage.

TABLE 3-8

BLACK AND WHITE AERIAL PHOTOGRAPHY AVAILABILITY, FDOT TALLAHASSEE

COUNTY (N to S)	1966	1968	1969	1972	1974	1976	1978	1980	1981	1983	1984	1986	1988	1989	1992	1993
Volusia			Nov		Oct	Jan			Apr		Mar		Feb		Mar	
Brevard				Mar				Feb		Nov		Apr		Feb		Mar
Indian River		Mar			Feb		Jan		Jan		Nov		Feb		Jan	
St. Lucie			Nov					Feb		Mar		Apr			Jan	
Martin	Jan				Feb			Feb		Apr		Apr			Jan	

Scale: 1" = 2,000 feet up to July 1989 (inclusive)
1" = 2,083 feet after July 1989

3.2.4 State Universities

A number of useful sources exist at state universities. In particular, the Coastal Archives at the University of Florida (UF) Department of Civil Engineering and the Map archives at the UF library in Gainesville are useful sources of materials. The Florida Resources and Environmental Analysis Center (FREAC) at Florida State University maintains an APSRS CD-ROM database accessible through its work stations.

3.3 LOCAL SOURCES

Local entities are an important source of aerial photographs covering the region, although some limitations exist. Most of these sources contain information only for specific counties or cities, with little multi-county coverage available at any single location. In most cases, materials can not be removed from the offices. Some of the materials are in poor condition and will not copy well. Coverage is often not complete for an entire county, and comparable dates are often not available for adjacent counties.

Aerial photographs available within each county have also been compiled in tables, including the agency that originated and/or currently possess the photos. Tables 3-9 to 3-13 are footnoted for easy reference to the contact person(s) for each agency, including address and phone number.

Tables 3-9 to 3-13 also list coverage available from SCS, ASCS, and centralized county agencies in each county. Additional materials may also be available from county assessor offices, individual city planning departments, and other county offices such as the mosquito control districts. County assessor offices are good sources for blue-line paper reproductions of aerial photographs at large scales of 1"=400' to 1"=1000'. While the quality of blue-lines may be of poorer quality than photographic prints, the large scale makes them useful for many purposes, including land use analysis and wetlands delineation.

Several private sources also exist in the region. These include educational facilities and research organizations such as Harbor Branch Oceanographic Institution. Local historical societies also are a source of other photographs and localized coverage.

TABLE 3-9

VOLUSIA COUNTY AERIAL PHOTOGRAPH AVAILABILITY

DATE	FILM[2]	SCALE	REMARKS
1943	B & W	1" = 1320'	D.C. Archives for prints[3]
1951	B & W	1" = 1320'	Salt Lake for prints[3]
1958	B & W	1" = 1320'	Salt Lake for prints[3]
1963	B & W	1" = 2000'	Lab will print for County[3]
1967	B & W	1" = 2000'	Lab will print for County[3]
1971	B & W	1" = 2000'	Lab will print for County[3]
1972	B & W	Unknown	SCS and SWCD[4]
1973	Color, B & W	1" = 2000'	Lab will print for County[3]
1975	Color, B & W	1" = 2000'	Lab will print for County[3]
1978	Color, B & W	1" = 2000'	Viewing only, negatives lost in fire[3]
1980	Color, B & W (ortho)	1" = 400'	Lab will print for County[1,3]
1980	B & W	Unknown	SCS & SWCD[4]
1982	Color, B & W	1" = 2000'	Lab will print for County[3]
1984	Color, B & W	1" = 2000'	Lab will print for County[3]
1984	Color Infrared	Unknown	SCS & SWCD[4]
1986	Color, B & W	1" = 2000'	Lab will print for County[3]
1987	B & W (ortho)	1" = 400'	Lab will print for County[3]
1988	Color, B & W	1" = 2000'	Lab will print for County[3]
1990	Color, B & W	1" = 2000'	Lab will print for County[3]
May 1992	B & W	1" = 400'	Tax Assessor (1st floor[3])
1993	Color, B & W	1" = 2000'	Lab will print for County[3]

1 = County Growth Management 1980 and 1988 Index Sheets available- Flight Agency: ASCS

2 = Some infrared aerials are available, from Growth Management, but dates are not known.

3 = Contact: Martha Downing, second floor, Volusia County Growth Management, (904) 736-5959, Deland.

4 = Contact Jason Ammons, Volusia County SCS, and Soil and Water Conservation District, (904) 822-5022. Black & White Blueline reproduction in house.

TABLE 3-10

BREVARD COUNTY AERIAL PHOTOGRAPH AVAILABILITY

DATE	FILM	SCALE	REMARKS
1943	B & W	1" = 660'	USAAF[1]
1951	B & W	1" = 660'	USAF[1]
April, 1958	B & W	1" = 1320'	SCS[2]
April, 1958	B & W	1" = 400'	USAF[1]
1959	B & W	1" = 400'	USAF[1]
January 1963	B & W	1" = 1320'	SCS; (RPC-1M[2])
1963	B & W	1" = 2000'	USAF[1]
January 1965	B & W	1" = 1320'	SCS[2]
1967	B & W	1" = 2000'	USAF[1]
December, 1969	B & W	1" = 2000'	SCS[2]
1969	B & W	1" = 400'	USAF[1]
1973	B & W	1" = 2000'	Brevard County Soil Survey[2]
1983	B & W	1" = 1320'	SCS[2]
1984	Color IR	1" = 2000'	U.S. Forest Service[2]
1986	Color IR	1" = 2000'	FDER[4]
1989	Color IR	1" = 2000'	FDER[4]
1989 - 90	B & W	1" = 2000'	Redi Real Estate Maps[2]
1990	B & W	1" = 2000'	9"x 9" ($80), 20" x 20" ($80)[3]

1 = Contact Frank Skarvelis, Brevard County Maps & Reproduction, County Courthouse, Building D (407) 633-2174

2 = Contact David Millard, Brevard County Soil Survey, Cocoa (407) 632-0546

3 = Contact Charles Woodward or Dave, ACA Aerial Cartographics of America, 1722 West Oakridge Road, Orlando (407) 851-7880

4 = Contact Conrad White, Brevard County Office of Natural Resources Management

USAAF = U.S. Army Air Force (predecessor of U.S. Air Force)
USAF = U.S. Air Force
SCS = Soil Conservation Service
FDER = Florida Department of Environmental Regulation

TABLE 3-11

INDIAN RIVER COUNTY AERIAL PHOTOGRAPH AVAILABILITY

DATE	FILM	SCALE	REMARKS
1943	B & W	Unknown	SCS[1]
1944	B & W	Unknown	City of Vero[2]
1946	B & W	Unknown	SCS[1]
1951	B & W	Unknown	SCS[1]
1957	B & W	Unknown	SCS[1]
1958	B & W	Unknown	SCS[1]
1971	B & W	Unknown	SCS[1]
1976*	B & W	1" = 660'	ASCS[3]
1980*	B & W	1" = 660'	ASCS[3]
1984	B & W, Color IR	1" = 1000'	ASCS[3]
1984	B & W	Unknown	SCS[1]
1987	B & W	Unknown	SCS[1]
1992	B & W	Unknown	SCS[1]

1 = Contact Clare Nickels or Jim Carl (407) 770-5005 or 562-1923

2 = Miscellaneous Aerials flown for the city. Source unknown. Contact Jeff Maasch, Property Appraisers Office, I.R. Co. Admin. Bldg., 1840 25th Street (old hospital), first floor, (407) 567-8000 ext. 373

3 = Contact Janita Norwood, St. Lucie County, ASCS, (407) 464-2074

* = Also available for Martin and St. Lucie Counties
SCS = Soil Conservation Service
ASCS = Agricultural Stabilization and Conservation Service

TABLE 3-12

ST. LUCIE COUNTY AERIAL PHOTOGRAPH AVAILABILITY

DATE	FILM	SCALE	REMARKS
1944	B & W	Unknown	ASCS[2]
1952	B & W	Unknown	ASCS[2]
1958	B & W	Unknown	ASCS[2]
1976[1]	B & W	Unknown	ASCS[3]
1980[1]	B & W	1" = 660	ASCS[3]
1984[1]	B & W	1" = 1000'	ASCS[3]

1 = Also available for Martin and Indian River Counties

2 = Contact: Donna Smith, USDA-SCS assigned to Indian River Lagoon NEP, (407) 461-4546. These photos and indexes may not be complete.

3 = Contact: Janita Norwood, St. Lucie County, ASCS, (407) 464-2074 (same building as D. Smith)

TABLE 3-13

MARTIN COUNTY AERIAL PHOTOGRAPH AVAILABILITY

DATE	FILM	SCALE	REMARKS
1940[4]	B & W	1" = 1000' - 2000'	SCS[1]
1952[4]	B & W	1" = 1000' -2000'	SCS[1]
1958[4]	B & W	1" = 1000' - 2000'	SCS[1]
1972[4]	B & W	1" = 1000' - 2000'	SCS[1]
1980[4]	B & W	1" = 1000' - 2000'	SCS[1]
1980[3,4]	B & W	1" = 660'	ASCS[2]
1984[3,4]	B & W	1" = 1000'	ASCS[2]
1984[4]	Color IR	1" = 1000' - 2000'	SCS[1]
1991[4]	Color IR	1" = 1000' - 2000'	SCS[1]

1 = Contact Jim Freeman, Martin County SCS, County Adminstration Building, 3rd Floor, Stuart, (407) 221-1303

2 = Contact Janita Norwood, St. Lucie County, ASCS, Ft. Pierce, (407) 464-2074

3 = Also available for St. Lucie and Indian River Counties

4 = Also covers Palm Beach County portion of the Indian River Lagoon

SCS = Soil Conservation Service
ASCS = Agricultural Stabilization and Conservation Service

A final local source is the regional planning councils. The Treasure Coast Regional Planning Council in Stuart and the East Central Florida Regional Planning Council in Winter Park also have some aerial photographic coverage of their respective regions which include the Lagoon area.

4.0 APPLICABILITY OF IMAGE TYPES TO HISTORICAL TRENDS ANALYSIS

4.1 SUITABILITY AND LIMITATIONS OF FILM TYPES FOR SAV MAPPING

Black and white, color, and color IR imagery have been used in this study and others to interpret and map submerged aquatic vegetation. All film types have been found suitable for this purpose, although some limitations exist for each.

Down (1978) found color IR to be superior to true color imagery in differentiating submerged objects such as grass beds and capable of revealing features to depths of 10 ft. Virnstein (1993) stated that there did not appear to be much effective difference between film types in distinguishing SAV beds. Fletcher (1993) feels that the use of backlit transparencies as opposed to paper prints is more important than the type of film image.

Thompson (1976) first mentioned the difficulties of distinguishing SAV beds in the presence of drift algae. In the Indian River, drift (unattached, free-floating) algae and seagrasses often occur in the same area. Distinguishing drift algae from seagrass beds was found to be difficult in this study, especially in water depths greater than 2 ft 0.7 m. Problems increase with increasing depth. The major resultant problems in bed definition are the inability to accurately locate the outer edge of seagrasses in mixed grass/algae beds and difficulty in distinguishing between grasses and algae. This is especially true in water deeper than about 4 ft.

White (1986) and Virnstein and Cairns (1986) found it impossible to distinguish between seagrasses and benthic algae on aerial photographs. Fletcher (1993) was able to differentiate some differences in the signature of predominately benthic algal beds and seagrass beds on color IR photos but not on black and white photos. Seagrass beds in general had a more diffuse black signature with less distinct edges than algae beds. However, both Fletcher (1993) and Virnstein (1993) state that the difference between predominately *Caulerpa* algal beds and *Halophila* or *Halodule* seagrass beds is largely indistinguishable. The extent and density of seagrasses is also undeterminable on aerial photographs in mixed beds of algae and seagrasses.

Accurate delineation from aerial photographs of seagrasses is possible to depths of 3 ft to 6 ft in the Indian River Lagoon system. The limiting depth varies with location and is a function of water clarity and color, bottom type and color, and SAV density and type. Depth of delineation may be limited to less than 2 ft in some mud bottomed areas around creeks and marshes. The combination of dark bottoms and turbid or colored water due to suspension of organic materials causes this effect.

Areas in which light penetration or bottom factors complicate SAV bed interpretation in the Indian River Lagoon system (Down, 1978; White, 1986; Fletcher, 1993) include the following:

- Deep edge of SAV beds in the Indian River north of Titusville, due to a combination of depth, abundant algae, and highly colored water

- Banana River and Indian River between Titusville and Pineda Causeway, due to presence of large amounts of drift and attached algae

- Areas around marsh islands in Mosquito Lagoon south of New Smyrna Beach, in the Vero Narrows near Vero Beach, around Jack Island north of Ft. Pierce Inlet, and in Great Pocket south of St. Lucie Inlet, possibly due to darker bottom material and suspended particles in the water column

- Pecks Lake to Jupiter Inlet area of Indian River Lagoon, due to colored water and water depth

Virnstein and Cairns (1986) also point out a fundamental difficulty in using aerial photographs for SAV mapping in the Indian River Lagoon. Because of the naturally high color and suspended/dissolved solids content of the Lagoon, it is critical that photographs be taken during periods of greatest water clarity. For the Indian River, this occurs in winter and early spring when the seagrass beds are at their lowest density. Poorest photographic penetration due to atmospheric conditions and lower water clarity probably occurs in late summer (when seagrass density is greatest). Thus summer photos will have poor differentiation of beds and winter photos will not show the peak density of seagrasses. Deeper beds and sparse beds may not be apparent in either case. This observation is supported by use of October 1940 and January 1944 black and white photographs which showed substantially less seagrass detail than the spring photographs of the corresponding year. Where possible, photographic imagery from the February to May period should be used for seagrass mapping, with the understanding that deeper beds may be missed and that peak density will be greater than that shown in the photos.

The extent to which submerged features are apparent is a function of glare, reflection, and darkened images of the photographs, as well as water clarity. Waves or boat wakes that disrupt a horizontal water surface also contribute to this problem. Down (1978) recommended that a 60 per cent imagery side overlap between adjacent flightlines should be used to ensure that all areas are covered. Side overlap was found in the current study to be important in overcoming the problems of glare and dark areas on photos. In many cases, areas which were unusable on one photo had good bed definition on an overlapping photo where light angles were slightly different. In older data sets where overlap was minimal or adjacent photos were missing, several sections of the Lagoon could not be accurately interpreted. The lack of sufficient overlap is a problem that is most critical in deeper water bodies where good depth penetration is needed. Therefore, when photography is selected or specified for SAV mapping, a high degree of imagery side overlap is recommended. Any location should be visible on at least three separate images and should occur in the center and near the edge of at least one image, respectively.

Boat wakes were found to pose problems for interpretation of SAV beds, particularly in narrow portions of the Lagoon. In addition, resuspension of sediments by boats also may decrease water clarity and resulting interpretational quality of the photographs. High boat traffic in the narrow portions near Vero Beach and in the Hobe and Jupiter Narrows were found to compromise interpretation quality of the 1992 color IR photos. As boating activity increases in the Indian River Lagoon system, it will become more important to consider periods of high boat traffic in selecting times for photography.

4.2 EVALUATION OF AREAL COVERAGE BY TIME PERIOD

Locally available sources of aerial photographs in each county were contacted by phone or letter, and photographs were examined in this project to determine applicability and quality of the historical imagery database as well as the extent of coverage of the Lagoon for wetland and SAV mapping uses. The extent and quality of locally available coverage for several periods is summarized in this section.

4.2.1 Pre 1951

No vertical aerial photographic coverage has been identified prior to 1940 through either the APSRS system or from local sources. Some low altitude oblique aerial coverage may exist, but documentation of time period is difficult. The St. Lucie County Historical Museum has a good oblique aerial photo of the Ft. Pierce Inlet and waterfront area from the 1920s.

Black and white coverage is available for most of the Lagoon and watershed from the 1940s. Most of the photo coverage is available for inspection locally at either SCS or county offices as shown in Tables 3-9 to 3-13. Years of coverage are 1943 for Volusia and Brevard Counties, 1943, 1944, and 1946 for Indian River County, 1944 for St. Lucie County, and 1940 for Martin County. The Palm Beach County portion of the Indian River is covered in the Martin County photo set.

All portions of the Indian River Lagoon are covered within the 1940 to 1950 period in the locally available photos with the following exceptions:

- The center of the wide portions of the Indian River Lagoon north of Titusville and between NASA Causeway (SR 405) and Brewer Causeway (SR 406)

- The central portion of Indian River County from south of Vero Beach to the City of Sebastian (scattered coverage of portions is available at the Property Appraisers Office)

- The portion of St. Lucie County from St. Lucie Inlet to about Joe's Cove north of Highway A1A, Stuart Causeway

All pre-1951 photos were produced by the U.S. Army Air Force or SCS and are generally of good quality. The 1943 aerials cover periods in April and May, but coverage of the 1940 and 1944 photos ranges between October and February. Thus these photos were taken when SAV beds were at their minimum densities and these photos are of limited use in differentiating SAV beds, particularly in deeper areas. The Ft. Pierce area was the subject of extensive dredging and other activities during the period of coverage. Extensive sediment plumes and suspended solids in these photos limit the utility of the photo set in this area. High color also limited light penetration into deeper areas in north Indian River.

In addition to these sources, the Jacksonville COE also has some coverage from the Intracoastal Waterway East Coast Project completed in 1947 (Fales, 1993).

4.2.2 1951 To 1960

Black and white photographic coverage is available for all counties within two time frames, 1951-52 and 1957-58. Coverage appears to be complete for both periods with the limitations in the deeper mid-channel areas of the northern Indian River as noted for the 1940s coverage. Brevard County is not covered in one single photo set for the 1957-59 period, but coverage can be obtained by combining sets from successive years. Most photos from the 1950s were produced by SCS or ASCS and are of good quality from April and May.

The 1951-52 aerial photos appear to be of better clarity and resolution than the later photos, but both sets are useful for SAV and wetlands mapping. Scale presents a problem for easy use of the Brevard County photographs for both the 1940s and 1950s periods. The large scale of the photographs means that many frames have to be examined to cover the area. Maps produced on overlays of these maps are very large and cumbersome to use or convert to smaller scales. Landmarks are also more difficult to locate on these maps. Thus the time required to use these photographs is much greater than for the smaller scale photographs.

4.2.3 1961 To 1970

Coverage during the 1960s available from local sources is less complete and more variable than that from the 1950s. All coverage is again in black and white. Volusia County is represented by 1963 and 1967 and Brevard County by 1963 (two different sets), 1965, 1967, and 1969 (two different sets). However, local coverage is not available for other counties. The 1965 photo set for Brevard County is variable in quality and contains significant gaps in coverage, while the 1963 coverage is in very poor physical condition.

Other sources of imagery are available for the 1960s period however. FDOT in Tallahassee has black and white coverage for all counties except Brevard within the 1966-1969 period and the COE has some coverage of the St. Lucie Canal (Tables 3-8 and 3-9).

This period marks the first availability of color photographs and of IR photographs. The APSRS search results identified several data sets for each county (Tables 3-1 to 3-6). Local sources are not available, but prints can be ordered through the NCIC. These photos are the outputs of the NHAP or are from small, project specific areas.

4.2.4 1971 To 1980

Coverage is generally complete throughout the region for this period, although there is no single year available locally in which all counties are represented. Color coverage is available locally only in Volusia County, although color and IR coverage of portions of all counties are available through NCIC. Volusia County also has the most complete temporal coverage with all years represented except 1974, 1976, 1977, and 1979. Other counties are represented for only one or two years.

The COE Jacksonville District Office has black and white cover for the entire region and scattered color coverage. The St. Johns River Water Management District has color IR prints at a scale of 1" = 5000' covering the District for the 1972-74 period (Kinser, 1993). Color and black and white aerial photos and transparencies for the Indian River from the southern tip of Merritt Island to St. Lucie Inlet at a scale of 1" = 2000' were produced by Harbor Branch Foundation in April, 1976 (Thompson, 1976). These are currently stored at the Harbor Branch Oceanographic Institute library (Metzger, 1993).

4.2.5 1981 TO 1990

Black and white and color IR photos are available locally within this period for all counties through county agencies, county SCS/ASCS offices, or the regional planning councils.

Color photos are also available for most counties. Coverage is generally complete and quality of photos is good. All counties have 1984 coverage in either black and white or color IR.

Aerial photography specifically intended for SAV mapping and similar uses was first produced in 1985 and 1986. A primary advantage of these photos was production of transparency images as well as paper prints. Color and color IR photography was obtained in March, 1985 for portions of Indian River and Banana River by the Brevard County Office of Natural Resources Management and NASA Environmental Operations and Research Laboratory at KSC (White, 1986). True color transparencies were obtained in April, 1986 for St Johns River Water Management District (SJRWMD) for the area from St. Lucie Inlet to Sebastian Inlet (Virnstein and Cairns, 1986). Similar imagery was obtained in 1989 from St. Lucie Inlet to the north end of the Indian River Lagoon by SJRWMD and SFWMD (Virnstein, 1993). Black and white coverage of the entire Lagoon is also available for 1980-81 and 1984-85 at COE in Jacksonville. However, the small scale (1:96,000) limits applicability for SAV or detailed wetlands mapping.

Quality of both black and white and color IR photos is good throughout the region. Color IR photos have somewhat limited penetration, particularly in highly colored waters. Differentiation of seagrass beds on darker prints with high color saturation is particularly difficult. This limits effectiveness, particularly on prints. As a result, the 1984 color IR photos are limited in value for defining seagrass beds in the Indian River between St. Lucie Inlet and Jupiter Inlet (Pecks Lake, Hobe Sound, Jupiter Narrows) and in deeper portions of the northern Indian River north of Titusville.

4.2.6 Post-1990

Recent (1991-1993) imagery is locally available for all counties except St. Lucie. Coverage is black and white except in Martin County where color IR was used. True color is also available for Volusia County. SJRWMD produced color IR imagery of the entire Indian River Lagoon system from Ponce Inlet to Jupiter Inlet in February, 1992. Because it was produced in transparency form as well as paper print form, this set of aerials is extremely useful for both SAV and wetlands mapping.

5.0 EVALUATION OF SAV COVERAGE

5.1 REVIEW OF SAV MAPPING STUDIES

The first large-scale SAV mapping studies within the Indian River Lagoon system were performed by Thompson (1976) and Down (1978) . Down's study for the Brevard County Health Department covered the Banana River south of the Bennett Causeway (SR 528), the Brevard County portion of Mosquito Lagoon, the Indian River north of the NASA railroad bridge at Titusville, and Indian River from Melbourne to Sebastian Inlet. Thompson's study at Harbor Branch Foundation covered the Indian River from the southern end of Merritt Island to St. Lucie Inlet.

Down's study mapped only submerged vegetated areas and dredged areas. Comments in the text of her report identify dominant species of seagrass and algae, as well as other water chemistry and physical features. Thompson's study mapped only presence of seagrass beds. However, it also showed sampling station locations and data on percent vegetation cover and relative abundance of seagrass species and attached algae.

The Indian River Lagoon and Banana River from St. Lucie Inlet to the north end of Indian River was mapped in 1985 and 1986 as part of two studies. Indian River from Sebastian Inlet to St. Lucie Inlet was mapped by Virnstein and Cairns (1986) based on April 1986 true color transparencies. SAV beds in the Banana River and northern Indian River were mapped by White (1986) based on true color transparencies. The data from these two studies has been combined into a single coverage that has been included in the SJRWMD ArcInfo GIS system. These studies utilized a SAV classification system with four SAV density classes [i.e., <10 percent (%), 10-45%, 45-70%, and 70-100%], and an open water class. Species composition was not identified on a detailed site-specific basis in these studies, although ground-truthing data was collected which included this information.

At approximately the same time, the southern portion of Mosquito Lagoon and the northern portion of Banana River that fall within the federal property limits of KSC, Merritt Island National Wildlife Refuge (MINWR), and Canaveral National Seashore were mapped by Jane

Provancha at Bionetics Corp. This study used a classification scheme similar to that of White, Virnstein and Cairns. This material has been compiled into ArcInfo GIS form at Bionetics. Incorporation of this data into the 1986 seagrass layer on the SJRWMD GIS system is planned, but has not yet occurred.

Seagrasses were again mapped in the Banana River and Indian River north of St. Lucie Inlet by Virnstein in 1989, based on color IR photography obtained by SJRWMD. This updated the 1986 seagrass maps and included ground-truthing along transects. Methods and classification scheme were identical to those used in 1986.

Seagrasses were again mapped by Fletcher (Natural Systems Analysts, 1993) based on February, 1992 color IR transparencies. This study, produced under the SJRWMD SWIM program, was the first to cover the entire Indian River Lagoon system (including Mosquito Lagoon, Banana River, and Hobe Sound) from Ponce Inlet to Jupiter Inlet. The classification scheme was modified to provide additional information including dredged areas and subtidal and intertidal spoil or sand bar areas potentially suitable for seagrass colonization. A new category was also added for beds of the attached algae *Caulerpa prolifera* since this species was found in great abundance in the 1986 surveys. The four categories of seagrass density were reduced to two classes (sparse - $<40\%$; dense - $\geq 40\%$). Seagrasses within the Merritt Island National Wildlife Refuge (MINWR) were also remapped in 1993 by Provancha (1993), maintaining the four density classes used in 1986. The 1986 through 1992 studies utilized per cent cover templates for interpretation of density classes based on Braun-Blanquet (1965). All of these studies utilized some degree of ground-truthing, allowing an accuracy check on the mapping. A comparison of maps based on four and two SAV density classes indicated that use of four classes provided much more information on SAV density and overall condition. Although it appears that the photo-interpretation effort is similar for both cases, digitization of four classes into GIS form is much more time consuming.

Haddad and Harris (1985) and Haddad and Hoffman (1988) undertook a comparison of seagrass occurrence in different periods in several portions of the Indian River system. This study utilized imagery from prior years and thus could not be ground-truthed. LANDSAT MSS and thematic mapper (TM) satellite imagery was used for the first time on the Indian River Lagoon in this study in an attempt to classify seagrasses and intertidal wetlands.

Haddad and Harris (1985) found that 1982 satellite imagery was both useful and cost-effective in mapping emergent and intertidal wetlands such as mangrove swamp, salt marsh, and mudflats. Mapping of these communities from the LANDSAT TM data was about three times as efficient (based on hours of effort) as manual interpretation of aerial photography. However, Haddad and Harris (1985) found that the satellite imagery was unsuitable for delineating submerged seagrass beds due to turbidity of the water. Color IR photography (1984) had to be used to supplement satellite imagery.

The Haddad and Harris (1985) study evaluated seagrass and mangrove community extent from Satellite Beach at the southern tip of Merritt Island to St. Lucie Inlet based on 1982/84 imagery. They found that seagrasses covered 8.3% (6,859 ac) of the submerged bottom in this section, while mangroves covered 7,899 ac. They also compared seagrass and mangrove coverage for a 8.7 mi stretch between Ft. Pierce and Vero beach between 1958 and 1984, based on black and white aerial photographs. Their study indicated that a loss of 27% of the mangroves had occurred during this period, due primarily to development of the land.

During the same period, they found that a 25% loss of seagrasses had occurred, with almost half (11%) of the loss occurring between 1970 and 1984. They also made an evaluation of seagrass and salt marsh changes between 1943 and 1984 in a 6.8 mi portion of the Mosquito Lagoon/Halifax River complex centered on Ponce Inlet. This analysis indicated a loss of the entire 74 ac of seagrasses in this area during this period. Salt marsh habitat decreased from an estimated 5,234 ac prior to dredging of the Intracoastal Waterway in 1943 to 4,742 ac in 1943 and to 3,883 ac in 1984.

6.0
HISTORICAL SEAGRASS TRENDS

6.1 OBJECTIVES

The primary objective of this section of the report is to evaluate the existing information on the status of seagrass and other SAV communities in the Indian River Lagoon system based on mapping studies and readily available historical imagery. Information from the studies described in Section 5.1 is reviewed and compared on a lagoon-wide basis to assess changes in SAV coverage over time. Such information is important in characterizing changes in habitat that have occurred in the Lagoon and adjacent watershed. Such an analysis helps to identify not only the overall extent of change, but also specific areas in which the greatest changes have occurred. Since the status of seagrasses has been described by the SAVI Program as an indicator of the overall health of the Lagoon (Morris and Tomasko, 1993), this information is important for determining which areas have been most impacted, which areas are still in a healthy condition, and which areas may be in a transition state meriting rapid responses. This knowledge will help decision makers determine priorities and options for implementing management and restoration practices to best protect the Lagoon.

Additional SAV mapping based on readily available historical imagery and unpublished data has also been used to demonstrate changes over time since the 1940s period in selected portions of the Indian River Lagoon system. These figures also provide a first step in developing an inventory of historical distribution of seagrasses within the Lagoon.

Seagrass cover in relation to the maximum depth of occurrence is also evaluated to assess if trends in depth of growth have occurred. This approach is based on the premise that light intensity within the water column is a primary factor affecting the distribution and vigor of seagrass beds. Changes in light intensity thus will be reflected in changes in the maximum depth at which seagrasses will occur. Factors affecting light penetration and intensity in the water column, described in the "Biological Resources Technical Report" and the "Water Quality and Loadings Assessment Technical Report", are directly related to the quality of water within the Lagoon and which enters the Lagoon through wastewater releases, and stormwater runoff. The assessment in this report is intended to give a preliminary indication whether changes have been occurring and if so, what areas may be most affected.

6.2 METHODS

6.2.1 Seagrass Distribution and Abundance

SAV abundance was calculated for the 1992, 1984-86, and 1970-74 periods based on existing SAV maps, supplemented by additional photointerpretation to fill in missing areas. The 1992 SAV distribution, described above as Natural Systems Analysts (1993), was computed using ArcInfo for the 1992 GIS seagrass layer on the Natural Systems Analysts computer system. The 1992 maps utilize the shoreline basemap layer developed from USGS topographic quadrangle maps by SJRWMD. This is the same basemap used for the 1986 seagrass map layer.

SAV abundance for 1986 was computed in the same manner, using the GIS database layer supplied by SJRWMD, which was based on the work of White (1986) and Virnstein and Cairns (1986). Although the 1986 database from SJRWMD was the most recent GIS layer available, it did not include coverage of Mosquito Lagoon or Indian River south of St. Lucie Inlet. These areas were mapped in this study using photointerpretation of 1984 color IR photographs at the Volusia County Growth Management Department, Brevard County Engineering Department Maps and Reproduction Office, and Martin County SCS offices. The data from the southern end of Mosquito Lagoon was based on unpublished seagrass maps provided by White (1993). All data was transferred to the Natural Systems Analysts GIS database. The classification categories were identical to those used in the original 1986 mapping performed by White (1986) and Virnstein and Cairns (1986).

SAV acreage determination for the 1970s period utilized the seagrass maps of Thompson (1976) and unpublished maps of 1974 distribution in Brevard County. The Brevard County maps were produced by Conrad White at the Brevard County Department of Natural Resources Management. Original maps of seagrass distribution in Volusia County, and south of St. Lucie Inlet were prepared as part of the characterization study. This mapping used 1973 black and white and true color aerial photographs at the Volusia County Growth Management Department, and 1972 black and white aerial photos at the Martin County SCS offices. Acreage calculations were calculated using a compensating polar planimeter on original map drawings and on the maps provided in Thompson's 1976 report. Maps were adjusted xerographically to a scale of 1" = 2,000' prior to acreage calculations.

Some of the 1970s maps utilized different scales and basemaps than the 1986 and 1992 map sets. Thus the total acreage of the water bodies and seagrasses differed. To provide an estimate of changes in percent cover of seagrasses, the total Lagoon water surface area from the 1992 basemaps was used as a standard for all time periods. Total water body area was calculated for each period and adjusted to match the 1992 total. Acreage of SAV beds was adjusted by a comparable amount.

The Indian River Lagoon system was divided into 56 discrete sections or subsegments and acreage was calculated for each section. Figure 1-3 shows the approximate locations of subsegment boundaries. The sections have been grouped within the six segments that have been used for partitioning the Lagoon for the Characterization analysis.

6.2.2 Seagrass Depth Distribution

Analysis of the vertical or depth distribution of seagrasses and utilization of available habitat was performed on the subsegment level. In this analysis, seagrass maps were compared to existing bathymetric maps of the Lagoon. The bathymetric data sources were NOAA Nautical Charts 11484 (11th ed., Oct.1991) and 11484 (27th ed., Aug., 1992). In the northern part of Indian River Lagoon, these were supplemented by data from Arnold (1993).

A water depth of 6 ft has been used as an approximate maximum depth for seagrass bed development in estuaries. This depth has also been used to define the potentially available habitat for seagrasses in estuarine water of good clarity. Estuarine management programs for Chesapeake Bay (Orth, 1993a; 1993b) and Tampa Bay (Ries, 1993) have used this depth to develop targets for re-establishment of seagrass habitats. In order to provide an approximation of the extent to which this potential habitat is currently utilized and has been historically utilized, the total acreage of water depth (mean low water) less than 6 ft has been calculated for each subsegment based on planimetry of the bathymetric maps. Total SAV acreage has been expressed as a percentage of this potential habitat area.

Further assessment of the depth distribution of SAV has been performed based on evaluation of the mean low water depth at which the outer edge of mapped beds occurs. In each subsegment, the approximate maximum depth of the outer edge of beds was determined based on depths shown in the bathymetric maps. The primary analysis was based on the edges of discrete beds which were defined for this purpose as having coverage greater than 40%. This corresponds to the two higher cover classes on the 1986 maps and the "dense" category on the 1992 maps.

SAV cover in selected areas for time periods prior to 1970 was also analyzed for bed depth to further define trends. This analysis utilized data from the above sources as well as unpublished data supplied by White (1993) for the years 1958, 1965, and 1974 and data developed in the course of this study for 1943 and 1958.

6.3 TRENDS IN SAV ABUNDANCE

Table 6-1 shows the estimated acreage of SAV by subsegment for the periods 1992, 1984-86, and 1970-74. Figure 6-1 shows the changes in abundance for each of the six segments during this period. This figure provides a good summary of the distribution of seagrasses throughout the Lagoon system. Approximately 70% of the total seagrass acreage occurs north of a line drawn from Cocoa to Cocoa Beach in Segments 1A, 1B, and 1C. (Figures 1-2 and 6-1), which include Mosquito Lagoon, Banana River, and north Indian River. Less than 10% of the total acreage occurs in Segments 2 and 3 between Ft. Pierce and Sebastian Inlets.

Figure 6-2 shows trends in total acreage within each segment of the Indian River Lagoon system. Similar geographical patterns of SAV cover occur for each of the time periods studied. In Mosquito Lagoon and Banana River, the larger concentrations of beds are in the less developed subsegments within the Merritt Island National Wildlife Refuge (MINWR) and Kennedy Space Center (KSC) at the north end of Banana River and the south end of Mosquito Lagoon. In the Indian River, abundant seagrass beds occur north of Titusville (Subsegments I1 to I4), near Sebastian Inlet (I16 to I18), near Link Port (I23 to I25), and from Ft. Pierce to St. Lucie inlets.

TABLE 6-1

SAV COVER (ACRES) THROUGHOUT INDIAN RIVER LAGOON COMPLEX BETWEEN 1970 AND 1992

SAV COVER (ACRES) 1973 TO 1992					
SEGMENT	SECTION	1970s TOTAL SAV	1986 TOTAL SAV	1992 TOTAL SAV	TOTAL BOTTOM AREA
1A - Mosquito Lagoon	M1	0.00	0.01	7.36	991.75
	M2	0.92	4.99	93.89	336.27
	M3	56.93	17.80	251.23	1,271.15
	M4	311.31	397.74	1,514.36	2,842.67
	M5	2,344.35	1,430.10	2,531.42	4,253.55
	M6	2,651.06	1,502.85	2,259.06	5,729.80
	M7	2,853.08	3,554.07	4,379.08	7,191.21
	M8	2,204.36	2,297.66	2,538.93	4,782.11
	M9	3,160.81	3,208.71	3,124.08	5,732.78
	Total	**13,582.82**	**12,413.92**	**16,699.41**	**33,131.29**
1B - Banana River	B1	2,304.10	2,711.37	2,831.68	5,960.73
	B2	6,840.80	8,295.16	7,095.77	14,221.88
	B3	4,291.15	1,725.26	3,030.40	6,294.90
	B4	4,913.24	2,036.55	3,541.56	6,211.62
	B5	1,835.18	1,124.90	2,188.35	9,592.62
	B6	1,033.02	207.72	212.14	1,980.34
	B7	1,150.74	527.21	2,576.33	2,697.25
	Total	**22,368.23**	**16,628.17**	**21,476.23**	**46,959.34**
1A - North Indian River	I1	13,706.09	14,692.42	6,878.51	16,961.73
	I2	3,576.34	3,628.78	2,050.73	4,417.14
	I3	652.95	1,255.70	699.77	2,257.92
	I4	5,305.50	10,349.22	5,108.92	17,152.42
	I5	2,949.90	1,991.85	1,010.73	7,546.23
	I6	2,522.27	1,384.29	567.56	5,860.31
	I7	821.84	518.50	401.56	2,724.07
	I8	311.85	166.94	215.82	3,334.31

TABLE 6-1

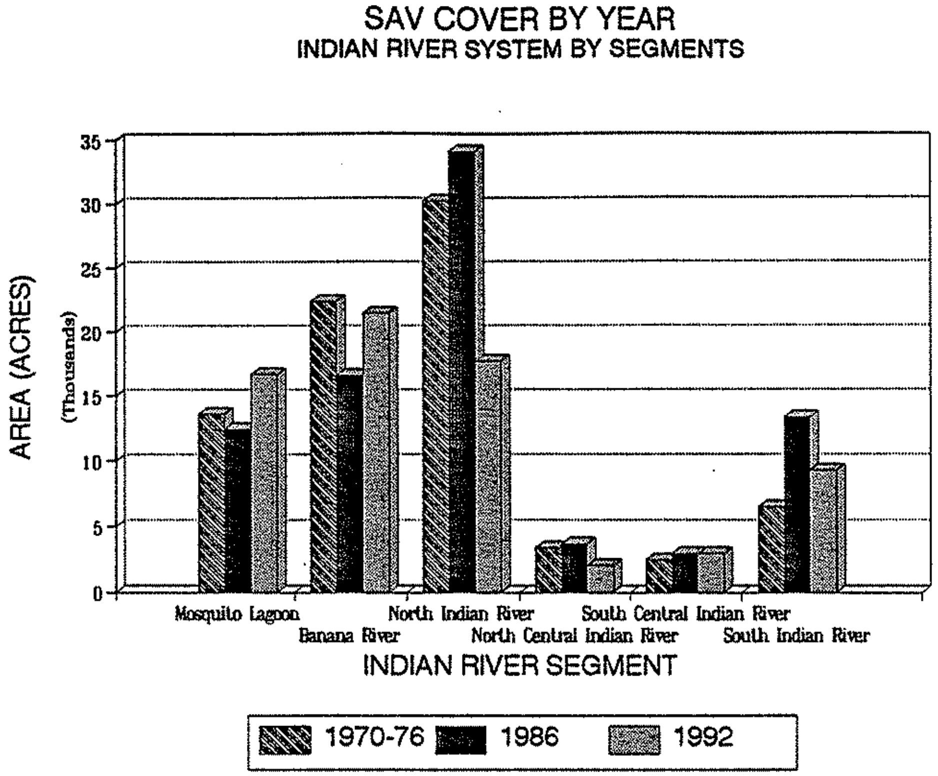
SAV COVER (ACRES) THROUGHOUT INDIAN RIVER LAGOON COMPLEX BETWEEN 1970 AND 1992, Continued

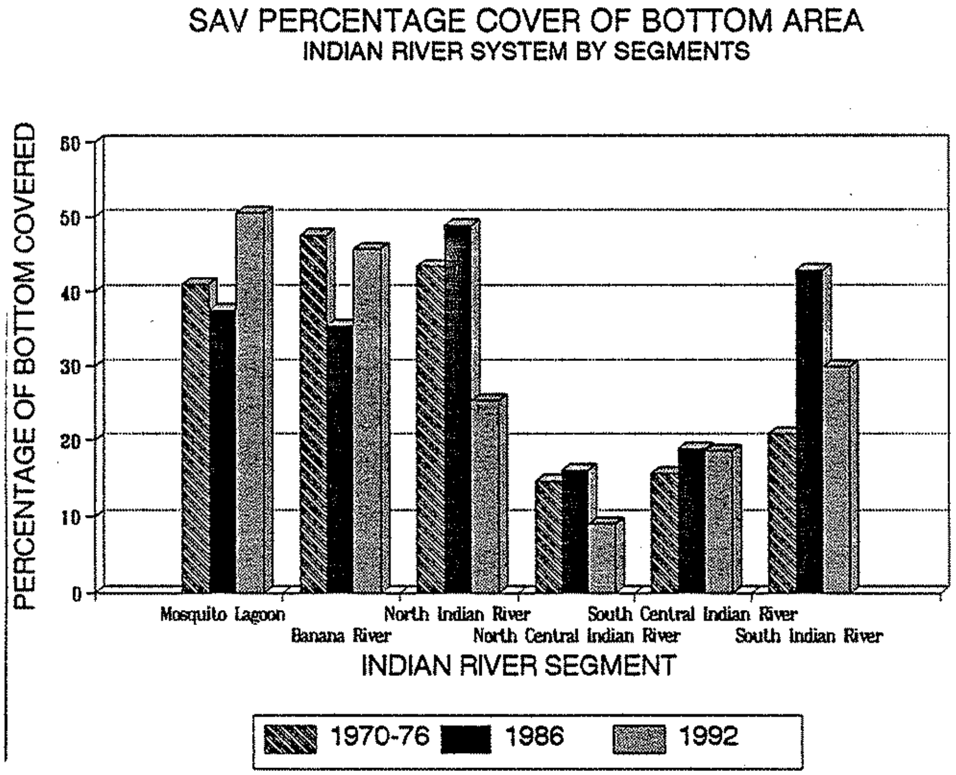
SAV COVER (ACRES) 1973 TO 1992					
SEGMENT	**SECTION**	**1970s TOTAL SAV**	**1986 TOTAL SAV**	**1992 TOTAL SAV**	**TOTAL BOTTOM AREA**
1A - North Indian River, Continued	I9	244.41	114.93	598.50	4,613.83
	I10	147.89	7.37	156.92	4,885.22
	Total	**30,239.03**	**34,110.00**	**17,689.02**	**69,753.18**
2 - North Central Indian River	I11	304.41	240.54	49.86	4,088.34
	I12	611.35	258.48	89.36	5,004.95
	I13	547.61	537.70	344.98	4,765.42
	I14	541.25	401.16	175.75	2,670.72
	I15	218.59	221.08	222.53	823.40
	I16	1,166.57	2,060.26	1,208.64	5,948.78
	Total	**3,389.77**	**3,719.23**	**2,091.12**	**23,301.61**
3 - South Central Indian River	I17	660.57	842.16	669.40	4,580.83
	I18	328.70	430.30	511.38	1,587.79
	I19A	70.46	98.93	100.18	834.01
	I19BC	323.79	529.72	419.49	2,479.55
	I20	76.69	162.00	191.78	1,089.68
	I21	102.05	52.57	97.68	1,192.86
	I22	166.24	89.32	79.31	1,422.14
	I23	731.21	772.12	864.62	2,606.71
	Total	**2,459.71**	**2,977.11**	**2,933.84**	**15,793.57**
4 - South Indian River	I24	261.24	401.12	439.14	936.30
	I25	1,121.51	2,222.84	1,683.01	3,703.01
	I26	277.45	359.69	292.10	928.56
	I27	175.64	226.30	202.05	671.83
	I28	985.19	2,691.19	1,577.80	4,285.16
	I29	1,234.93	2,205.39	2,101.41	5,052.18
	I30	547.58	1,370.15	391.12	4,019.22

TABLE 6-1

SAV COVER (ACRES) THROUGHOUT INDIAN RIVER LAGOON COMPLEX BETWEEN 1970 AND 1992, Continued

SAV COVER (ACRES) 1973 TO 1992					
SEGMENT	SECTION	1970s TOTAL SAV	1986 TOTAL SAV	1992 TOTAL SAV	TOTAL BOTTOM AREA
4 - South Indian River, Continued	I31	131.48	1,261.51	325.06	2,652.91
	I32	219.60	888.02	430.87	3,387.55
	I33	594.79	981.31	822.15	2,920.43
	I34	157.53	51.11	104.77	345.55
	I35	196.07	164.06	173.98	327.28
	I36	143.79	91.68	96.80	336.79
	I37	13.43	0.00	21.30	194.71
	I38	245.80	169.73	301.83	804.44
	I39	173.55	237.59	286.00	404.96
	I40	0.00	0.00	0.00	97.36
Total		**6,479.58**	**13,321.68**	**9,249.39**	**31,068.24**
Total Indian River		42,568.09	54,128.03	31,963.37	139,916.60
Total Mosquito Lagoon		13,582.82	12,413.92	16,699.41	33,131.29
Total Banana River		22,368.23	16,628.17	21,476.23	46,959.34
TOTAL SYSTEM		**78,519.13**	**83,170.11**	**70,139.01**	**220,007.23**

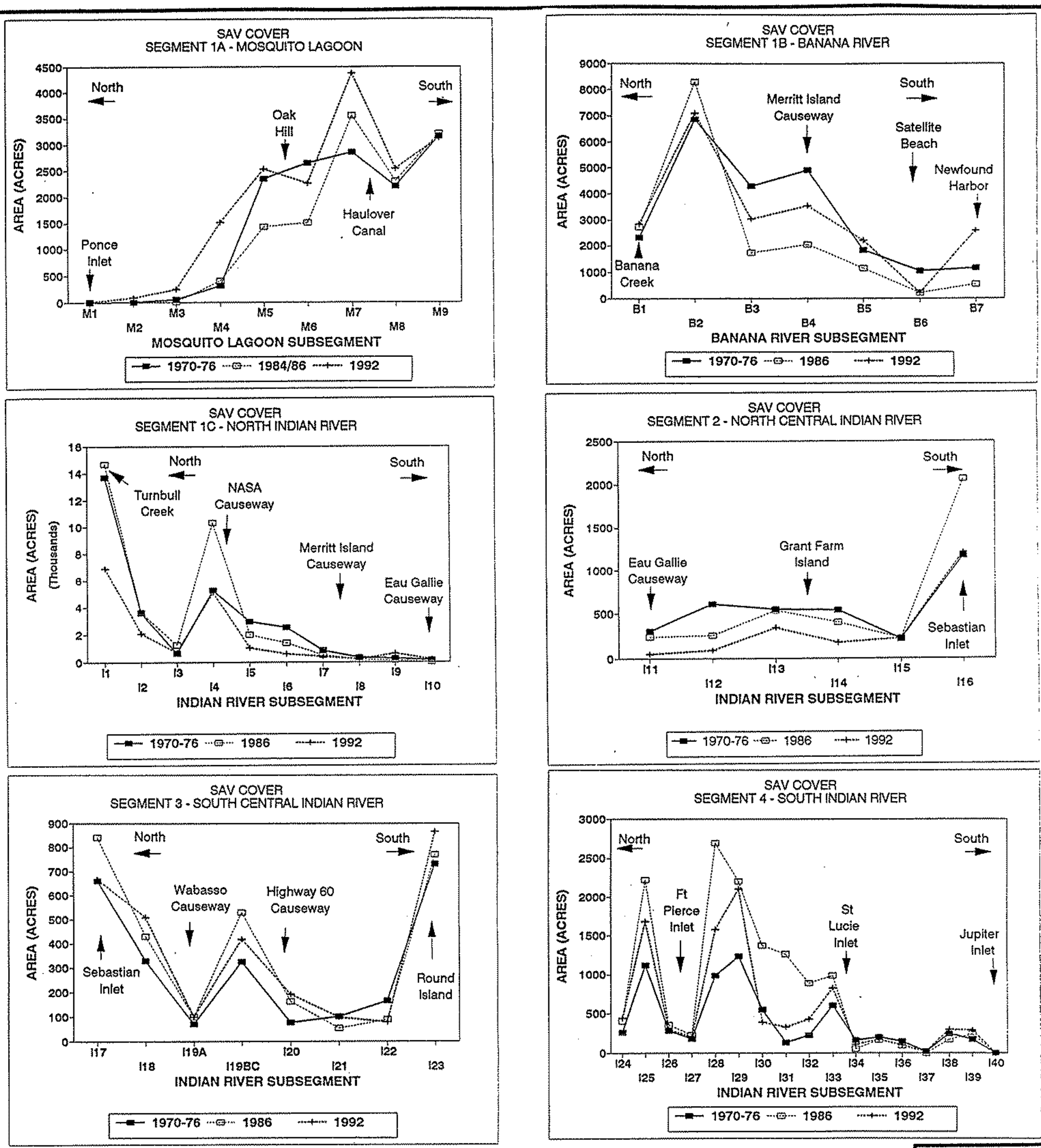




Sources: Thompson (1978), White (1983), NSA (1993), Fletcher (1993)

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-1 SAV DISTRIBUTION IN INDIAN RIVER LAGOON COMPLEX

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



Sources: Thompson, 1978; White, 1993; NSA, 1993

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

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FIGURE 6-2 SAV ABUNDANCE TRENDS WITHIN INDIAN RIVER LAGOON COMPLEX - 1970S TO 1992

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

6.4 SEAGRASS UTILIZATION OF AVAILABLE HABITAT

Awareness of the total acreage of SAV in each segment of the Lagoon system has important for management implications as it allows concentration of resources to protect the greatest amount of SAV beds. However, the absolute distribution of acreage is not indicative of how well SAV is adapting to conditions within any segment. To evaluate the health or success of seagrasses at various locations within the system, it is necessary to know the percentage of Lagoon bottom that is occupied by SAV.

It is even more important to know how much of the available or potential habitat is covered by SAV. For this assessment, the (6 ft) depth has been used as an approximation of potential seagrass habitat as defined by the SAVI (Morris and Tomasko, 1993). This is the approximate depth at which a sufficient amount of photosynthetically active radiation (PAR) exists at the bottom to support sustained photosynthesis in a healthy and vigorous SAV community. Table 6-2 shows the percentage of this "potential habitat" within each subsegment. This method provides a rough first approximation of potential habitat based only on water depth and an assumed average and constant light penetration factor. Differences in bottom types, light penetration, and other factors may influence available habitat and may limit the amount of acceptable good quality habitat even more.

The amount of potential cover reported in this section is based on approximate measurements of water depth and should be considered only as an approximation of the total potential habitat. Detailed and reliable bathymetry data does not currently exist for many parts of the Lagoon. The 6 ft depth also is only an approximation of the photosynthetically active zone. As described in the companion "Biological Resources" Technical Report, light penetration is influenced by many factors such as the water color, amount of suspended and dissolved solids, and the concentration of chlorophyll in the water column. These factors differ throughout the Lagoon such that light penetration also varies. Greater water clarity generally occurs nearest the inlets so the available habitat may be greater than estimated for these areas.

Other factors such as substrate type also may influence the ability of SAV to colonize areas of suitable depth. Many shallow areas in the tidal creeks have soft muddy bottoms which are not conducive to seagrass establishment. Thus the absolute degree to which habitat is

TABLE 6-2

POTENTIAL SEAGRASS HABITAT AS A PERCENTAGE OF TOTAL SUBMERGED BOTTOM AREA WITHIN EACH SEGMENT

TOTAL WATER AREA AND PAR AREA (0-1.8M DEPTH)					
			EXISTING CONDITION		
SEGMENT	SUBSEGMENT	LOCATION	TOTAL AREA (Acres)	DEPTH (Acres)	% OF TOTAL
1A - Mosquito Lagoon	M1	Ponce Inlet-New Smyrna Beach	991.8	395.2	39.8
	M2	New Smyrna Beach-Edgewater	336.3	197.9	58.8
	M3	Edgewater-Cedar Island	1271.2	453.7	35.7
	M4	Cedar Island-Eldora	2842.7	1440.9	50.7
	M5	Eldora-Oak Hill	4253.6	3240.3	76.2
	M6	Oak Hill-Bird Island	5729.8	5437.1	94.9
	M7	Bird Island-Haulover Canal	7191.2	6687.6	93.0
	M8	Haulover Canal-Turtlepen Point	4782.1	4756.8	99.5
	M9	Turtlepen Point-South End	5732.8	5711.3	99.6
		TOTAL	**33131.5**	**28320.7**	**85.5**
1B - Banana River	B1	Banana Creek-NASA Causeway	5960.7	4232.3	71.0
	B2	NASA Causeway-SR 528	14221.9	12861.2	90.4
	B3	SR 528-SR 520	6294.9	5567.2	88.4
	B4	SR 520-George Island	6211.6	5532.4	89.1
	B5	George Island-Pineda Causeway	9592.6	5271.6	55.0
	B6	Pineda Causeway-Indian River	1980.3	1533.3	77.4
	B7	Newfound Harbor	2697.3	2697.3	100.0
		TOTAL	**46959.3**	**37695.4**	**80.3**

TABLE 6-2

POTENTIAL SEAGRASS HABITAT AS PERCENTAGE OF TOTAL SUBMERGED BOTTOM AREA WITHIN EACH SEGMENT, Continued

TOTAL WATER AREA AND PAR AREA (0-1.8M DEPTH)					
			EXISTING CONDITION		
SEGMENT	SUBSEGMENT	LOCATION	TOTAL AREA (Acres)	DEPTH (Acres)	% OF TOTAL
1C - North Indian River	I1	Turnbull Creek-Black Point	16961.7	16767.3	98.9
	I2	Black Point-FEC Rail Bridge	4417.1	4246.9	96.1
	I3	FEC Rail Bridge-SR 402	2257.9	1569.7	69.5
	I4	SR 402-NASA Causeway	17152.4	12060.1	70.3
	I5	NASA Causeway-Jones Point	7546.2	4569.1	60.5
	I6	Jones Point-SR 528	5860.3	4530.3	77.3
	I7	SR 528-SR 520	2724.1	1700.5	62.4
	I8	SR 520-Riverview	3334.3	1423.9	42.7
	I9	Riverview-Pineda Causeway	4613.8	1620.8	35.1
	I10	Pineda Causeway-Eau Gallie Causeway	4885.2	2840.4	58.1
		TOTAL	**69753.2**	**51328.8**	**73.6**
2 - North Central Indian River	I11	Eau Gallie Causeway-Melbourne Causeway	4088.3	1933.3	47.3
	I12	Melbourne Causeway-Cape Malabar	5005.0	2424.4	48.4
	I13	Cape Malabar-Valkaria	4765.4	2754.9	57.8
	I14	Valkaria-Grants Farm Island	2670.7	2504.2	93.8
	I15	Grants Farm Iisland-Ballard Cove	823.4	779.5	94.7
	I16	Ballard Cove-Sebastian Inlet	5948.8	5465.6	91.9
		TOTAL	**23301.6**	**15862.0**	**68.1**

TABLE 6-2

POTENTIAL SEAGRASS HABITAT AS PERCENTAGE OF TOTAL SUBMERGED BOTTOM AREA WITHIN EACH SEGMENT, Continued

TOTAL WATER AREA AND PAR AREA (0-1.8M DEPTH)					
			EXISTING CONDITION		
SEGMENT	SUBSEGMENT	LOCATION	TOTAL AREA (Acres)	DEPTH (Acres)	% OF TOTAL
3 - South Central Indian River	I17	Sebastian Inlet-Green Point	4580.8	4311.7	94.1
	I18	Green Point-Mangrove Island	1587.8	1548.1	97.5
	I19A	Mangrove Island-Wabasso Causeway	834.0	803.6	96.4
	I19B	Wabasso Causeway-Grand Harbor	2479.6	2395.1	96.6
	I20	Grand Harbor-Highway 60	1089.7	994.3	91.2
	I21	Highway 60-Prang Island	1192.9	1035.5	86.8
	I22	Prang Island-Porpoise Point	1422.1	1380.2	97.1
	I23	Porpoise Point-Round Island	2606.7	2533.3	97.2
		TOTAL	**15793.6**	**15001.8**	**95.0**
4 - South Indian River, Continued	I24	Round Island-Link Port	936.3	908.6	97.0
	I25	Link Port-Ft Pierce North Causeway	3703.0	3513.6	94.9
	I26	Ft Pierce North Causeway-Ft. Pierce South	928.6	858.2	92.4
	I27	Ft Pierce South Causeway-Thumb Point South	671.8	655.3	97.5
	I28	Thumb Point South-Middle Point	4285.2	3700.9	86.4
	I29	Middle Point-FPL Plant	5052.2	4316.3	85.4
	I30	FPL Plant-Nettles Island	4019.2	3250.4	80.9
	I31	Nettles Island-SR 732	2652.9	2431.7	91.7
	I32	SR 732-A1A Causeway	3387.6	2951.1	87.1

TABLE 6-2

POTENTIAL SEAGRASS HABITAT AS PERCENTAGE OF TOTAL SUBMERGED BOTTOM AREA WITHIN EACH SEGMENT, Continued

TOTAL WATER AREA AND PAR AREA (0-1.8M DEPTH)					
			EXISTING CONDITION		
SEGMENT	SUBSEGMENT	LOCATION	TOTAL AREA (Acres)	DEPTH (Acres)	% OF TOTAL
4 - South Indian River, Continued	I33	A1A Causeway-St. Lucie Inlet	2920.4	2658.3	91.0
	I34	St. Lucie Inlet-Long Point	345.6	336.7	97.4
	I35	Long Point-Pecks Lake	327.3	295.7	90.4
	I36	Pecks Lake-Jupiter Narrows	336.8	288.2	85.6
	I37	Jupiter Narrows-Hobe Sound	194.7	140.9	72.4
	I38	Hobe Sound-Jupiter Sound	804.4	552.7	68.7
	I39	Jupiter Sound-Jupiter Inlet	405.0	274.5	67.8
	I40	Jupiter Inlet	97.4	48.2	49.5
		TOTAL	**31068.2**	**27181.3**	**87.5**

occupied may not be an indication of water quality or other potentially manageable condition. However, the magnitude of changes over time within the same segment is an indication of changing conditions such as water quality or clarity, which may respond to management activities.

Figure 6-3 shows the percentage of submerged bottom less than 6 ft in depth (PAR depth) that was covered by SAV beds in the 1970s mapping period and in 1992. Percentage cover of potential habitat has ranged from 0% to over 100% (which indicates growth of SAV below the 1.8 m depth). Over 50% cover of potential habitat consistently occurs in southern Mosquito Lagoon, Banana River, and north Indian River. In most other areas, it is less than 40%.

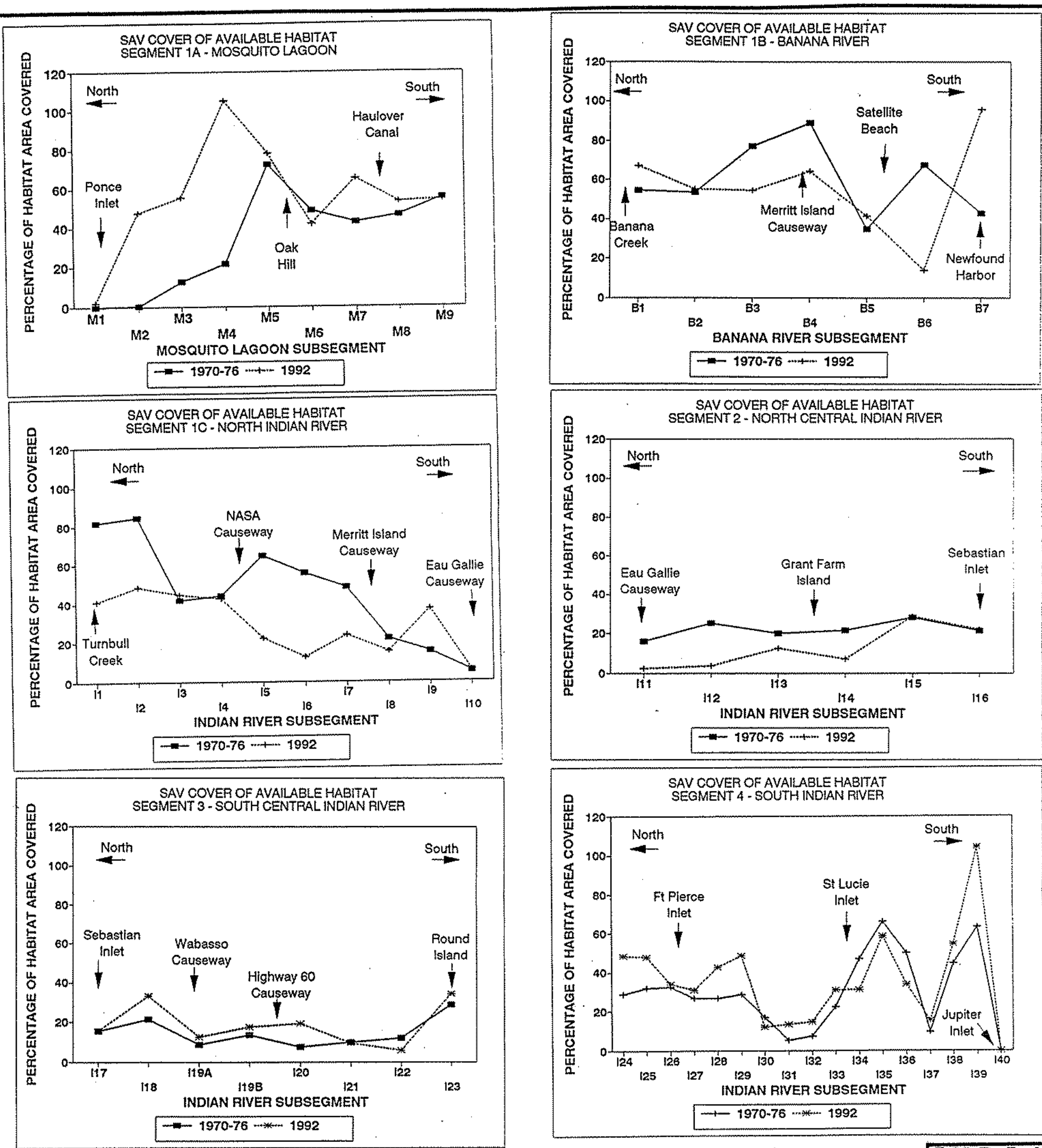
In some parts of the Lagoon system, the percentage of available habitat utilized has increased since the 1970s. Increases appear in northern Mosquito Lagoon (subsegments M1 to M5), South Central Indian River (I18 to I 20), and South Indian River (I24 to I 29) (Figure 6-3). Substantial decreases in coverage have occurred in southern Banana River (B6) and North Indian River and North Central Indian River (I1 to I14 - Turnbull Creek to Link Port).

6.5 TRENDS IN SEAGRASS DEPTH DISTRIBUTION

Figure 6-4 shows the maximum depth limits of dense SAV beds with discrete edges ("defined seagrass beds") from the most recent aerial photographs (1992) and the earliest available photographs (1943 or 1958). Figure 6-5 shows similar results based on the deepest documented occurrence of SAV from the photos.

In almost all instances, both the maximum depth of defined beds and the maximum depth of observed SAV occurrence have decreased since the earliest observations. The degree of change has been relatively minor in some locations, but has decreased by as much as 76% at others (subsegment I19B - Plover Point to Pineda Causeway).

The deeper edges of the defined dense beds were found at depths at or near the 6.7 ft mark in several scattered subsegments throughout the Lagoon system in 1943 or 1958. The edge was deeper than 4.7 ft at 27 of the 58 subsegments. However, in 1992 the deep edge occurred deeper than 1.4 m in only 10 of the subsegments.



Note: Potentially available habitat is defined as Lagoon bottom less deep than the 6.7 ft mean low water contour

Sources: Thompson, 1978; White, 1993; NSA, 1993

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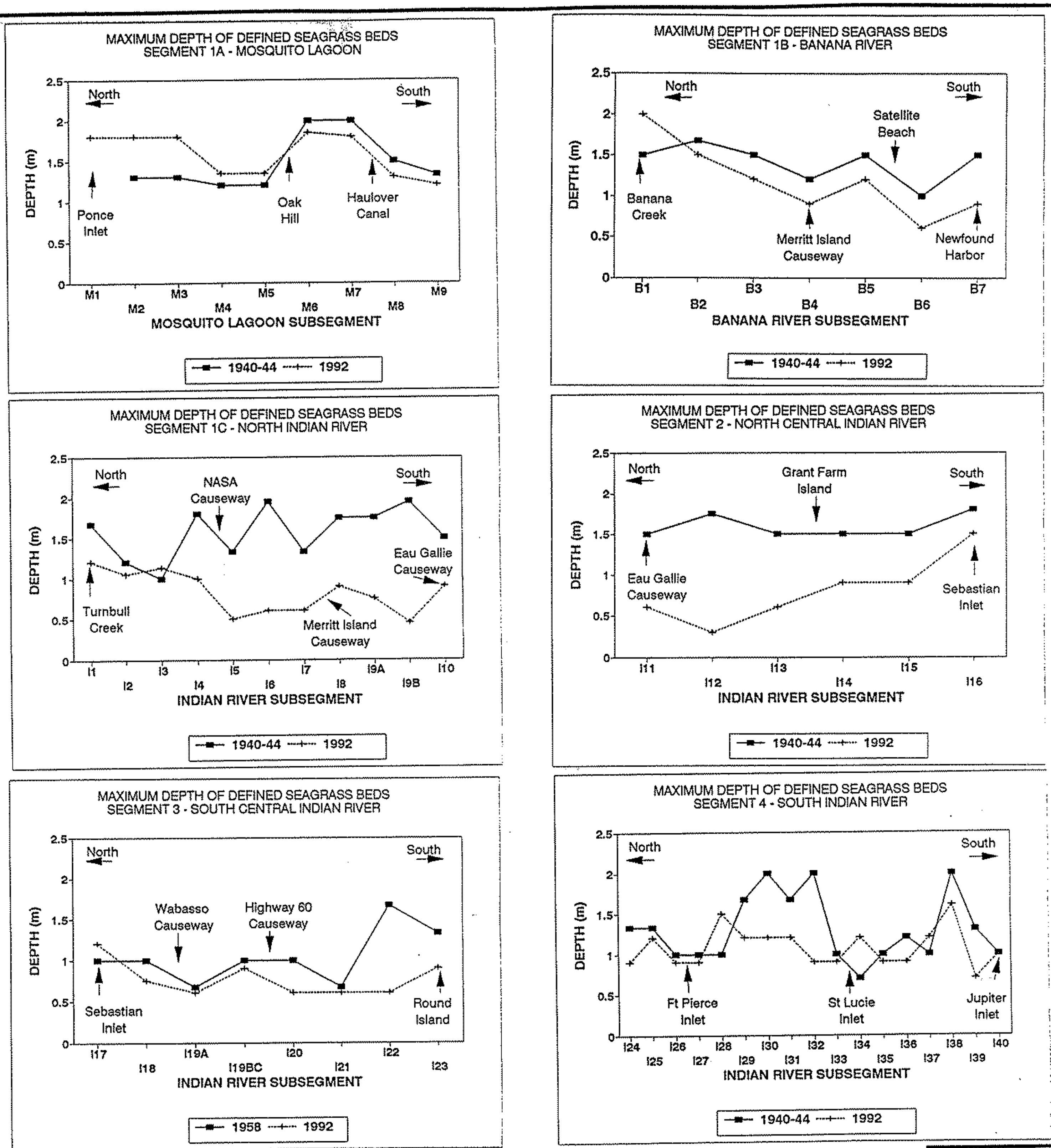
• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-3	PERCENTAGE OF POTENTIALLY AVAILABLE HABITAT COVERED BY SAV IN 1970S AND 1992



Sources: Thompson, 1978; White, 1993; NSA, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-4	CHANGES IN THE MAXIMUM DEPTH OF DEEP EDGE OF DEFINED SEAGRASS BEDS BETWEEN 1943 AND 1992

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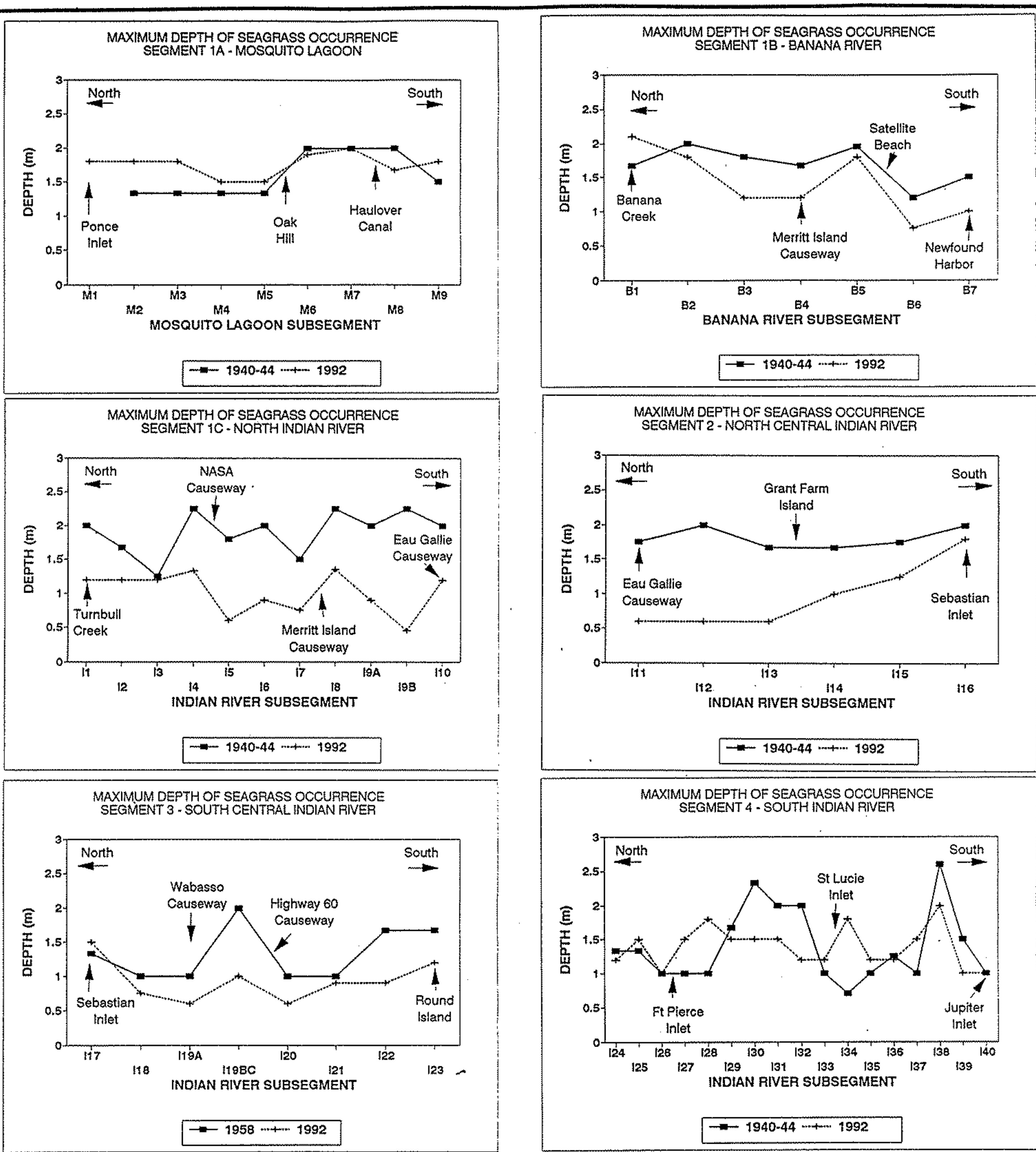

Sources: Thompson, 1978; White, 1993; NSA, 1993

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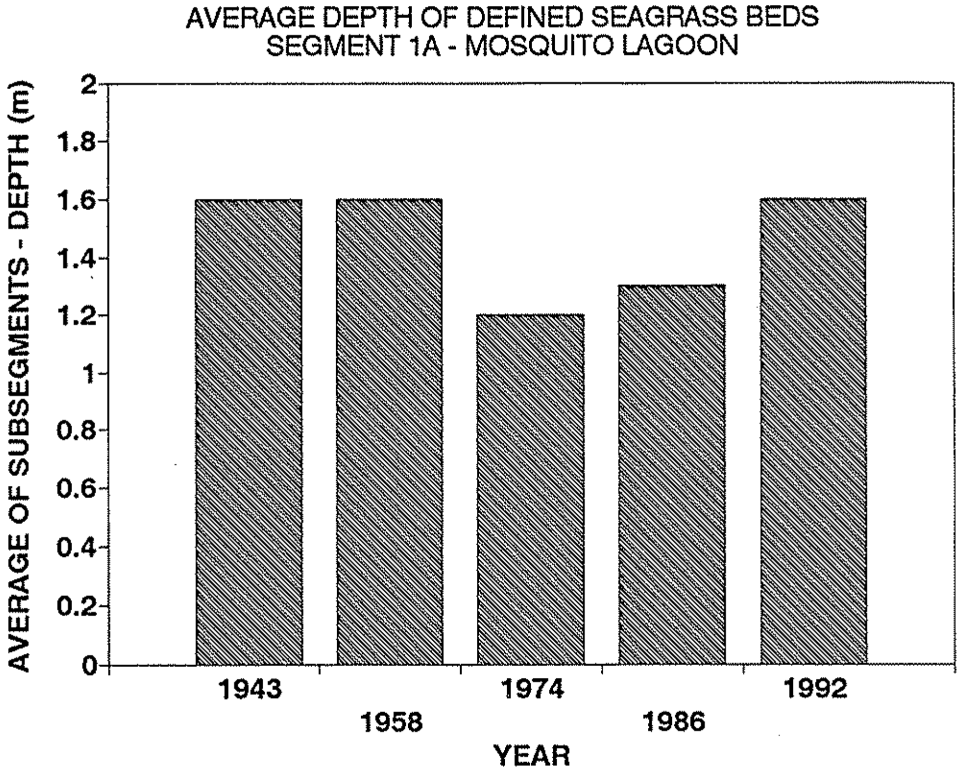
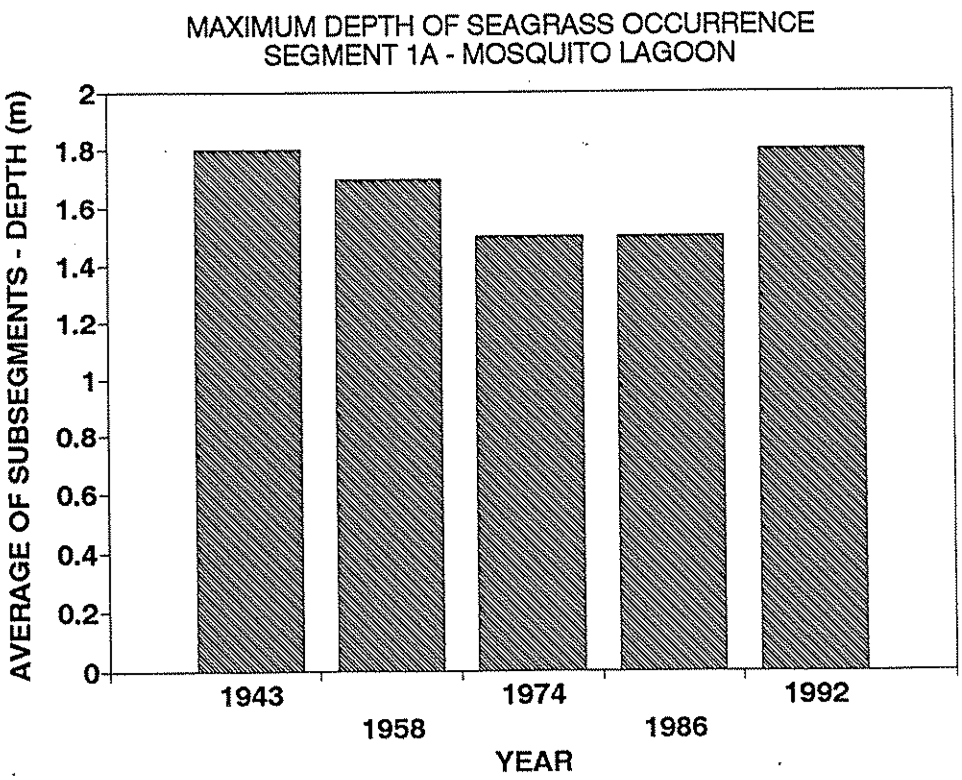
FIGURE 6-5 CHANGES IN THE MAXIMUM DEPTH OF SEAGRASS OCCURRENCE BETWEEN 1943 AND 1992

Figures 6-6 through 6-11 show the maximum defined bed depth and maximum occurrence depth for several periods between 1943 and 1992 for each segment. There is no pattern of change common to all segments. In some cases, there has been a steady decline, and in others there has been an increase. In still others, there have been declines followed by increases or the opposite pattern. Such differences may be due to several factors, including differing seasons and quality of photography used for the analysis, differences among interpretations, and site-specific environmental differences. The 1943 photographs of the Ft. Pierce area (I26 and I27) illustrate this latter effect. At the time of the photography, dredging was occurring in the inlet, the north causeway was under construction, and a U.S. Navy base was operating on the south causeway. The photographs show a large and dense turbidity plume extending south from the inlet that totally restricted light penetration. The plume passed over an area that contained a major seagrass bed in 1992. If the seagrass beds were present in 1943, they were invisible under the plume.





Sources: Thompson, 1978; White, 1993; NSA, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-6	TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 1A - MOSQUITO LAGOON

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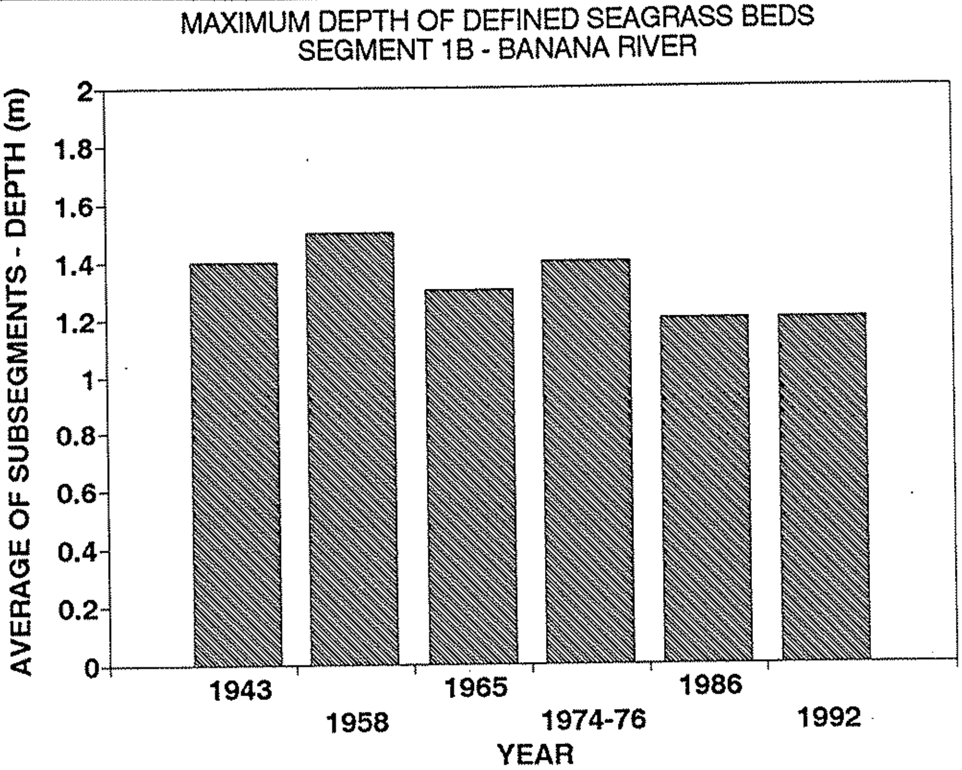

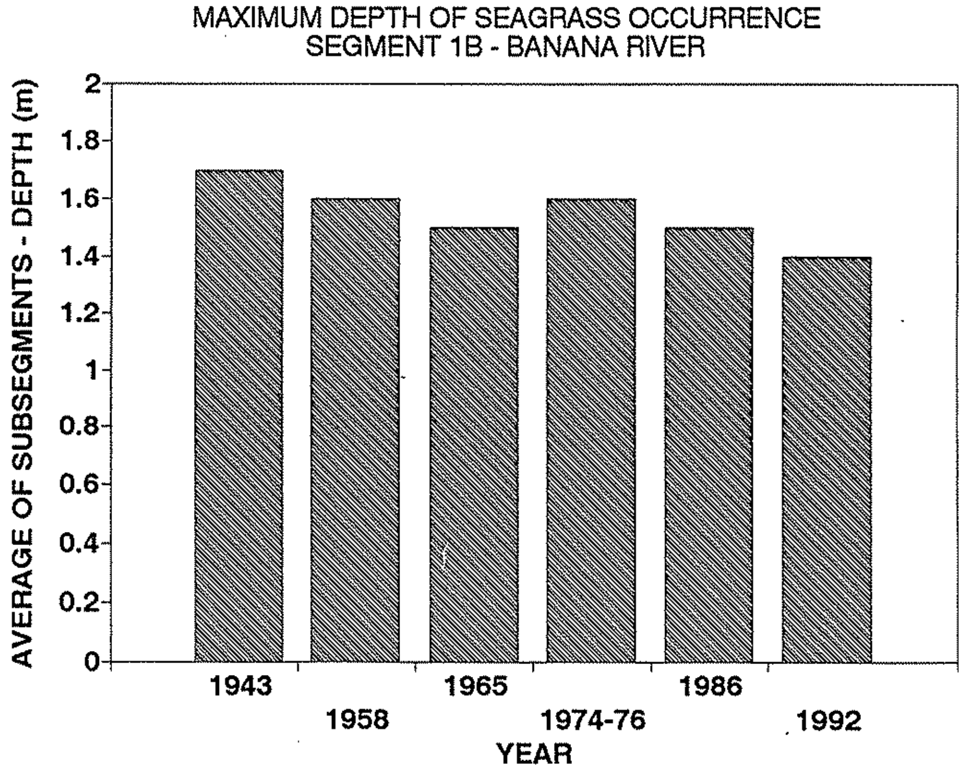

Sources: Thompson, 1978; White, 1993; NSA, 1993

- Woodward–Clyde Consultants
- Marshall McCully & Associates
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FIGURE 6-7 TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 1B - BANANA RIVER

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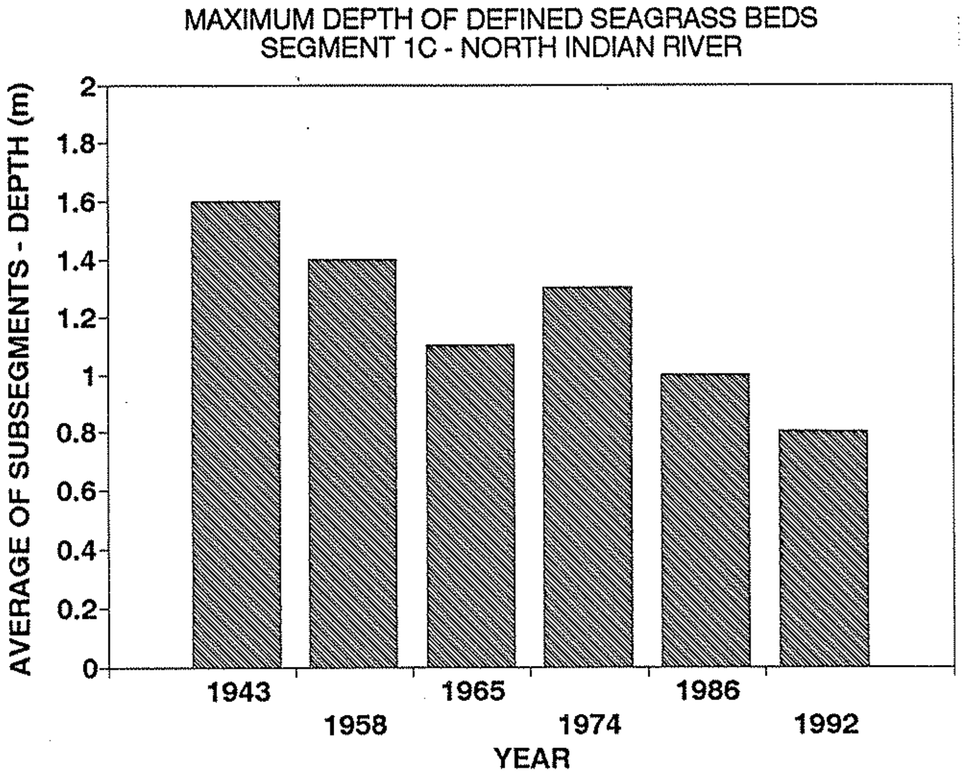

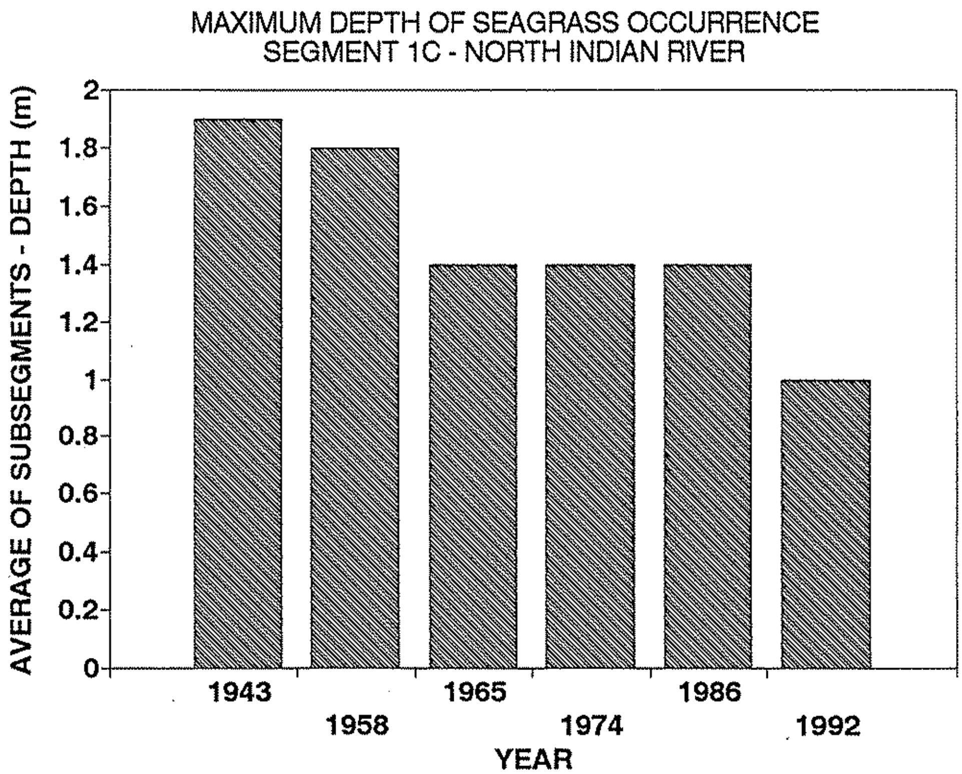

Sources: Thompson, 1978; White, 1993; NSA, 1993

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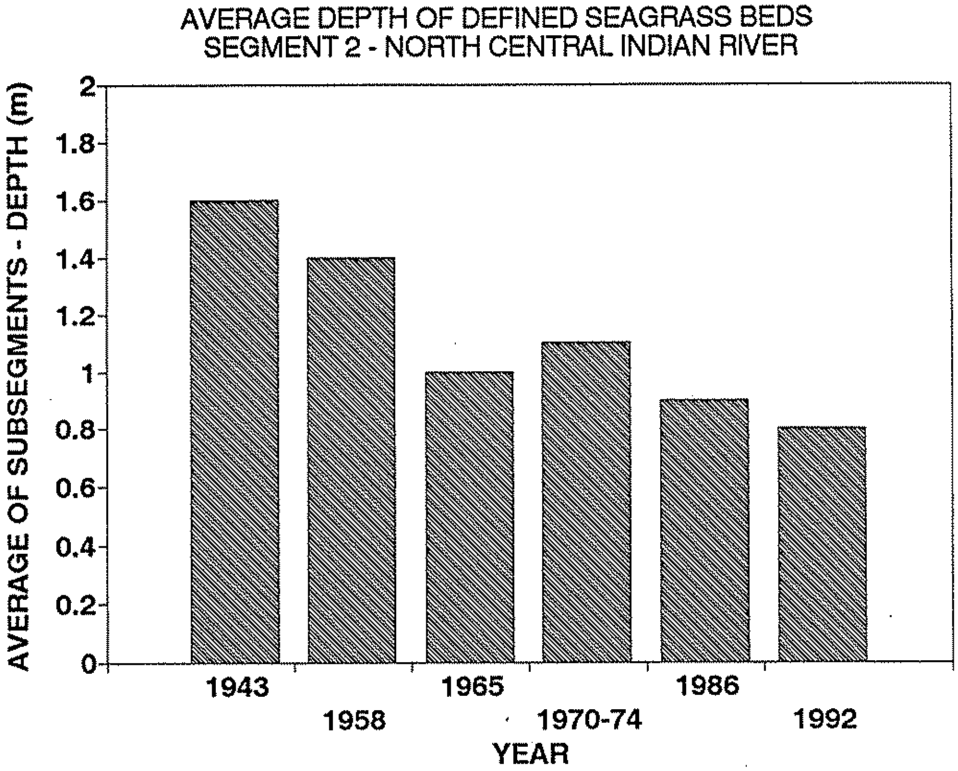
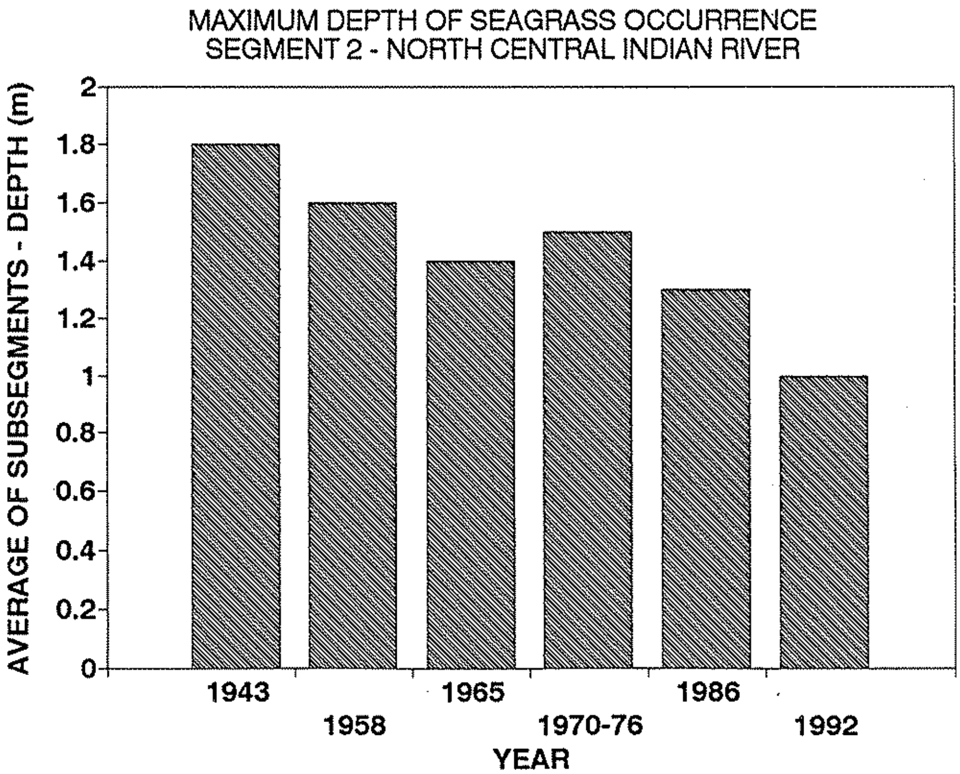
• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-8	TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 1C - NORTH INDIAN RIVER LAGOON





Sources: Thompson, 1978; White, 1993; NSA, 1993

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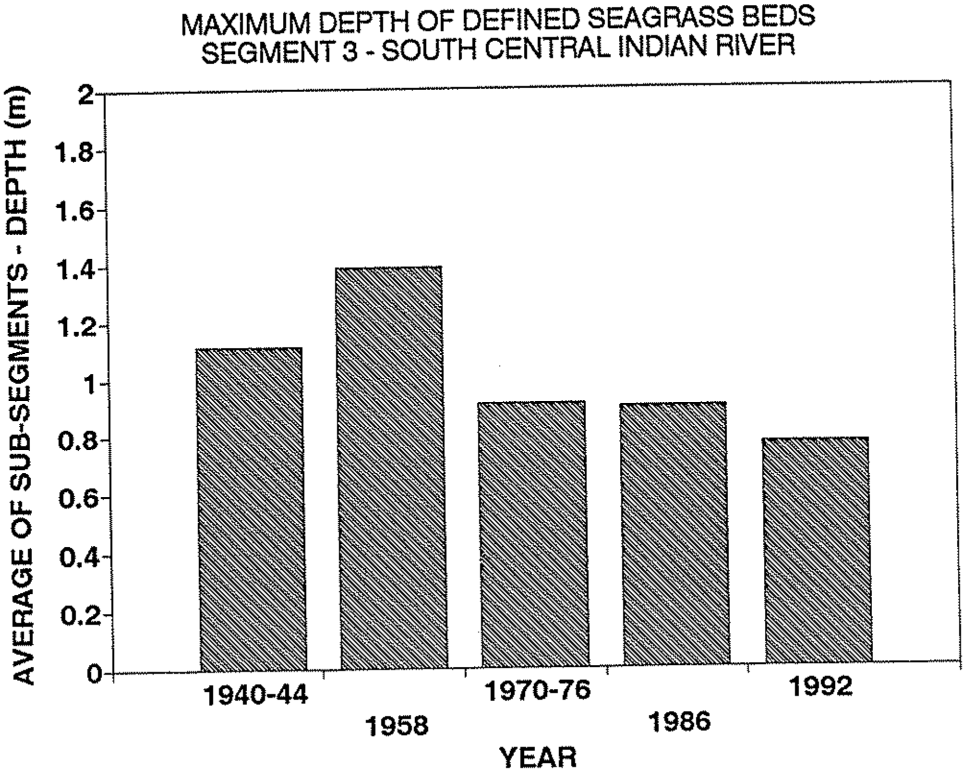
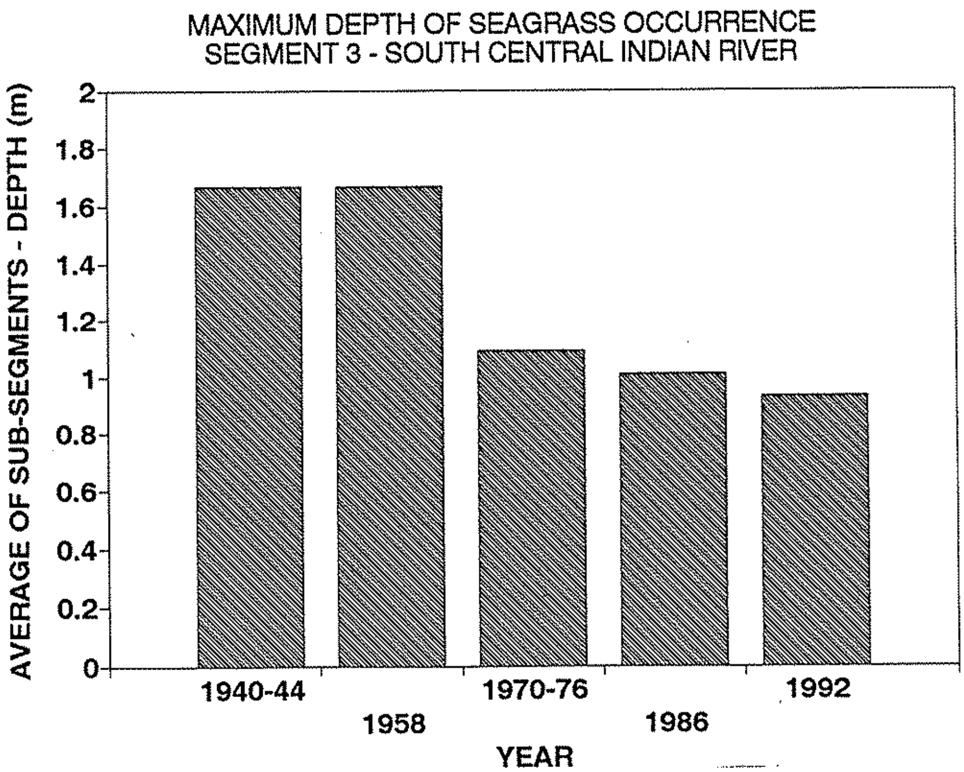
• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-9 TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 2 -NORTH CENTRAL INDIAN RIVER LAGOON





Sources: Thompson, 1978; White, 1993; NSA, 1993

• Woodward–Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-10	TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 3 - SOUTH CENTRAL INDIAN RIVER LAGOON

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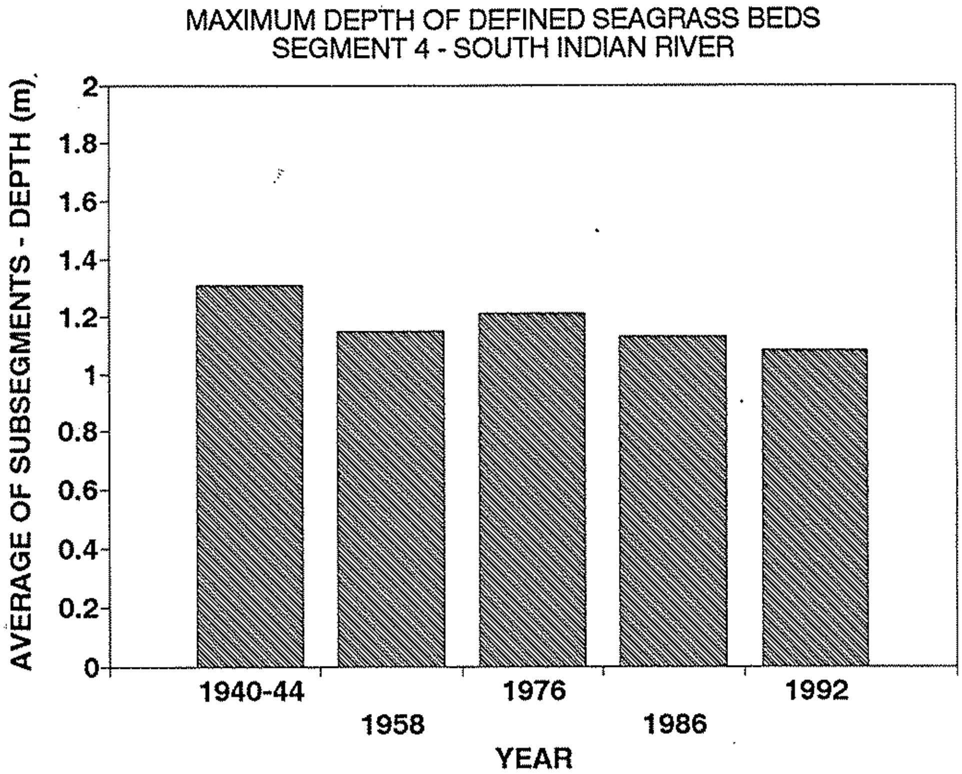

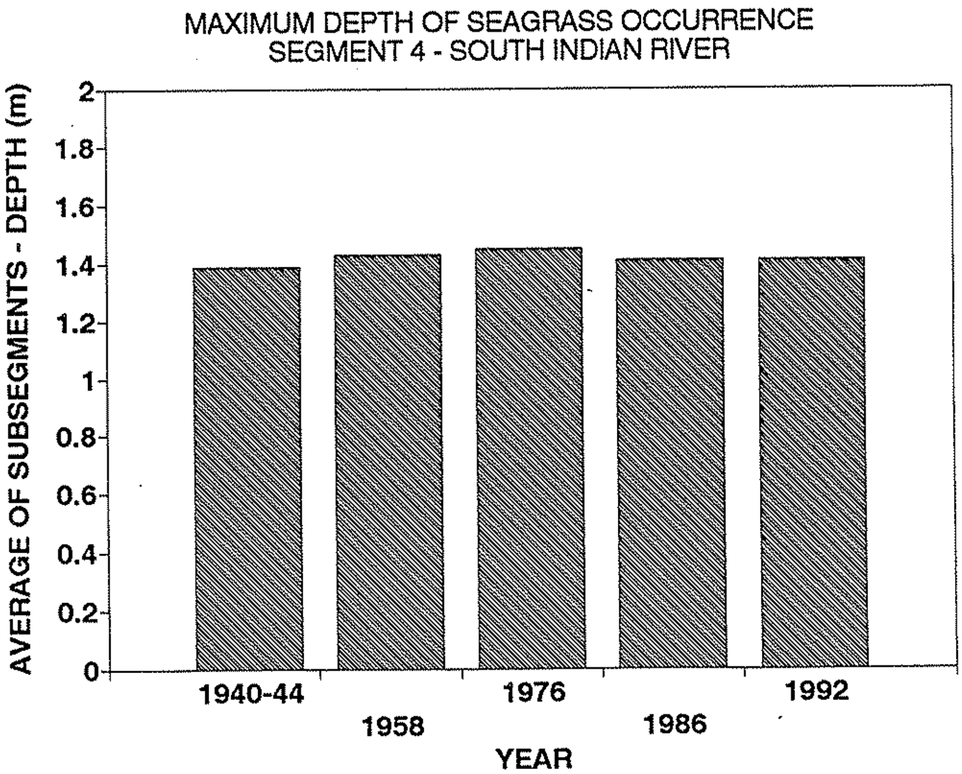

Sources: Thompson, 1978; White, 1993; NSA, 1993

• Woodward-Clyde Consultants • Marshall McCully & Associates • Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE 6-11	TRENDS IN MEAN MAXIMUM SEAGRASS BED AND OCCURRENCE DEPTHS SINCE 1943 IN SEGMENT 4 - SOUTH INDIAN RIVER LAGOON

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7.0
ASSESSMENT OF SAV TRENDS

7.1 SAV DISTRIBUTION

During the period from 1970 to 1992, a fairly consistent pattern of SAV distribution has occurred in the Indian River Lagoon system. The majority (70%+) of SAV occurs in the northern end of the system north of a line from Cocoa to Cocoa Beach (Figure 6-1). A very small amount (<10%) occurs in the middle portion of the Indian River Lagoon between Cocoa and Ft. Pierce.

This pattern has been similar for all three periods studied, although wide variability in abundance has occurred among the different periods in the three northern segments (1A, 1B, 1C). Lagoon-wide, total SAV acreage appears to have decreased from 78,519 ac in 1970-76 to 70,139 ac in 1992 (Table 6-1). Acreage was higher in 1984/86 than in the preceding or succeeding period. Almost all of the apparent decrease in acreage from 1984-86 to 1992 results from declines in Segment 1C - North Indian River (north of the south end of Merritt Island). Periodic increases and decreases in cover in various subsegments throughout the rest of the Lagoon seem to balance out among years. Specific changes in distribution that have occurred are described in the following sections.

7.1.1 Segment 1A - Mosquito Lagoon

SAV coverage has generally been consistent throughout most of this segment since 1973-74. Some variation among years has occurred in the southern end of the Lagoon, but no long-term trends are apparent. Year to year variation was apparent in the 1970s, based on mapping interpretations from different sources. Down (1978) reported almost twice as much cover from 1976 photographs in subsegments M8 and M9 as did White (1993), who based his interpretation on 1974 photographs. Fletcher (1993) found significant bare patches and 30% less acreage in subsegments M6 and M7 for 1973 than did White for 1974. It is likely that much of these variations resulted from differing interpretations of algal cover or from variability in seasonal development of seagrasses among the years. However, this period did follow several years in which many mosquito control impoundments were constructed in the area and in which NASA was very active at KSC, so effects from these activities can not be excluded as potential causes of actual variation in seagrass cover.

A small increase in SAV cover appears to have occurred in the northern end of Mosquito Lagoon (M2 - M4). The northern limits of seagrasses in the Lagoon system have generally been considered to extend to about Oak Hill (M5), although Haddad and Hoffman (1985) did report minor amounts of seagrasses near Ponce Inlet in 1943. Figure 6-6 indicates that some colonization may be occurring in this region. However, the cover represents a small fraction of the total available acreage in Mosquito Lagoon. These new occurrences have not been well-documented in the field and may represent algae or ephemeral beds. Substrates or other physical or chemical factors in this area may not be optimal for seagrasses.

7.1.2 Segment 1B - Banana River

Total acreage for this segment in 1992 was virtually identical to that in the 1969-74 period, although a general decline from the 1970s levels appears to have occurred throughout Banana River proper (B3 to B6) south of the Bennett Causeway (SR 528). Increases in cover within the Newfound Harbor subsegment (B7) have offset the decreases in the rest of the system.

A trend not apparent from the figures is a possible shift in species composition. The cover increase in the Newfound Harbor area is probably largely due to increase of algal species rather than seagrasses, while the declines in the rest of the segment probably consist of seagrass losses. Algae may also account for higher percentages in northern Banana River in the more recent years, although algae has been reported as being a major component of the beds in 1976 (Down, 1978) and 1986 (White, 1986).

The trends reported in Figure 6-7 also do not cover changes prior to the 1970s. Significant changes in the bathymetry of the Banana River occurred prior to this time. Among the changes shown on historical imagery which resulted in losses of potential seagrass habitat (bottom <6.6 ft depth) have been dredging of canals, dredging of the southern basin near Patrick Air Force Base, and filling of submerged bottom for residential and recreational developments such as the Cocoa Beach Golf Course.

7.1.3 Segment 1C - North Indian River

About 6,000 ac of the 10,000 acre loss of coverage between 1986 and 1992 in this segment (extending from the south end of Merritt Island to Turnbull Creek) occurred in the northernmost end, north of Titusville (I1 and I2) (Table 6-1). In 1986, water conditions were described as having good clarity, resulting in good growth of *Syringodium filiforme* and *Halophila englemanni* in the deeper zones. The alga *Caulerpa prolifera* was also described as being abundant in the deeper portions of this area, and the SAV maps of this period include the acreage contributed by these species. *Caulerpa prolifera* did not appear to be as abundant anywhere in the Lagoon system in 1992, and its decreased abundance in this area had a major effect on the total reported SAV acreage.

A large storm event in 1991 also produced highly colored and turbid water in much of this area for a period exceeding one month. Great mortality of above-ground SAV biomass has been reported following the storm (White, 1993), and the 1992 decrease in acreage also may be a result of the declines following that storm. Density and cover may not yet have returned to pre-storm levels.

A consistent decline in percent cover over the 1970 to 1992 time period has occurred between NASA Causeway and Pineda Causeway (I5 to I8) with cover declining from over 40% to 10% in one subsegment (I6 - Jones Point to SR 528). This decline accounts for about 5,000 ac of the 8,380 ac total Lagoon-wide decline, and is significant because it does not appear to be related to any specific natural event (such as the storm in the northern subsegments) or to differences in mapping techniques. The trends seem to indicate a permanent and long-term decline in this area.

A significant decline in the maximum depth of the defined seagrass beds south of NASA Causeway has also occurred (Figure 6-3), changing from a range of 4.7 to 6.3 ft in 1943 to a range of 1.3 to 3.3 ft in 1992 (declines ranging from 40 to 76% depending on bed). The rate of decline in this portion of the segment has been much greater than that north of NASA Causeway where the percent changes have ranged from a 45% decrease to a 10% increase.

7.1.4 Segment 2 - North Central Indian River

This segment, from the south end of Merritt Island to Sebastian Inlet, has had the least SAV percentage cover in all periods. In terms of absolute acreage, it had the least SAV in 1992, but had more SAV than the South Central Segment in previous periods. Total SAV cover has remained less than 600 ac in each of the subsegments except I16, which abuts Sebastian Inlet. Available habitat is naturally limited in much of the segment, due to sharp drop-offs to deeper water near the shores.

The percent of available habitat covered by SAV has consistently been below the average for the Lagoon system. However, there has been a dramatic decrease in the amount of bottom coverage between 1970 and 1992 north of Grant Farm Island (I15). Percent cover of available habitat has declined from the 20 to 30% range in the 1970s to less than 10% in 1992 in much of this segment. The low coverage of available habitat is a trend that continues north into Segment 1C as far north as Merritt Island Causeway (SR 520).

SAV in this segment has shown a steady decline over time since 1970 in all subsegments except those nearest Sebastian River. Total SAV loss between 1970 and 1992 has been over 1300 ac or about 65% of the 1970 acreage. This loss trend is supported by the trends in maximum depth distribution of SAV beds, which has shown a steady decrease since the 1940s. The largest decrease in defined bed depth (from 5.7 to 1.0 ft) occurred in subsegment I12 (Melbourne Causeway to Cape Malabar) which also had the greatest decrease in total acreage.

7.1.5 Segment 3 - South Central Indian River

This segment, extending from Sebastian Inlet to just north of Ft. Pierce Inlet, has a total SAV acreage almost identical to Segment 2, although the total water body area and total available habitat are somewhat smaller. Consequently, the percentage cover is larger. The percentage cover is, however, below the average for the Lagoon system. SAV cover is generally least near the towns of Sebastian and Orchid (I19A) and near Vero Beach and Vero Shores (I20 to I22).

This segment is one of the few areas where SAV coverage appears to have shown an increase since the 1970s, with over 2,900 ac in both 1986 and 1992, compared to 2,459 ac in the 1970s. A corresponding increase in the percent cover of potentially available habitat has also occurred.

Although SAV has increased in extent in this segment since the 1970s, there has been a decrease in the maximum depth of the defined seagrass beds since 1958. This decrease has been less than 25% except in subsegment I22 (opposite the Vero Main Canal Drainage Basin) where the decrease has been 65%. However, this decrease is based on a maximum depth of occurrence of 5.7 ft in 1958, a level which was abnormally high in relation to other nearby areas. The depth of beds in this subsegment in 1992 was similar to that in nearby subsegments.

The late 1960s and 1970s represented a period of intense urban development in this segment as indicated by the aerial photographs of that period. This growth period seems to correspond to growth spurts that occurred in earlier periods to the north of this segment. Several areas of highly turbid water were apparent on the 1970s photographs of this area. Improvements in erosion and sediment control for developments of the 1980s and 1990s appear to have led to a decrease in turbidity in these areas. Thus the depressed levels of seagrasses in this segment during the 1970s may have been a result of the intense development and resulting turbidity at that time. It appears that SAV coverage and depth of occurrence still is less than it was in earlier periods such as 1958 and 1943.

7.1.6 Segment 4 - South Indian River

SAV cover in the South Indian Lagoon from approximately Ft. Pierce Inlet to St. Lucie Inlet appears to have peaked in 1986. However, total cover was 43% higher in 1992 than it was in the 1970s for this segment. In all years, the total acres of SAV was low in the Ft. Pierce Inlet area (I26, I27) and from St. Lucie Inlet south to Jupiter Inlet (I34 to I40) with little change among years in these subsegments.

The areas with the greatest change in SAV abundance have been subsegments I25 (south of Link Port) and I28 to I34 (Ft. Pierce Inlet to St. Lucie Inlet), where SAV has increased in abundance since 1970. However, the seagrass coverage as a percent of total available habitat

(6 areas less than ft deep) is still low (Figure 6-3). This indicates that a large amount of potentially available habitat has not been colonized by seagrasses.

Another reason for the large acreage increase in conjunction with a rather small increase in cover of the <6 ft depth zone is species composition of the seagrass beds. Much of the increase in coverage, especially for the 1986 period, came from mapping of deepwater beds of *Halophila* spp. This genus of seagrass is capable of growing in deeper water than other species. The 1986 mapping put heavy emphasis on identifying these areas, and the 1992 mapping also includes several areas dominated by *Halophila* spp. However, *Halophila* beds in deep water are often sparse and may not be discernable from aerial photographs. Since the 1970s photographs could not be ground-truthed, it is impossible to know if additional acreage was present at that time that could not be identified from the photos.

The *Halophila* species did not seem to be as prevalent during the 1992 mapping as during the 1986 mapping, and this accounts for most of the decrease in cover between 1986 and 1992. The change may be due to actual changes in cover or to differences in interpretation of cover. Cover in these beds is often so sparse that different interpreters can differ in opinion as to whether the presence of the grasses actually represents a bed of sufficient density to be mapped.

Kenworthy (1993) performed a separate field study on seagrass depth distribution in the Hobe Sound/Jupiter Sound areas (I37 to I39) from 1987 to 1989 and found the maximum depth of the defined *Halodule wrightii* and *Syringodium filiforme* seagrass beds to range from 3.7 to 9.0 ft. *Halophila decipiens* was found to occur to 10 ft. These depths, obtained from intensive field investigations, are deeper than the bed limits as identified from aerial photographs for 1986 and 1992. The numbers were however almost identical to the maximum depth of seagrass occurrence identifiable from the aerial photographs.

This comparison indicates that the numbers presented for depth of occurrence in this report may be less than actual depths in the field, and that determination of actual depths may require intensive field verification. The difference also may be due to limitations of bathymetric data. The bathymetry maps used for this report may not sufficiently indicate the extent of water depths greater than 6 ft. The poor differentiation of bottom details on aerial photographs of this portion of the system also may be due to deeper than reported water depths in much of Hobe Sound.

7.2 WATER QUALITY AND EFFECTS ON SAV DEPTH DISTRIBUTION

Comparison of SAV trends described in this report to the water quality data presented in the Water Quality Assessment Technical Report volume does not show readily apparent correlations. However, this is to be expected since the changes in SAV distribution are the result of changes over almost 50 years, while the water quality data represent a short window of only three recent years. The fact that declines in the extent of seagrass coverage in several subsegments correspond to declines in the maximum depth of seagrass occurrence indicates that reduced depth of occurrence may be a cause of reduced bed extent. Since it has been documented that depth of seagrass occurrence is primarily dependent on light penetration (see Biological Resources Technical Report volume), it is reasonable to postulate that declines are a result of decreases in light penetration in the waters of the Lagoon.

Factors which may influence light penetration include dissolved solids such as the salts in seawater, suspended solids such as silt and organic particles, chlorophyll *a*, and color of water. The extent to which each of these influences light penetration probably varies throughout the Lagoon and also over time. Eyewitness accounts have implicated color due to tannic acids as a cause of seagrass decline in at least one case (White, 1993). Chlorophyll *a*, which is a function of phytoplankton abundance, appears to be somewhat elevated, but not greatly so in most parts of the Lagoon (see Water Quality Assessment Technical Report volume).

The role or effect of suspended solids on light penetration in the Lagoon is not well known. On an average basis, turbidity appears to be similar throughout the Lagoon, but varies on a local and temporal basis. This variation has not been described well enough throughout the Lagoon complex to allow correlation to seagrass occurrence. From available evidence, it appears that color and suspended solids may be the primary factors affecting seagrass depth distribution in the Lagoon, but confirmation is not available.

Salinity also may affect different SAV species in differing amounts. This may lead to changes in relative abundance of species. Since some species may colonize or spread faster than others, salinity may thus be a factor affecting the extent of cover within an area. Other water quality or physical factors may also be influencing, or have influenced, seagrass occurrence. A combination of historical analysis through aerial photographs and assessment of other data and reports may show the importance of numerous factors on short-term or site-specific bases. However, the fact remains that long-term decreasing trends are present in some portions of the Lagoon complex of sufficient scale to indicate effects of water quality over large areas as a factor in influencing distribution.

8.0 EVALUATION OF TRENDS IN REPRESENTATIVE SEAGRASS AREAS

8.1 AREAS SELECTED

Several areas corresponding to USGS 7.5 minute quadrangle (quad) maps have been selected as being representative of types of seagrass bed changes over time in the Indian River Lagoon complex. The availability of existing maps or aerial photographs covering sufficient areas and dates also was a factor in area selection. Coverage from 1943, 1958, 1965, 1974, 1976, 1986, and 1992 has been examined although all of these dates are not available for all quadrangles. Several other areas were considered for inclusion, but were rejected because of insufficient coverage. Each quad map has a name assigned by USGS and a map section number which refers to the number of the map in the SJRWMD GIS system files. The mapped beds represent total SAV coverage. In most cases, this cover is comprised primarily of seagrasses. In the Oak Hill and Grant quads in particular, macroalgae species may also represent a substantial portion of the total cover. Cover has been condensed into two classes representing density of the vegetation within each polygon. Dense cover includes areas with vegetation covering 40% or more of the bottom area. Sparse cover includes all areas with more than 0% cover and less than 40% cover.

The following USGS quad maps have been included in the assessment in this section:

- Oak Hill - (SJRWMD Map Number 543; Segments 1A and 1C)
- Melbourne East - (SJRWMD Map Number 695; Segment 2)
- Grant - (SJRWMD Map Number 720; Segment 2)
- Sebastian NW - (SJRWMD Map Number 721; Segment 2)
- Sebastian - (SJRWMD Map Number 746; Segments 2 and 3)
- Ft. Pierce - (SJRWMD Map Number 822; Segment 4)

The 1992 coverage in both of the water bodies was similar to that in 1943, indicating little overall change in SAV extent and density since 1943. This supports the premise that conditions in this region have remained fairly consistent over the past 50 years.

8.3 MELBOURNE EAST QUADRANGLE

This area includes the Indian River Lagoon from Hawthorn Point just south of the Eau Gallie River in the City of Melbourne to a point just south of Cape Malabar and the southern limits of the City of Palm Bay in Brevard County. In contrast to the previous area, this portion of the Indian River Lagoon is within one of the most heavily developed areas in the Indian River Lagoon system watershed and contains one of the highest percentages of urban land cover adjacent to the Lagoon. The area also represents an area where the natural drainage basin has been moderately expanded by artificial drainage canals. Turkey Creek and the Eau Gallie River discharge near each end of this reach. Therefore, this is considered to represent a portion of the Lagoon which has been most heavily developed and impacted by man.

SAV bed coverage in the years 1943, 1965, 1974, 1986, and 1992 is presented in Appendix A, Figure A-2 (a-e). Interpretation of beds was completed by C. White for 1965, 1974 and 1986 and by S. Fletcher for 1943 and 1992.

In 1943, this stretch was characterized by continuous beds on both sides of the Lagoon, except around the mouth of Turkey Creek. On the west side of the Lagoon, these beds were 1,000 ft to 1,500 ft wide and about half of the area had dense SAV. On the east side of the Lagoon the beds consisted of a narrow 200 ft band of dense seagrass, with sparse beds out to 1,000 ft from shore.

By 1965 the beds on the east side of the Lagoon south of Melbourne Causeway had almost disappeared and the remaining cover was sparse. On the north side of the causeway, the width of the beds had decreased by about 50%. The largest decreases occurred south of the Melbourne Causeway on the west shore of the Lagoon, where over 50% of the cover had been lost. By 1974, bed width in almost all areas had decreased to less than 350 ft SAV bed extent had been reduced to between 10% and 50% of the 1943 cover, depending on location.

8.2 OAK HILL QUADRANGLE

This area includes the north end of Indian River Lagoon (north of Haulover Canal) and the central Mosquito Lagoon between approximately Haulover Canal on the south and the town of Oak Hill on the north. This area is one of the least heavily developed areas in the Indian River Lagoon system watershed and contains the greatest percentage of natural land cover adjacent to the Lagoon. The area also represents an area where the natural drainage basin has been least expanded by artificial drainage canals. Therefore, this is considered to represent a current condition of the Lagoon which most closely represents the pre-development natural system.

SAV bed coverage in the years 1943, 1974, 1986, and 1992 is presented in Appendix A Figure A-1 (a-d), as obtained from aerial photographs. Interpretation of beds from aerial photographs was completed by C. White for the Brevard County portion in 1974 and 1986 and by S. Fletcher for the Volusia County portions in 1974 and 1986 and all areas for 1943 and 1992.

Comparison of seagrass coverage throughout this 49-year period shows a similar extent of beds in 1943 and 1974 with some changes between sparse and dense coverage primarily in the northern area of Indian River Lagoon. The 1986 cover extends almost entirely across the center of the Lagoon. Most of this increased cover was sparse coverage by the seagrass *Halophila englemanni* and the algae *Caulerpa prolifera, Gracilaria* sp., *Hypnea* sp., and *Acanthophora* sp. (White, 1986; Down, 1978). By 1992, these deeper beds did not appear. Possible reasons for the change include differences in mapping conventions and ground-truthing and lingering effects of a 1991 discharge of highly colored tannic water from Turnbull Creek, which caused a seagrass dieback (White, 1993). Average Secchi depths dropped after this event to less than 3 ft from a normal level of over 4.5 ft (see Water and Sediment Quality Assessment Technical Report).

SAV cover in this portion of Mosquito Lagoon has also remained very constant over the period. The outer edge of the SAV beds in Mosquito Lagoon has remained very constant, with the primary changes being density variations within this extent. The main exception is a loss of beds in the central area in 1974. This area had filled in again by 1986.

The declining trend has continued through 1986 to 1992 to an overall level about 10% of that in 1943.

The greatest loss in the area south of the Melbourne Causeway appears to have occurred between 1943 and 1965, while the period from 1965 to 1974 showed the greatest loss north of the causeway. There has been no significant recovery in this area .

Potential habitat for seagrasses is naturally limited in this reach because of deep drop-offs near shore and coquina rock outcrops. However, this trend analysis indicates that loss of SAV in this portion has been a major cause of the current low abundance. Water quality data from the 1989-1991 period indicates few consistent differences in this area as compared to other regions of the Lagoon. Salinity is generally lower and total nitrogen is generally higher than in most areas. However, most of the decline has pre-dated this water quality data and may be a result of previous conditions. If water quality has improved, the improvement has as yet not been reflected in SAV recovery.

8.4 GRANT AND SEBASTIAN NW QUADRANGLES

This area includes four miles of the Indian River Lagoon from a point two miles north of Sebastian Inlet to a point six miles north of Sebastian Inlet, adjacent to the communities of Grant and Valkaria in Brevard County. This portion of the Indian River Lagoon has moderately low development, but is in an area where the natural drainage basin has been moderately expanded by artificial drainage canals. Turkey Creek is to the north and the Sebastian River is to the south. Depending on wind, rainfall, and tide conditions, one of these tributaries may mix with the Lagoon within this reach (see Physical Features Technical Report). Therefore, this section represents a portion of the Lagoon possibly subject to the influences of tributary drainage. SAV bed coverage in the years 1943, 1974, 1986, and 1992 is presented in Appendix A, Figure A-3 (a-d). Interpretation of beds was completed by C. White for 1974 and 1986 and by S. Fletcher for 1943 and 1992.

The total SAV coverage for this section has probably remained fairly consistent since 1943, with a peak recorded in 1986, which was reported to be a very good year for seagrass growth (White, 1986). However, within different portions of this area, different patterns of change have occurred. On the west shore of the Lagoon, there has been a consistent and continual decline since 1943, while along the east shore and in the middle of the Lagoon (areas east of the ICWW), there has generally been an increase in cover. Much of the increase in the center of the Lagoon has been in deeper areas and may represent increases in algal beds in recent years. Decreases along the west shore may be related to discharges from Sebastian River and Turkey Creek which appear to mix in the Lagoon west of the ICWW under most conditions. However, the circulation patterns are not known well enough to adequately address this effect. Overall, SAV beds in this area appear to be subject to localized influences which may vary within the area.

8.5 SEBASTIAN QUADRANGLE

This area includes the Indian River Lagoon from two miles north of Sebastian Inlet to the town of Wabasso about six miles south in Indian River County. This portion of the Indian River Lagoon has moderately low development, which is concentrated around the town od Sebastian. The Sebastian River enters opposite Sebastian Inlet and may mix with the Lagoon within this reach (see Physical Features Technical Report). Therefore, this section represents a portion of the Lagoon possibly subject to the influences of tributary drainage as well as oceanic forces through the inlet.

SAV bed coverage in the years 1943, 1974, 1986, and 1992 is presented in Appendix A, Figure A-4 (a-d). Interpretation of beds was largely completed by C. White for 1974 and 1986 and by S. Fletcher for 1943 and 1992 and part of the southern end for 1974.

An apparent change in this reach has been the expansion of grass beds inside of the mouth of Sebastian Inlet since 1943. The development of these beds appears to have coincided with the stabilization of the inlet and the deposition of sandy sediments on the flood-tidal delta (see Physical Features Technical Report). Some beds have been filled and lost due to stabilization and growth of the islands adjacent to the inlet. This pattern of changing beds due to changing current patterns bathymetric patterns appears to be a characteristic of all of the inlets in the complex.

Beds on the west side of the Lagoon have generally decreased in extent since 1943, although some increase was apparent in 1986. The south end of this portion appears to have changed little over time, but beds south of the Sebastian River through the town of Sebastian have consistently become more fragmented.

8.6 FT. PIERCE QUADRANGLE

This area includes the Indian River Lagoon in St. Lucie County from three miles north of Ft. Pierce Inlet to a point about six miles south midway between Ft. Pierce and Port St. Lucie. This portion of the Indian River Lagoon has experienced moderate development, which is concentrated around the City of Ft. Pierce. This section represents a portion of the Lagoon subject to oceanic forces through the inlet as well as urban and waterfront influences.

SAV bed coverage in the years 1943, 1958, 1976, 1986, and 1992 is presented in Appendix A, Figure A-5 (a-e). Interpretation of beds was completed by J. Thompson for 1976, R. Virnstein and K. Cairns for 1986, and by S. Fletcher for 1943, 1958, and 1992.

The aerial photographs from 1943 showed a large amount of activity around the inlet and City of Ft. Pierce. The inlet was being dredged: the north causeway was under construction; and the U.S. Navy was operating a base on the south causeway island. As a result of these activities, large turbidity plumes were apparent within the Lagoon, sweeping south from the inlet and into the cove on the east side of the Lagoon. At that time, there were very few SAV beds along the inlet or within three miles to the south, presumably as a result of the activity and the resulting turbidity. Several of the larger beds of that time have since been covered by fill. Beds more than three miles south of the inlet were well developed, but beds two miles to the north were fairly small.

In the period through 1958, there was generally additional erosion of SAV beds. However, by 1976, large beds had appeared south of the inlet adjacent to the City of Ft. Pierce. Increases continued through 1986 with some decline between 1986 and 1992. At the same time that beds have increased near the inlet and adjacent to the city waterfront, beds along the west shore more than three miles south of the inlet have generally declined.

The north end of this section adjacent to Jack Island State Preserve is at the site of what was the most recent inlet location prior to the stabilization of the present Ft. Pierce Inlet. After the old inlet closed and the sediments of its delta stabilized, seagrass beds increased in the years 1943 to 1986. This increase extended over several decades and may be indicative of the rate at which seagrass beds might increase following removal of a perturbation.

9.0
RECOMMENDATIONS AND PRIORITY ISSUES

On the basis of this analysis and on the previous seagrass mapping studies and other studies cited in this report and the Biological Resources Technical Report, several conclusions and recommendations can be made concerning the status of seagrasses and other SAV in the Indian River Lagoon.

- Between 1970 and 1986, SAV acreage appears to have increased by approximately 6%, but by 1992 the acreage was about 10% less than in the 1970s. Much of the changes appear to be in deeper (>3 ft) beds containing *Halophila* seagrass species and the alga *Caulerpa*. An additional factor between 1986 and 1992 was decline in the north end of Indian River Lagoon, probably in response to a heavy discharge of stormwater from Turnbull Creek. These changes illustrate dynamic changes over time, but not enough is known about the SAV dynamics to state whether these changes are within the natural variability levels for the Lagoon or represent major perturbations. There is insufficient data to determine whether these patterns illustrate long term trends. Since seagrasses may be selected as a living resource indicator for the IRLNEP and SWIM programs, it is important to fill these data gaps to provide a more complete understanding of the trends and normal variability of SAV in the Lagoon. It is recommended that periodic seagrass mapping at three to four year intervals be continued. It is also recommended that additional historical mapping be performed for 5 to 10 year intervals back to the 1940s as a long-term baseline.

- It currently is difficult to evaluate changes in SAV abundance because of difficulties in defining coverage classes and a lack of standardized methodologies to evaluate changes in abundance. It is recommended that efforts to establish and standardize this program continue.

- SAV mapping studies have indicated a sizable algal component in the SAV community, at times exceeding the seagrass biomass. The population dynamics and ecological requirements of algae versus seagrasses are poorly known, but may be representative of responses to environmental conditions in the Lagoon. Future mapping studies should attempt to provide better resolution between seagrasses, drift algae, and attached algae. In addition, additional knowledge of the dynamics, functions, and requirements of these groups is needed.

- Results of seagrass field sampling and mapping studies in the Lagoon have indicated possible variation in seagrass species composition over time and area, as well as some zonation in relation to depth and other factors. As noted in the Biological Resources Technical Report, the different seagrass species respond differently to environmental factors. Thus changes in environmental factors such as salinity or water clarity may lead to changes in seagrass species composition in the Lagoon. Better knowledge of the ecological requirements and roles of the seagrass species is needed to evaluate the effects of such changes.

- Changes in seagrass and algae species composition may also be very indicative of changes in environmental conditions or water quality within the Lagoon. Consideration should be given to establishing a monitoring program that can detect such changes.

- This analysis indicated that a decrease in the maximum depth of seagrass beds occur has been occurring in many areas of the Lagoon since the 1940s. This effect appears to have been most pronounced in the North Central and South Central portions (Segments 2 and 3) of the Indian River Lagoon, and may correspond to decreases in seagrass acreage. A more detailed statistical analysis of these trends is recommended to provide more conclusive evidence and better understanding of the relation between reduced abundance and reduced depth of occurrence and, by inference, water clarity.

- It is recommended that a centralized inventory of aerial photographs be established for the Lagoon region, with local coordinators assigned to provide updates, coordinate acquisition, and possibly establish some form of inter-agency loan program.

10.0 SUMMARY OF HISTORICAL ANALYSIS OF SEAGRASS STATUS

The analysis of historical imagery and mapping studies concentrated on comparing SAV abundance and acreage in the periods from 1970-76, 1984-86, and 1992. For these periods, total abundance was compared as well as the percentage of the potentially available seagrass habitat that was occupied by these beds. Potentially available habitat was defined as that which was within the depth limits of potentially sufficient light penetration for survival of the three dominant species of seagrasses (*Halodule wrightii, Syringodium filiforme, Thalassia testudinum*). An average depth of 6 ft was used as the approximation of the maximum penetration of this photosynthetically available radiation (PAR). The maximum depth of seagrass beds and the maximum depth of occurrence of seagrasses, as apparent from aerial photographs and existing mapping studies was also compared. This comparison covered several periods (1940-44, 1957-58, 1965-67, 1970-76, 1984-86, 1992) over approximately the last 50 years.

SAV abundance and depth distribution was assessed in the Indian River Lagoon, Banana River, and Mosquito Lagoon system from Jupiter Inlet to Ponce Inlet. SAV was analyzed separately for each of the six segments that have been defined for the system. The segments were further divided into 56 smaller subsegments for a more detailed assessments of area specific conditions throughout the system.

An assessment and inventory of readily available aerial photographs and sources of historical imagery applicable to SAV and other resource mapping studies was conducted within the region. Aerial photographic coverage was found to be available on a local basis within the counties of the system on a fairly consistent basis. This photography extended as far back as 1943 for almost all areas of the Lagoon, with coverage of most areas for all subsequent decades. It is not possible to obtain local coverage of all areas within a single year, except for 1992. However, the 1943-44, 1952-54, 1957-58, and 1984-86 periods provide full coverage. Coverage in the 1960s is sporadic, with a wide range of years necessary to cover all areas. Most of the region is covered between 1973-76, but coverage in Martin County and parts of Banana River exists only for 1970.

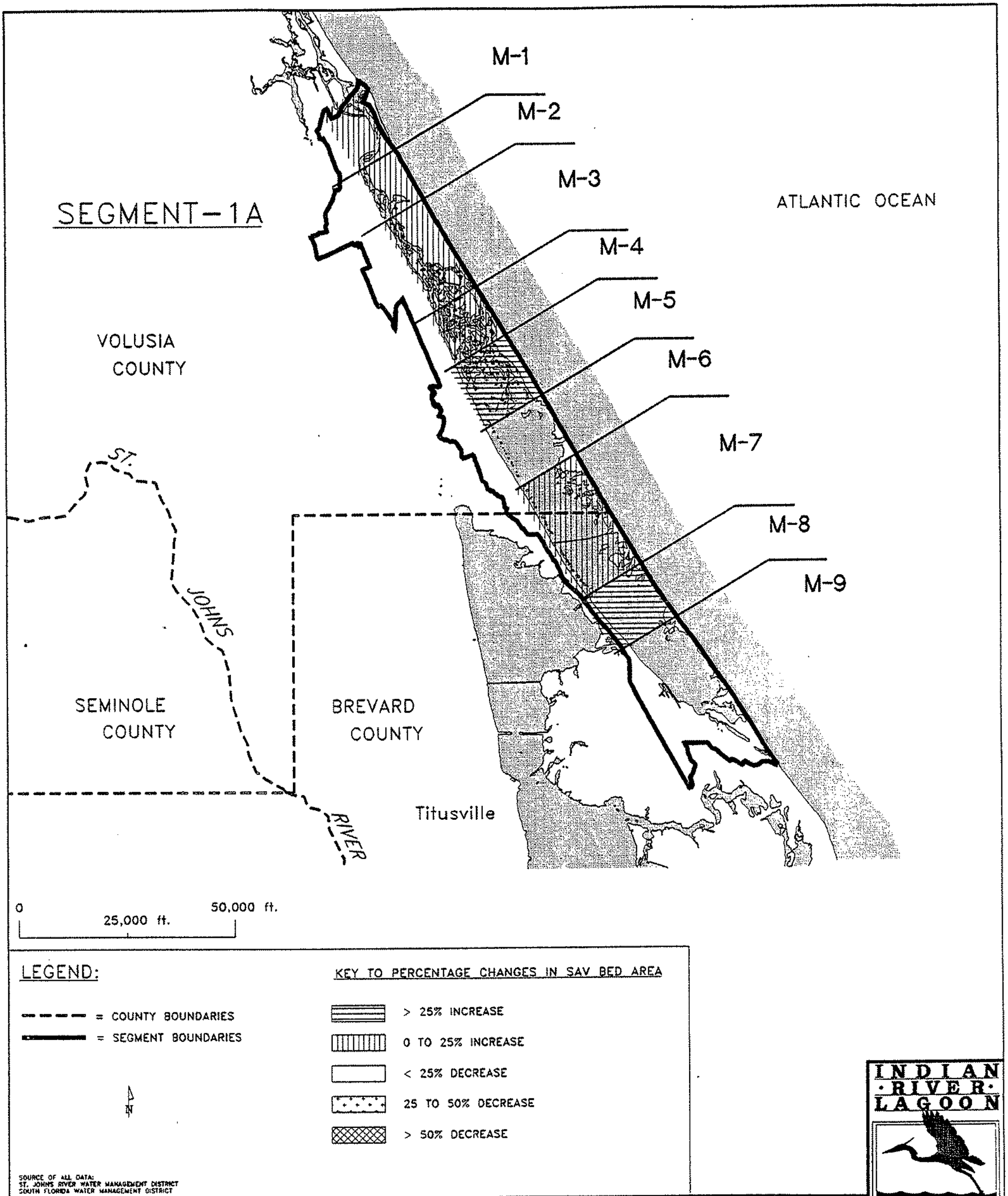
SAV apparently has decreased 11% system-wide since the 1970s. However, total acreage was higher 83,170 ac in 1986 than in either the 1970s 78,519 ac or 1992 70,139 ac. The greater abundance in 1986 may be due to better identification and/or an increased abundance of deep *Halophila* spp. and *Caulerpa prolifera* beds. As discussed in Section 7.1.1, the variation among these years, as well as variation noted among closely spaced years such as in Mosquito Lagoon in the 1973-76 period, indicates that periodic variation may occur and that long term trends may not be apparent from just two or three observations.

Trends in SAV abundance appear to be present in some smaller portions of the system. In particular, decreases of 38 and 42% have occurred in the North Central Indian River (Segment 2 - Melbourne Causeway to Sebastian Inlet) and North Indian River (Section 1A - Turnbull Creek to Melbourne Causeway) segments. Some of the decrease in the North Indian River segment appears to be due to a decrease in deep beds south of Turnbull Creek, possibly a response to a major storm in 1991. Figure 10-1 shows the trends and subsegments of the Lagoon.

However, the portion of the Indian River Lagoon from NASA Causeway to Grant Farm Island (I5 to I14) has experienced decreases of 31 to 83%. The decreases in this area represent a long-term trend. In most subsegments within this portion, cover progressively has decreased from the 1970s through the 1980s, with the lowest coverage in 1992.

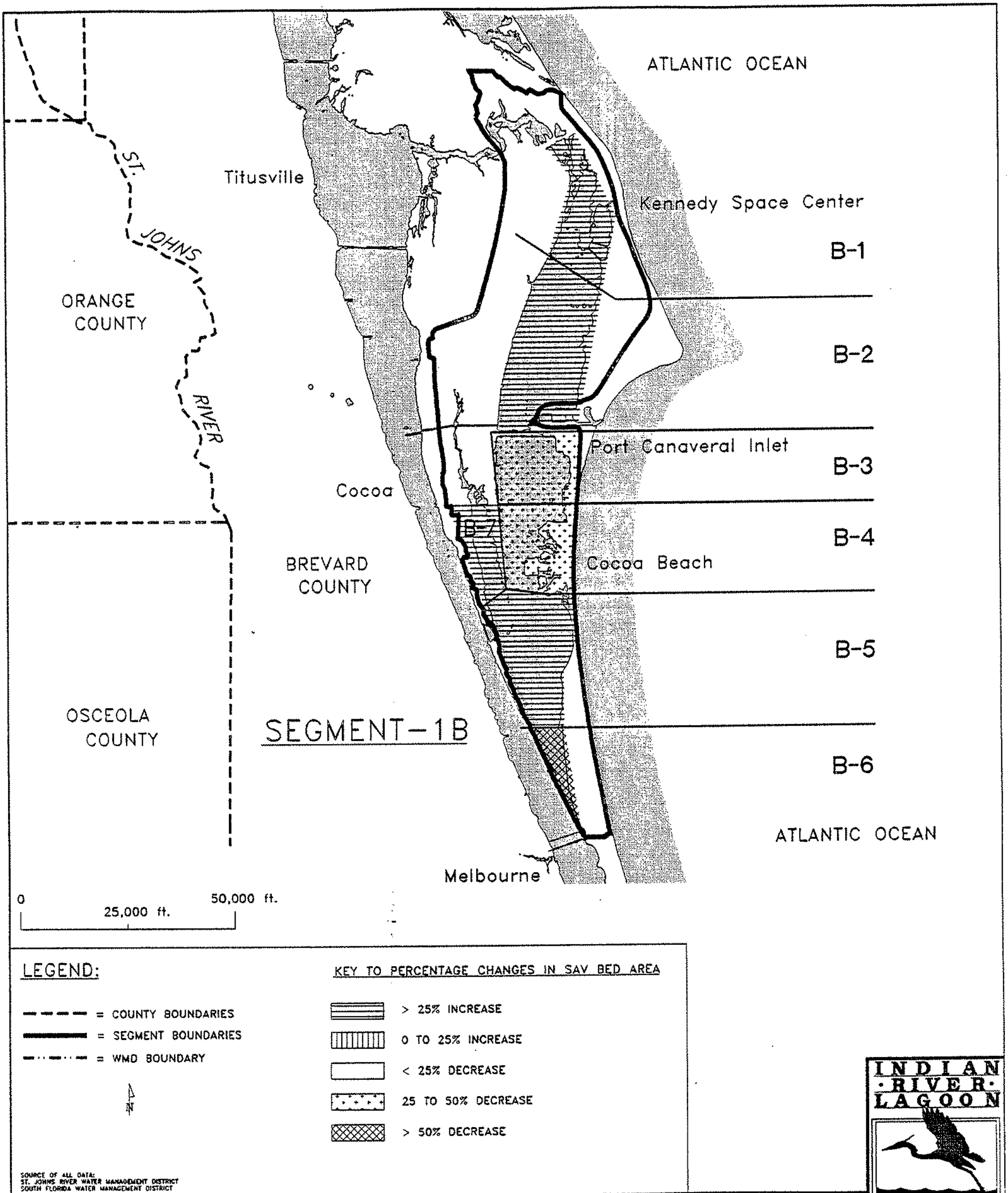
Trends in maximum depth of the outer edge of the seagrass beds supports the concept of a long-term decreasing trend in this area. The decrease in average maximum depth of the beds varied between 3 and 19% in Segments 1B (Banana River), 1A (Mosquito Lagoon), and 4 (South Indian River) in the 1943 to 1992 period. In Segment 1C (North Indian River), the change was a 50% decrease from 1943 to 1992, with a steady decrease over this period. Similar steady decreases with a maximum loss of 37% in area occurred in Segment 2 (North Central Indian River) and 44% in Segment 3 (South Central Indian River).

The prolonged decrease (continuing over a 20 to 40 year period) in SAV acreage and depth SAV occurs in the central part of Indian River Lagoon indicates a long-term trend of seagrass decline in this area related to an inability to survive in deeper water. The SAV Initiative has demonstrated that depth of seagrass occurrence is a function of light penetration into water, and that light penetration is a function of water quality. Thus there appears to



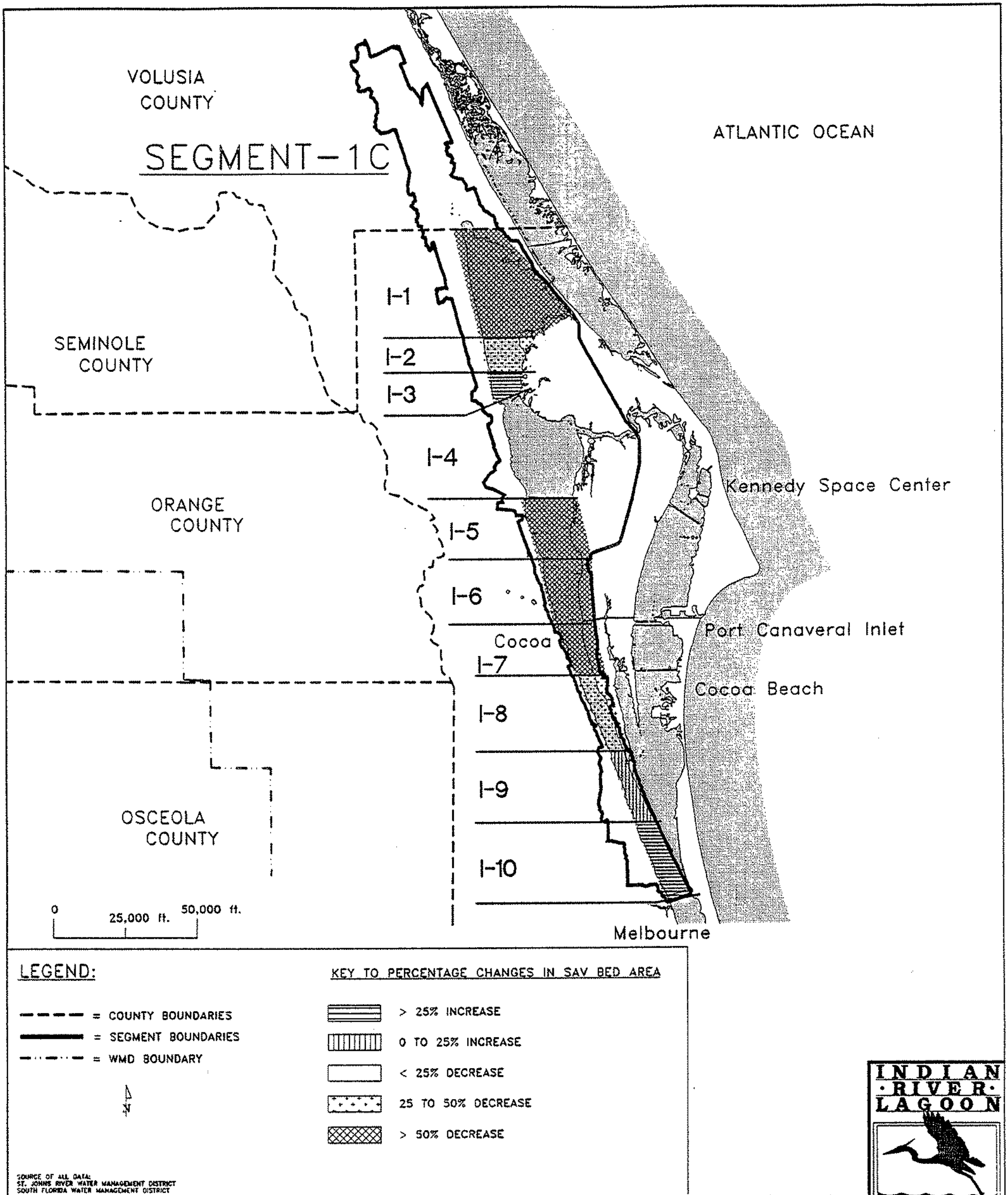
•Woodward–Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: GRASS07.DWG DATE: 7-13-94	FIGURE 10-1	SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 1A)

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



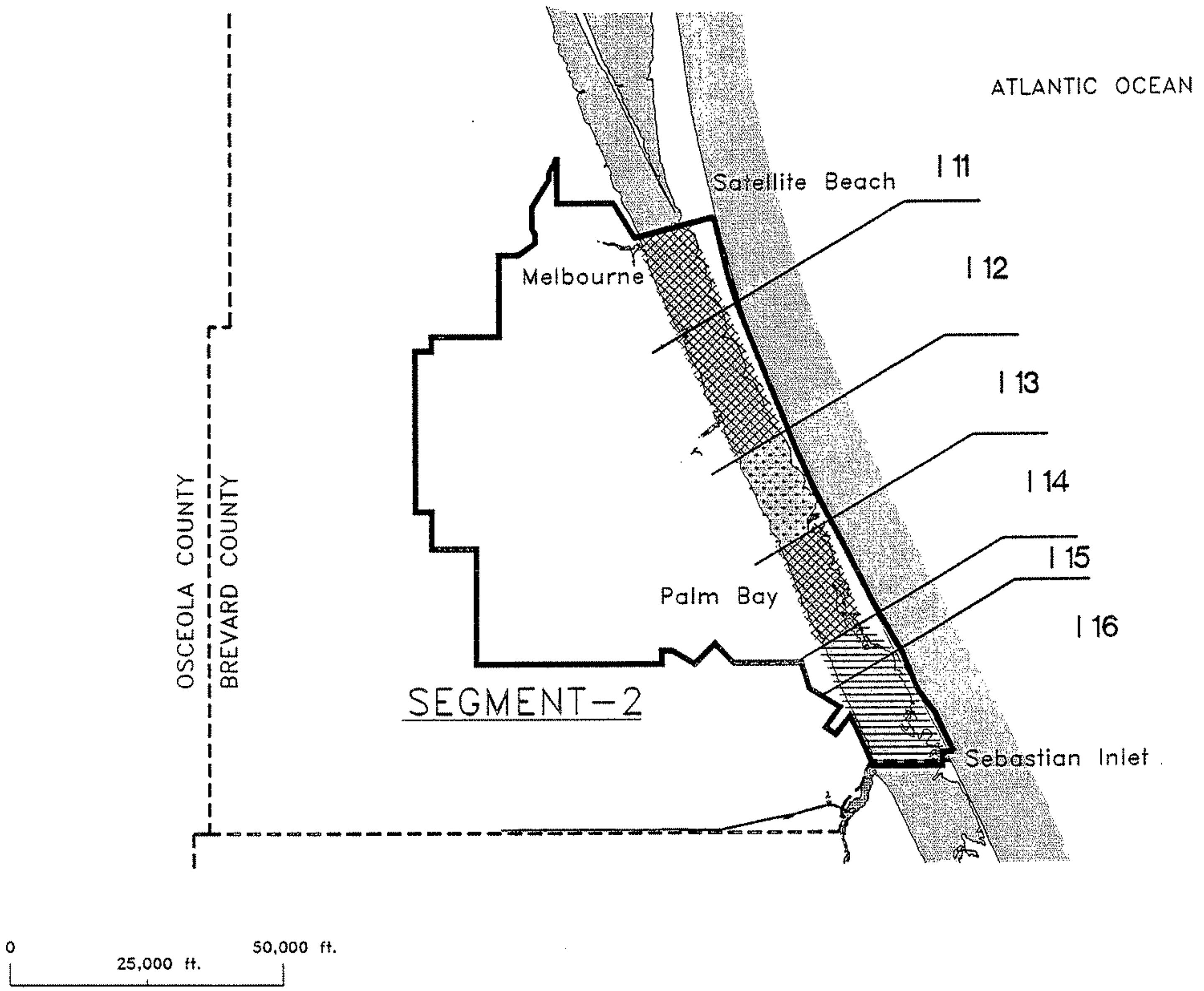
INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: GRASS08.DWG DATE: 7-13-94	FIGURE 10-2	SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 1B)



•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: GRASS09.DWG DATE: 7-13-94	FIGURE 10-3	SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 1C)

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



LEGEND:

- - - - = COUNTY BOUNDARIES
▬▬▬ = SEGMENT BOUNDARIES

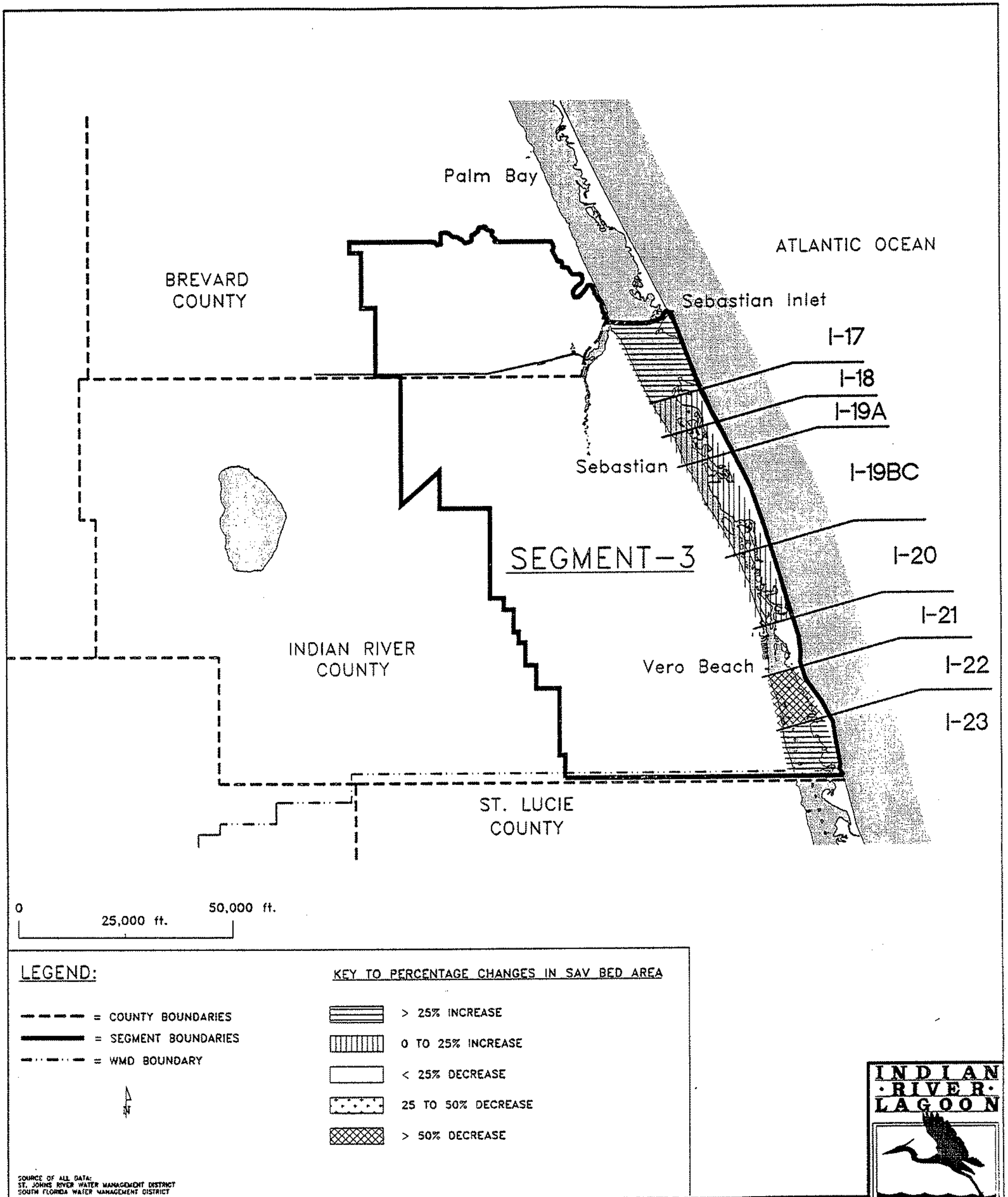
KEY TO PERCENTAGE CHANGES IN SAV BED AREA

- > 25% INCREASE
- 0 TO 25% INCREASE
- < 25% DECREASE
- 25 TO 50% DECREASE
- > 50% DECREASE

SOURCE OF ALL DATA:
ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

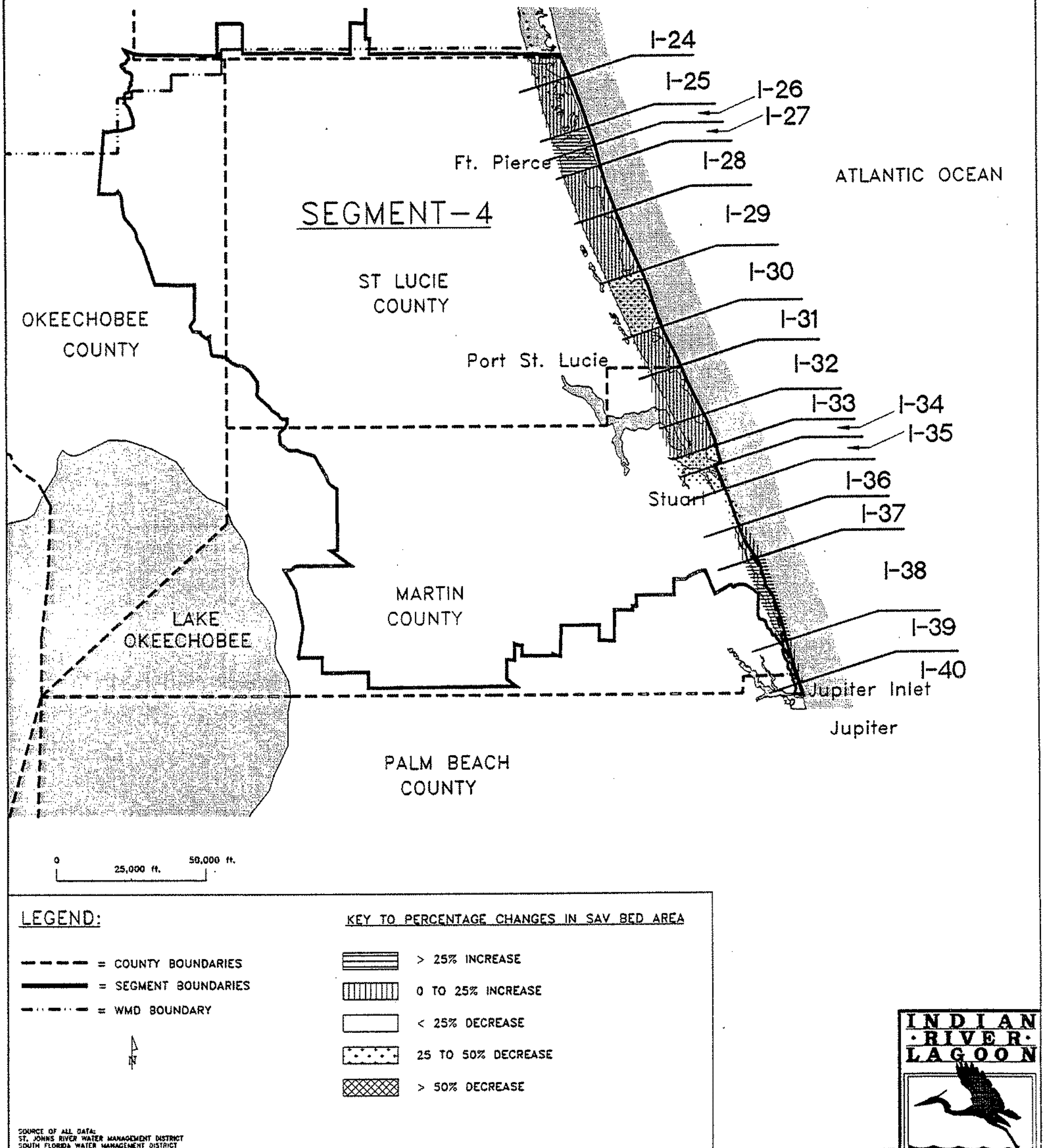
•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: GRASS010.DWG DATE: 7-13-94	FIGURE 10-4	SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 2)

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



•Woodward-Clyde Consultants •Marshall McCully & Associates •Natural Systems Analysts	DRAWING NO.: GRASS011.DWG DATE: 7-13-94	FIGURE 10-5	SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 3)

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM



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•Marshall McCully & Associates
•Natural Systems Analysts

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FIGURE 10-6 SUMMARY OF SEAGRASS CHANGES BETWEEN THE 1970S AND 1992 IN THE INDIAN RIVER LAGOON COMPLEX (SEGMENT 4)

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

be a cause and effect relationship between declining water quality and declining seagrasses in Segments 1A, 2, and possibly 3. Portions of Segments 1A, 2, and 3 have had the greatest long-term percentage declines in seagrass cover. Since these portions account for approximately 27% of the potentially available habitat in the Indian River Lagoon system, the seagrass decline in these areas is a cause of concern.

Seagrass status in the remaining segments appears to be generally stable, although some variation does occur. These variations appear related to sampling or interpretive differences among years, variation in deep-water seagrass and algal species between years, or seagrass reaction to site- and time-specific sporadic events such as individual storms. Some changing patterns of species composition and of seagrass/algal composition appear to be occurring in parts of the system, particularly in the Banana River, but existing data is insufficient to adequately describe any trends.

Lastly, seagrasses appear to cover a relatively small amount of potentially available habitat deeper than the 6 ft depth. Less than 40% of this available habitat in the Lagoon is covered by SAV. The greatest coverage is in Mosquito Lagoon (Segment 1A), Banana River (Segment 1B), and North Indian River (Segment 1C), where total cover has ranged between 25 and 51%. Lowest coverage is in the North Central Indian River (Segment 2) and South Central Indian River (Segment 3), where during the time periods reviewed by this project it has never been above 20%. These numbers indicate that additional environmental factors such as substrate type or salinity may also be influencing seagrass abundance and distribution.

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FIGURE A-1. SEAGRASS BED COVER IN THE OAK HILL QUADRANGLE FROM 1943 TO 1992.
a) 1943

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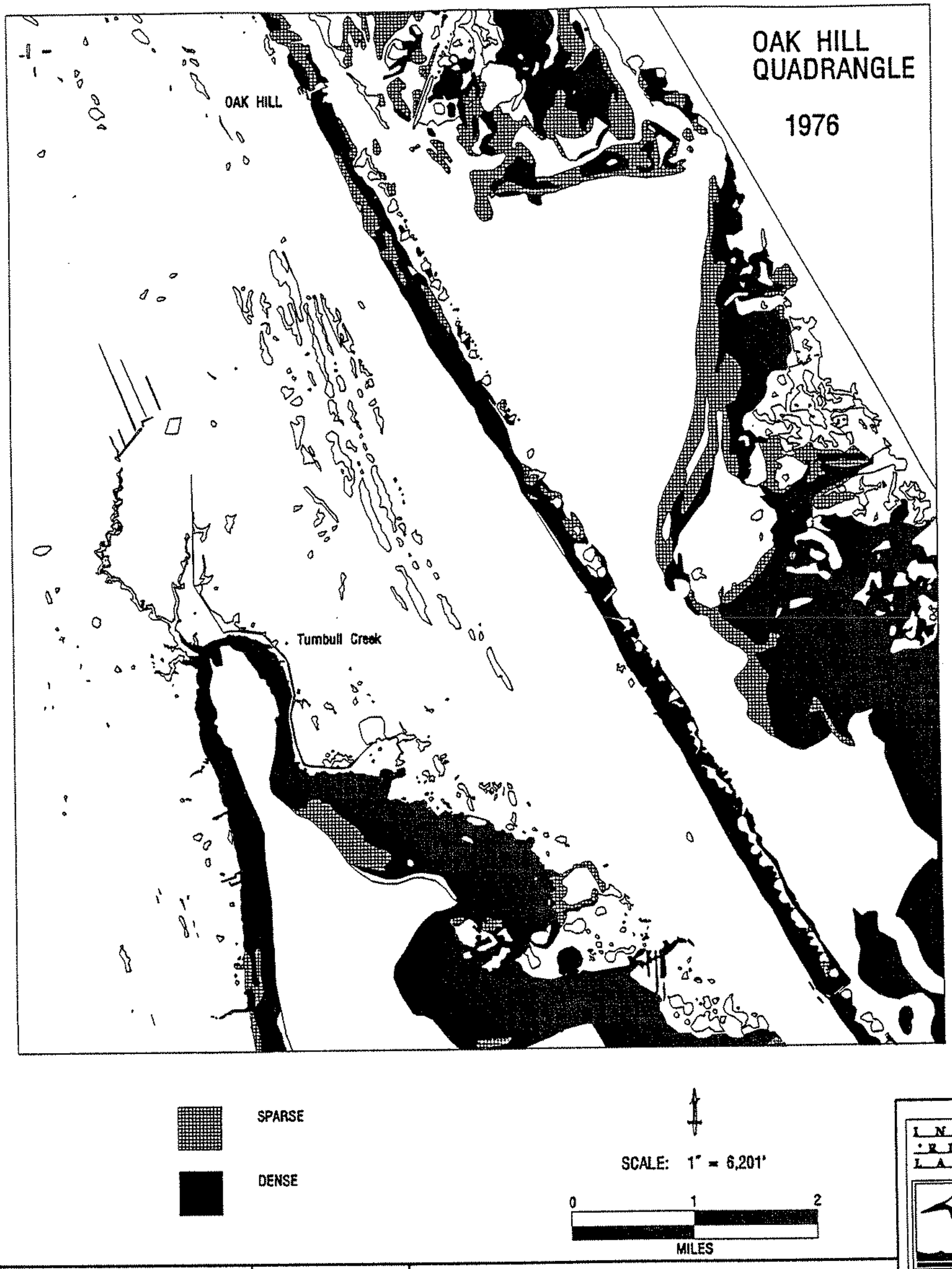

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* Natural Systems Analysts

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DATE:	

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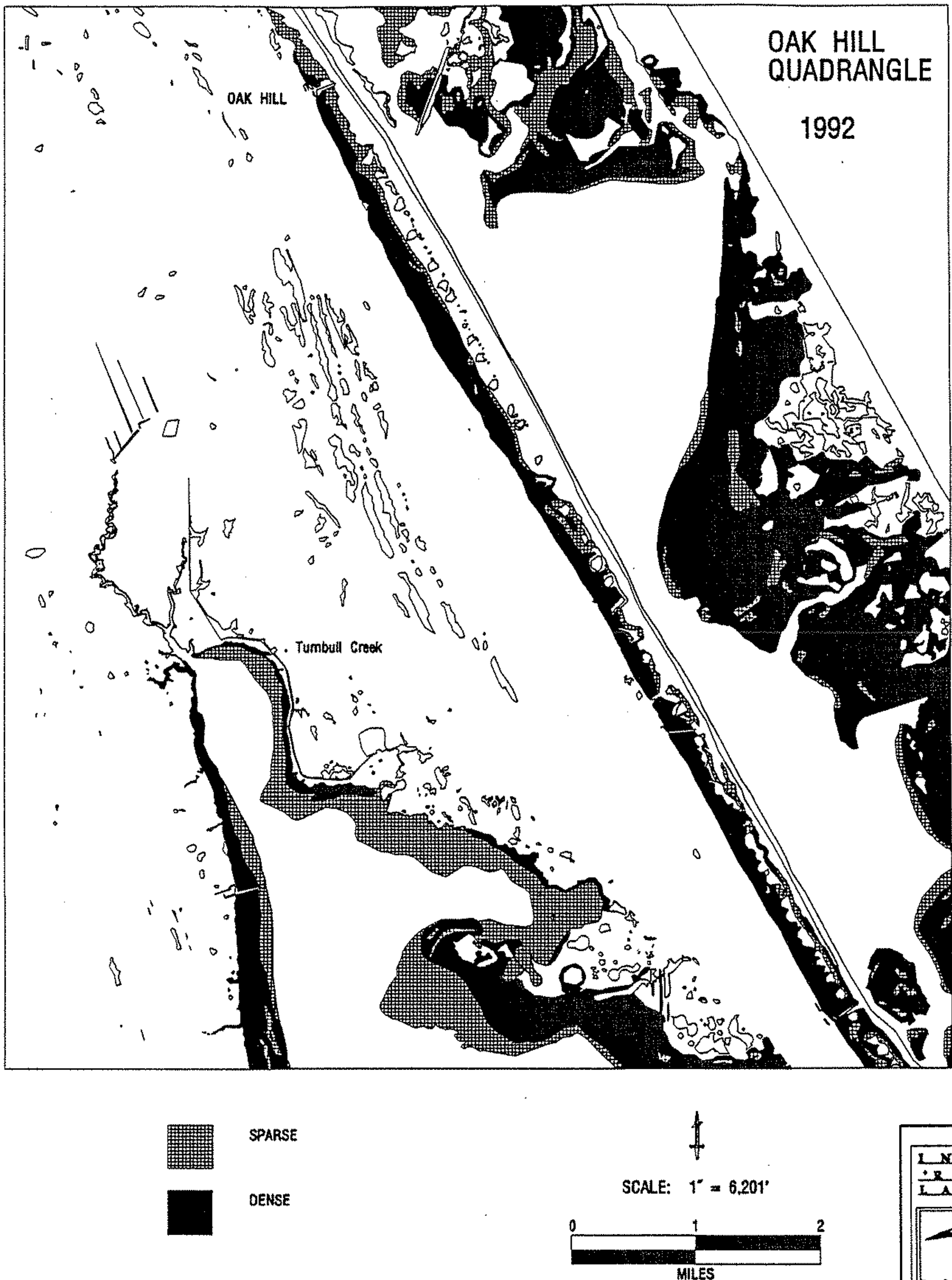

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FIGURE A-1. SEAGRASS BED COVER IN THE OAK HILL QUADRANGLE FROM 1943 TO 1992.
c) 1992

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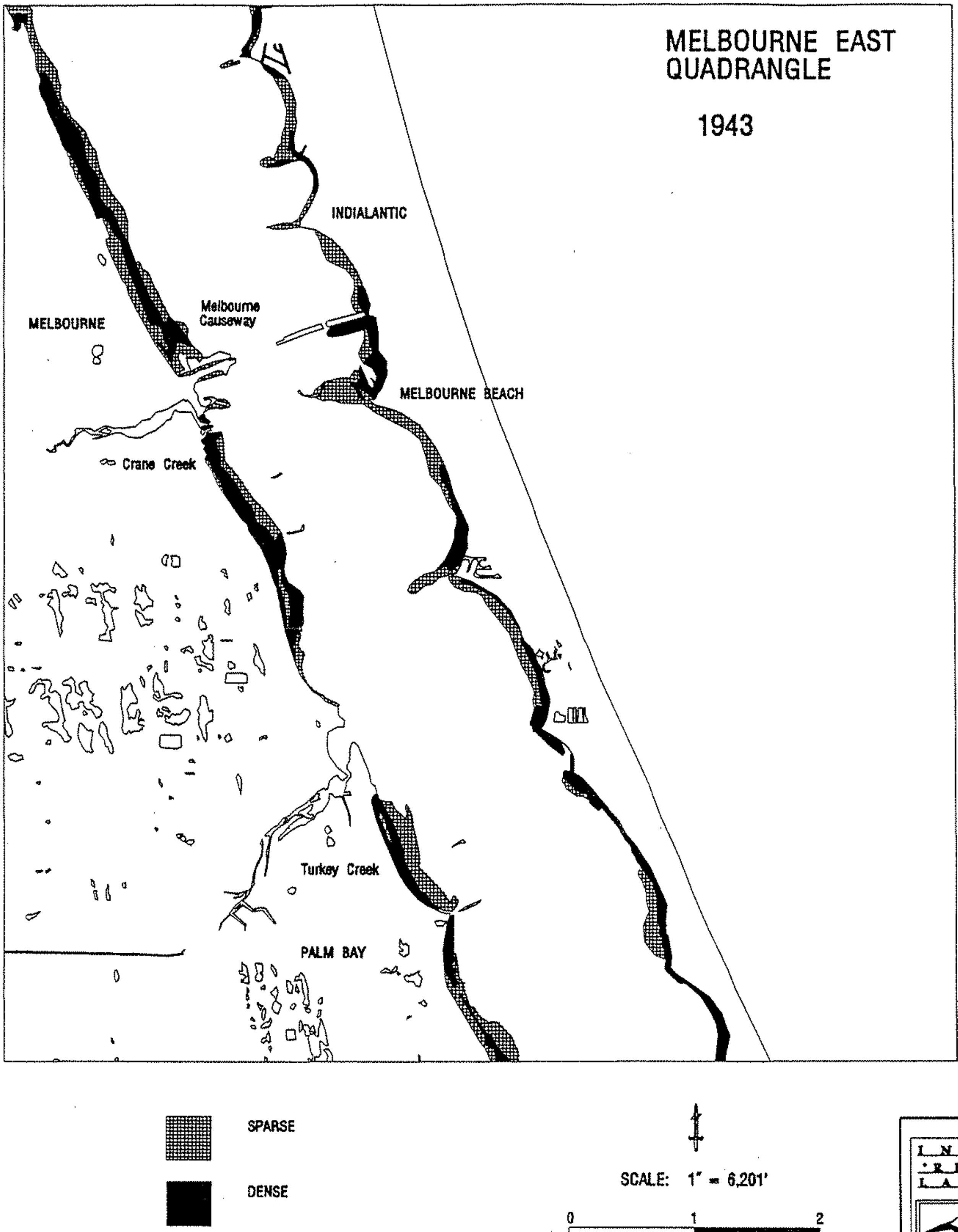

* Woodward-Clyde Consultants * Marshall McCully & Associates * Natural Systems Analysts	DRAWING NO.:	FIGURE A-2.	SEAGRASS BED COVER IN THE MELBOURNE EAST QUADRANGLE FROM 1943 TO 1992. a) 1943
	DATE:		

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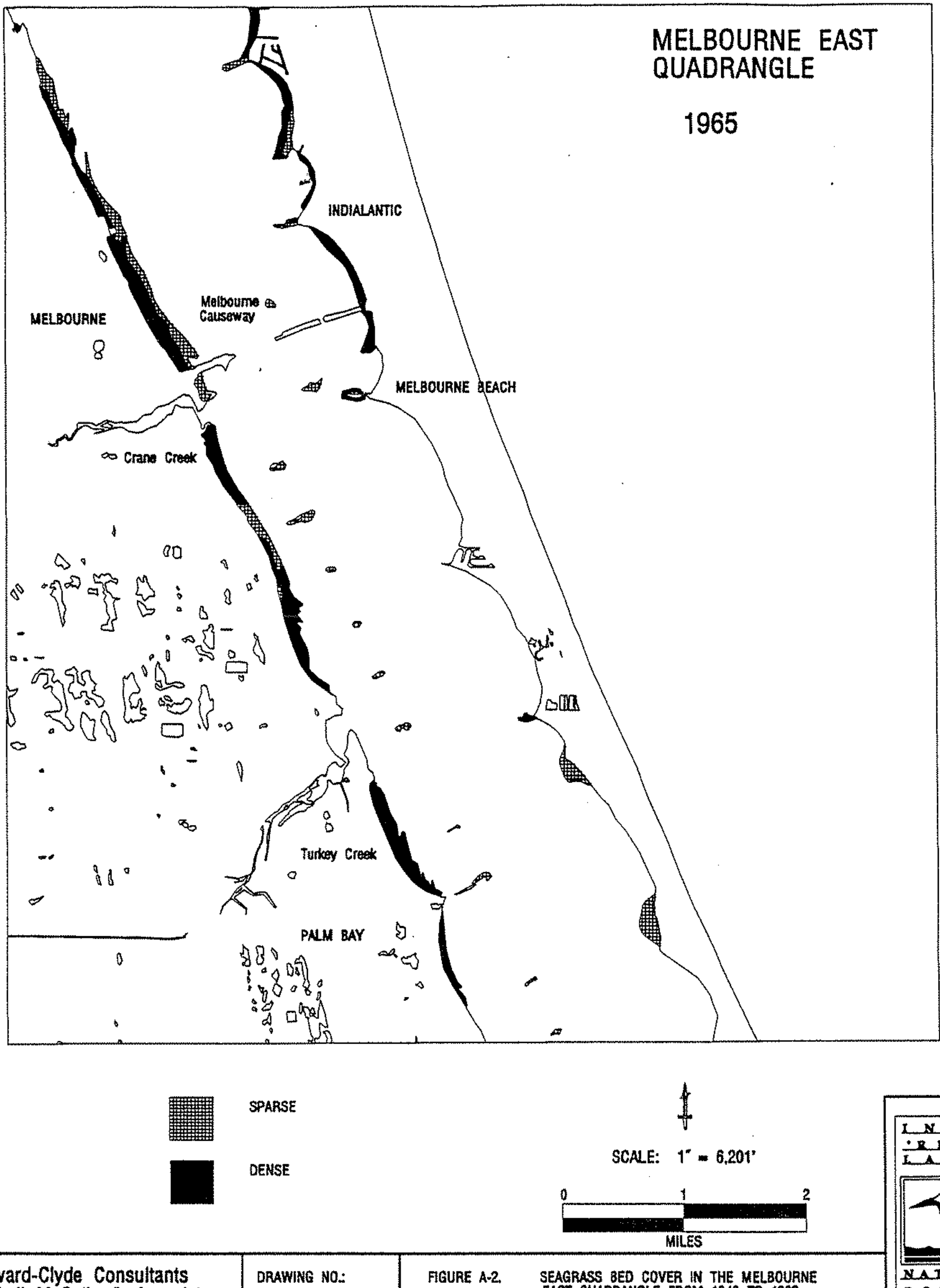

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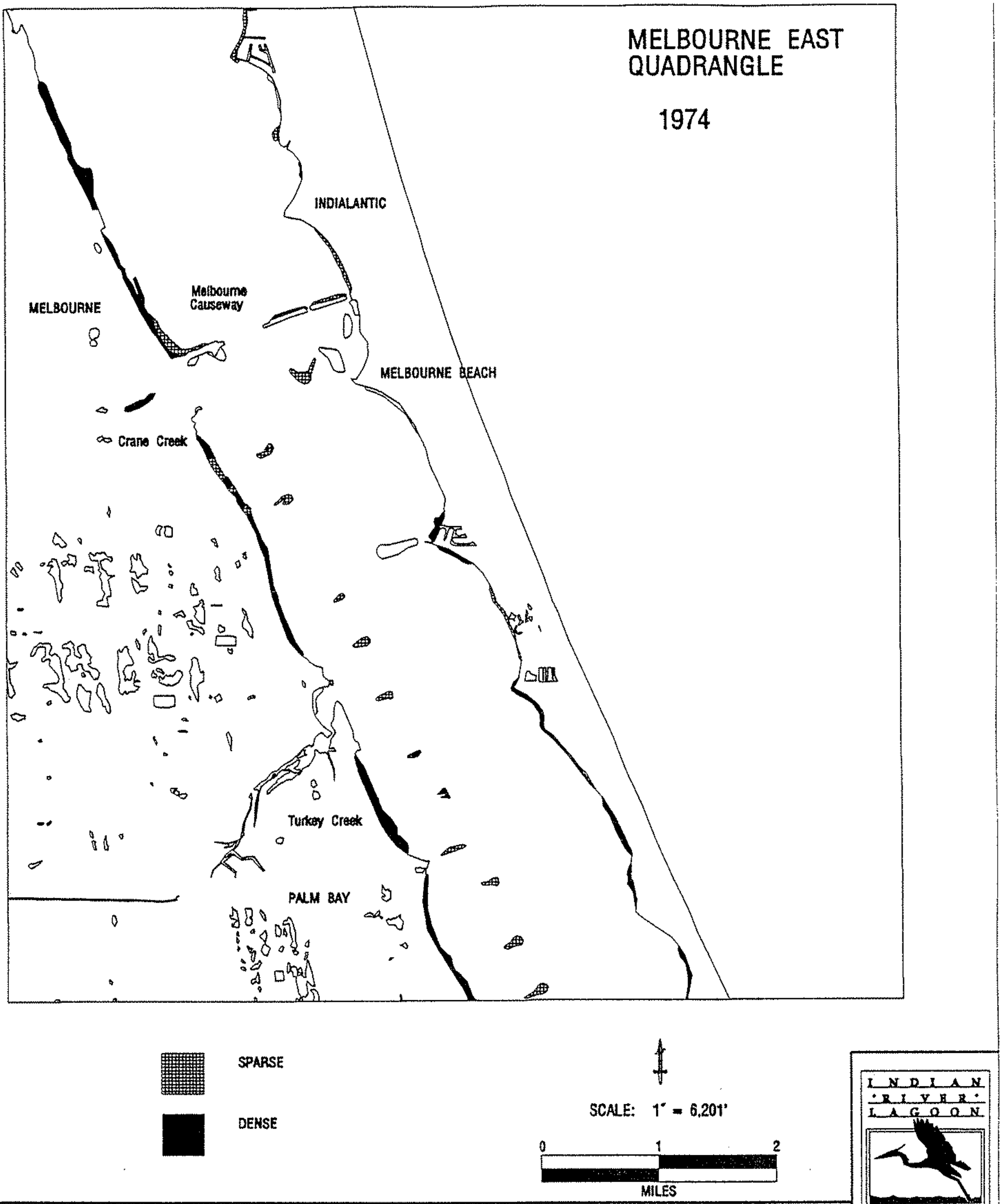
FIGURE A-2. SEAGRASS BED COVER IN THE MELBOURNE EAST QUADRANGLE FROM 1943 TO 1992.
b) 1965



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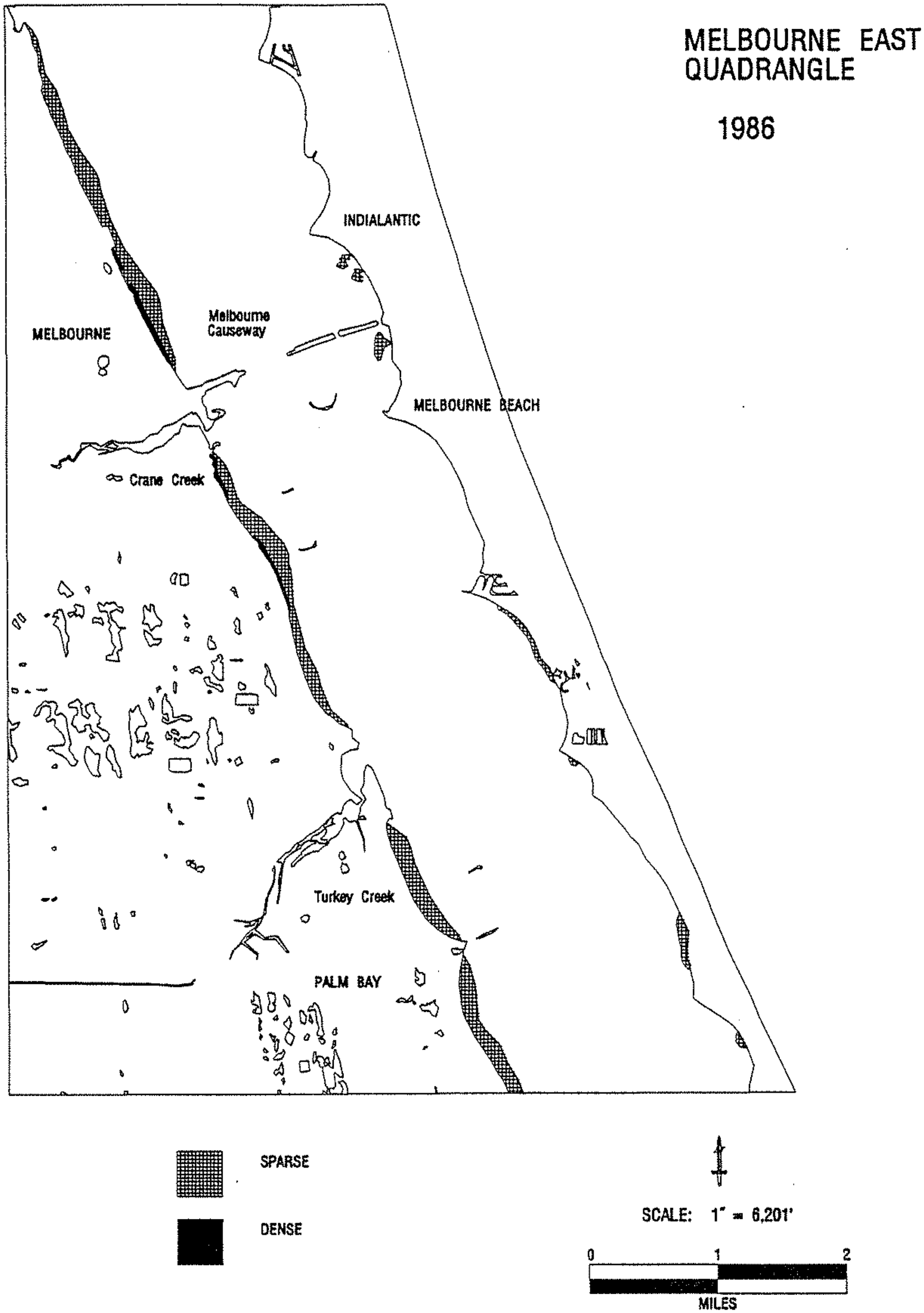

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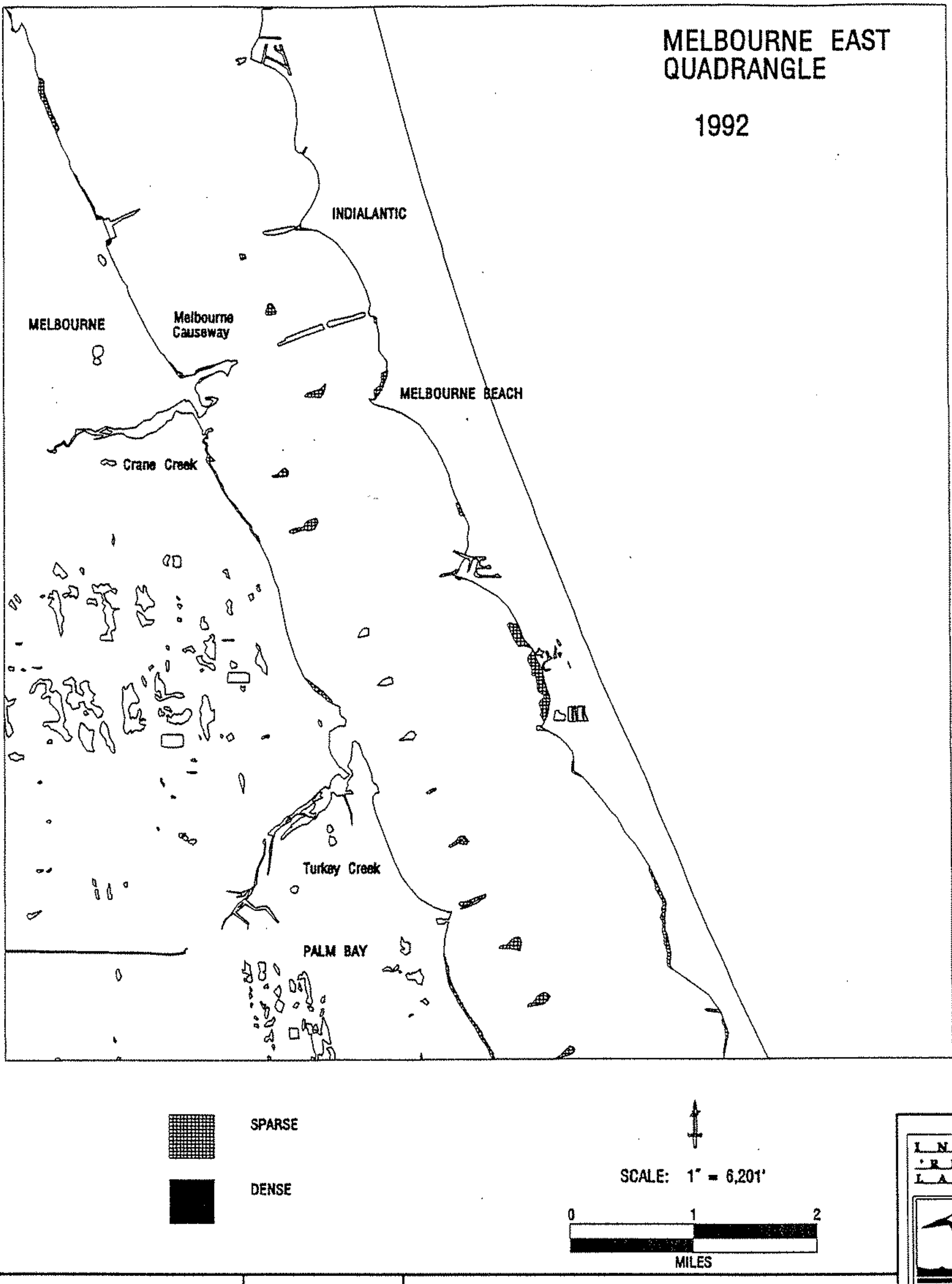

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FIGURE A-2. SEAGRASS BED COVER IN THE MELBOURNE EAST QUADRANGLE FROM 1943 TO 1992.
e) 1992

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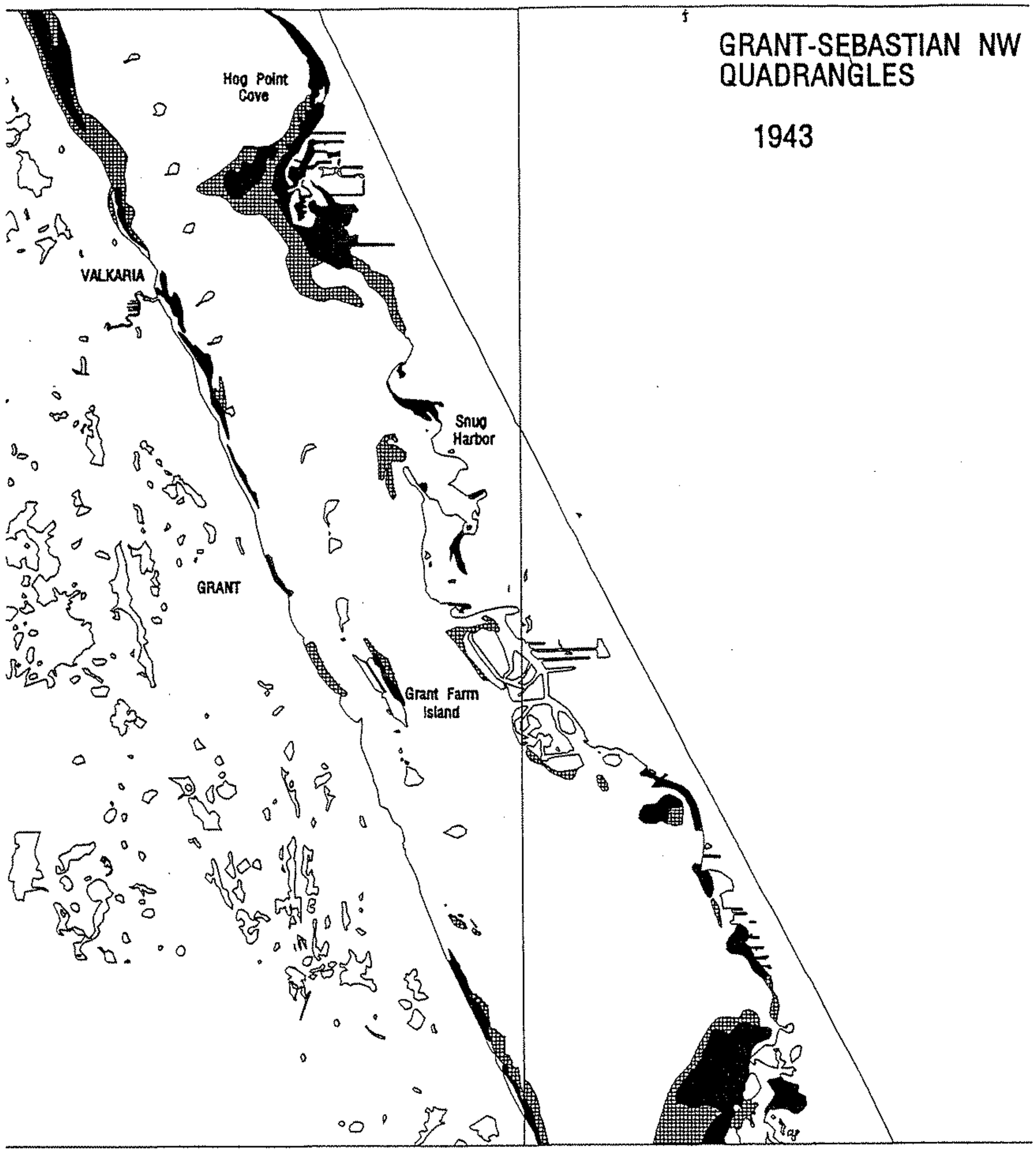

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FIGURE A-3. SEAGRASS BED COVER IN THE GRANT AND SEBASTIAN NW QUADRANGLES FROM 1943 TO 1992. b) 1974

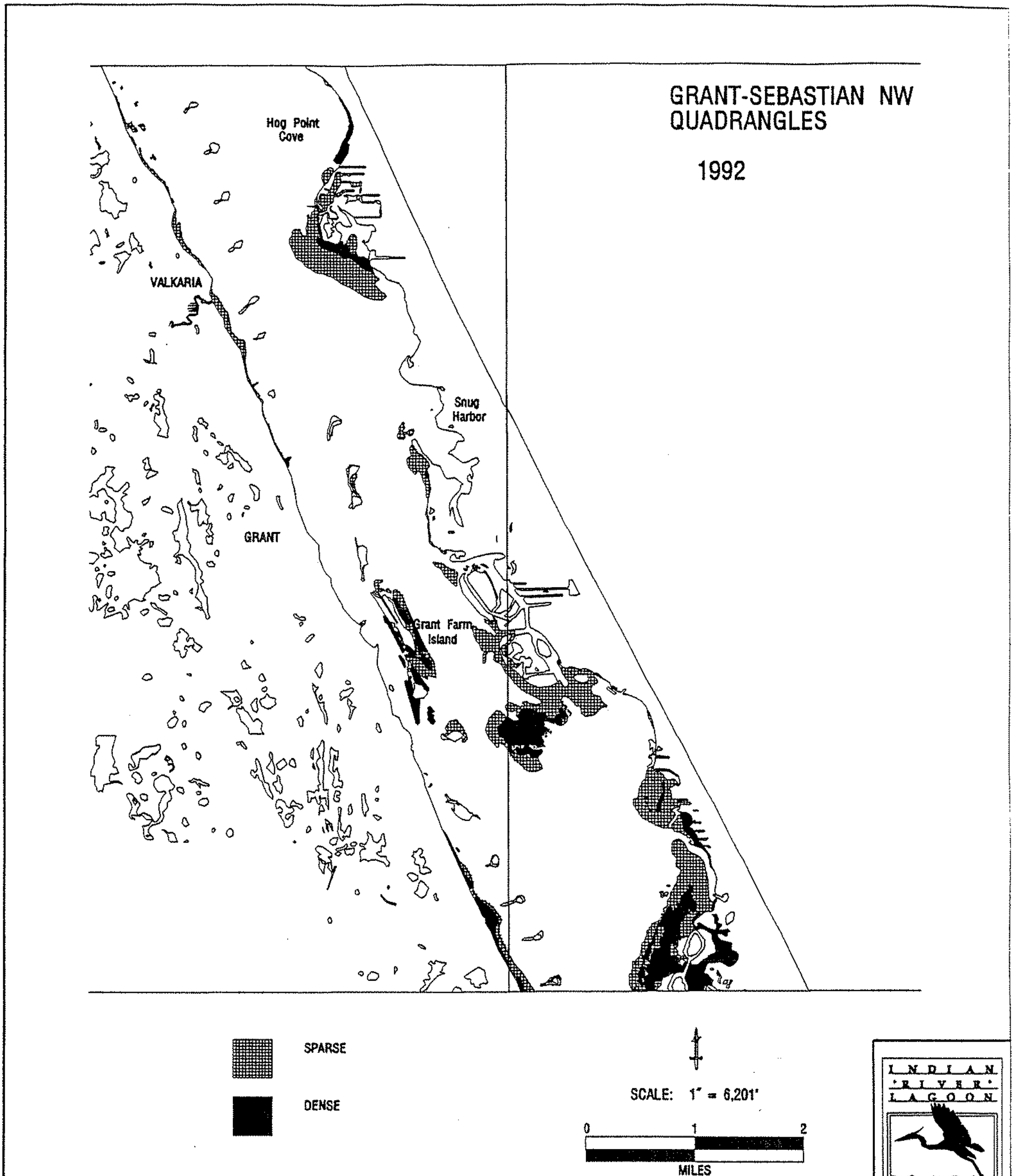

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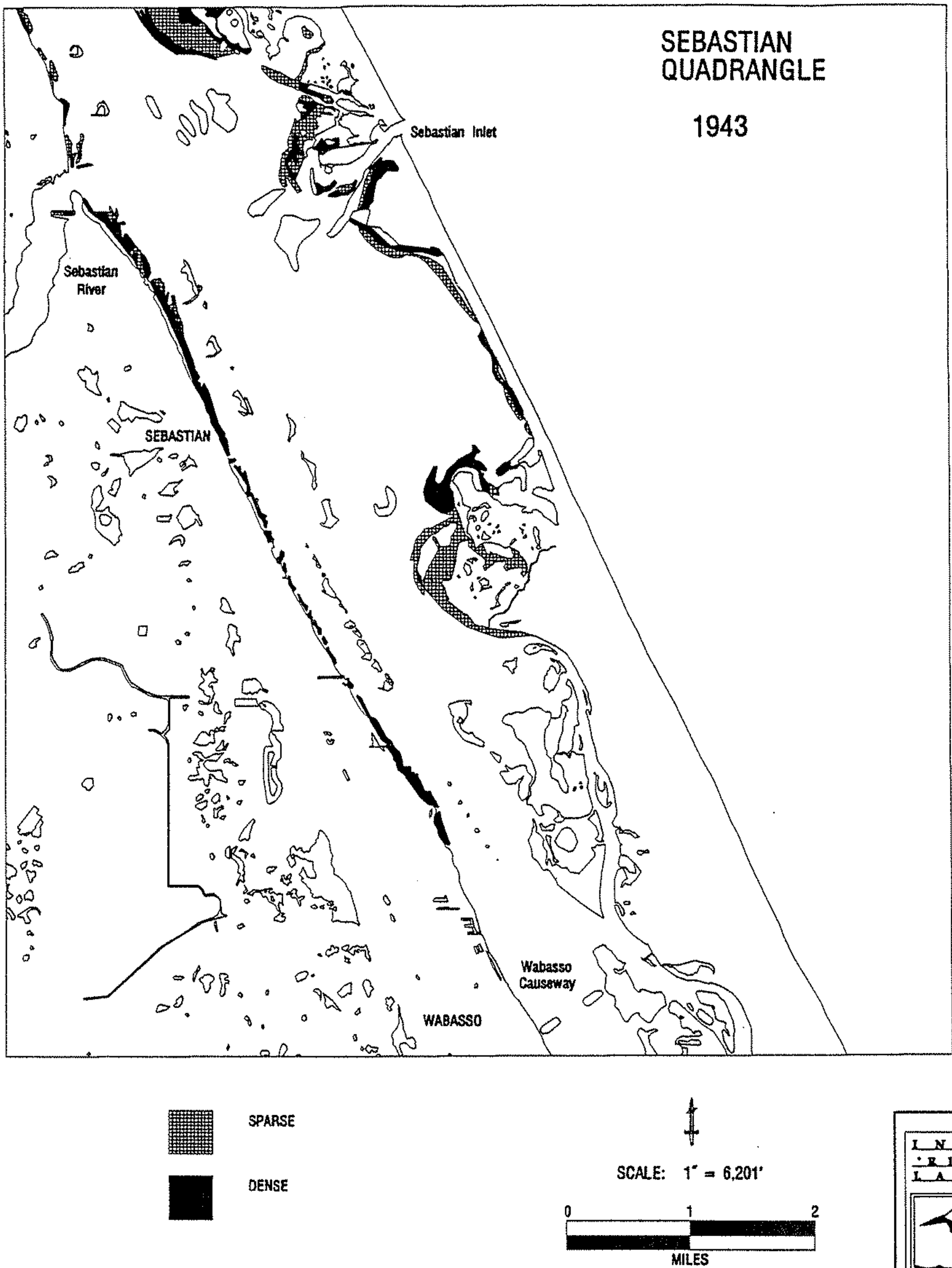
FIGURE A-3. SEAGRASS BED COVER IN THE GRANT AND SEBASTIAN NW QUADRANGLES FROM 1943 TO 1992. c) 1992.



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* Woodward-Clyde Consultants * Marshall McCully & Associates * Natural Systems Analysts	DRAWING NO.: DATE:	FIGURE A-4. SEAGRASS BED COVER IN THE SEBASTIAN QUADRANGLE FROM 1943 TO 1992. a) 1943

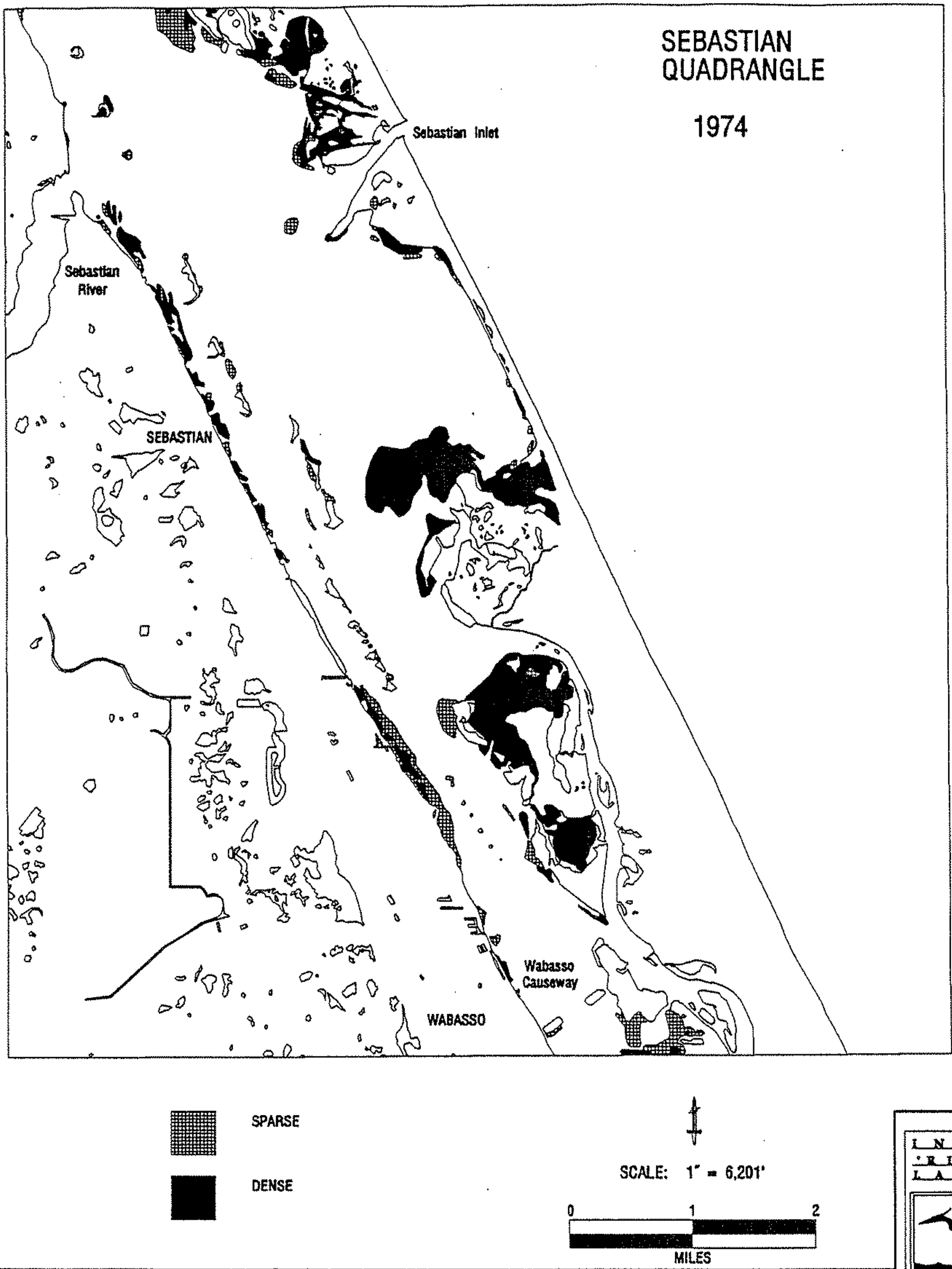

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FIGURE A-4. SEAGRASS BED COVER IN THE SEBASTIAN QUADRANGLE FROM 1943 TO 1992.
b) 1974

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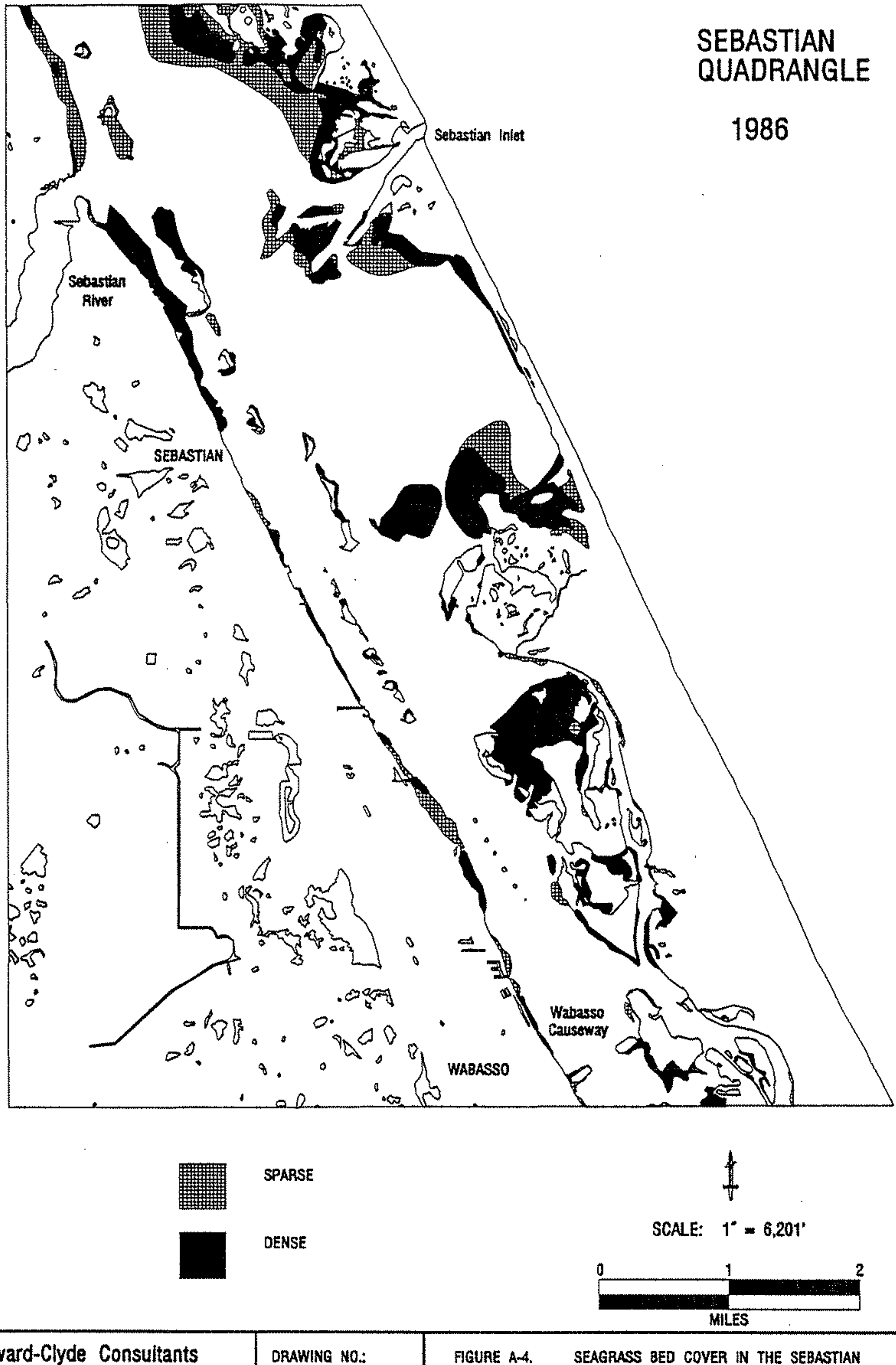

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FIGURE A-4. SEAGRASS BED COVER IN THE SEBASTIAN QUADRANGLE FROM 1943 TO 1992.
c) 1986

INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM

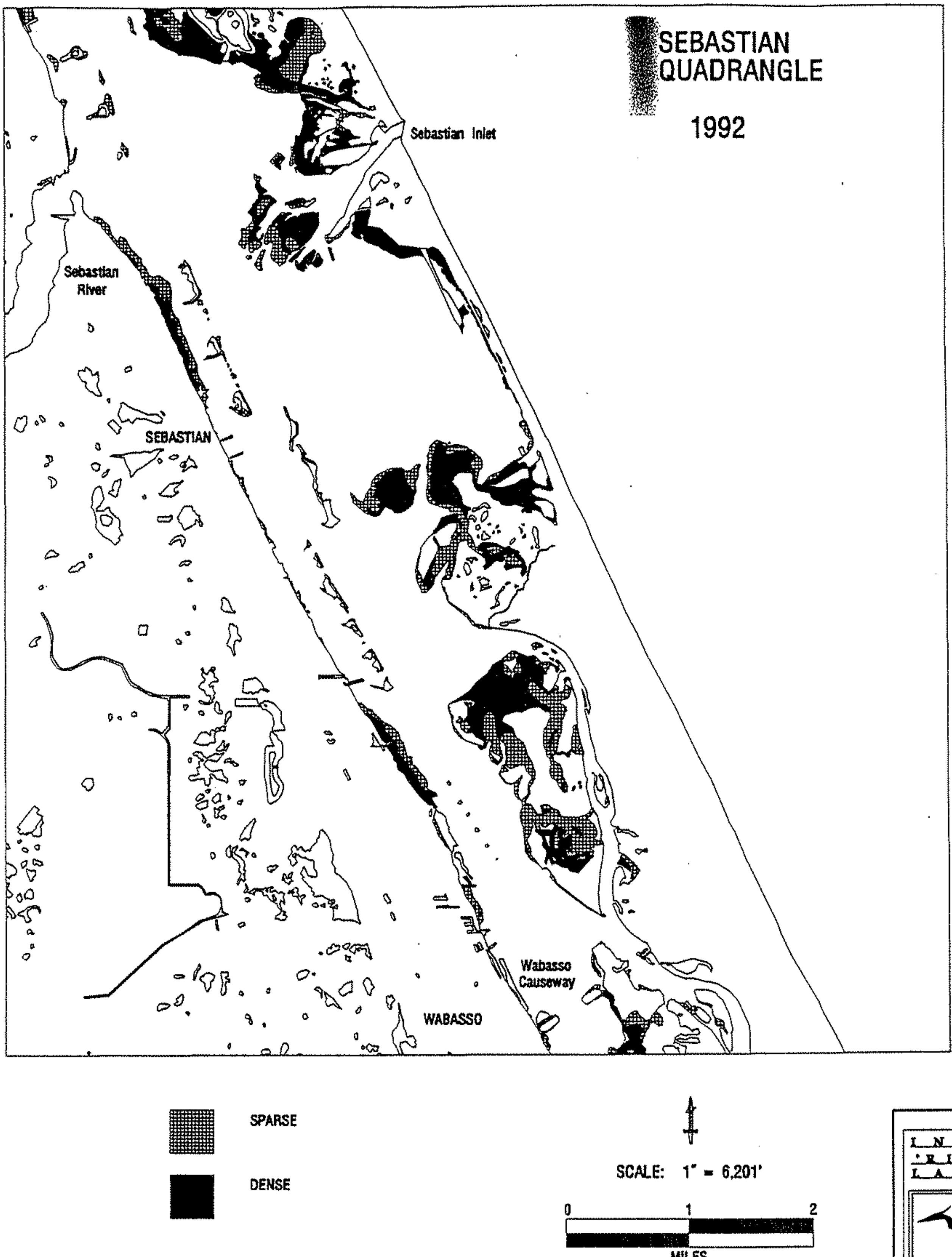

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FIGURE A-4. SEAGRASS BED COVER IN THE SEBASTIAN QUADRANGLE FROM 1943 TO 1992.
d) 1992

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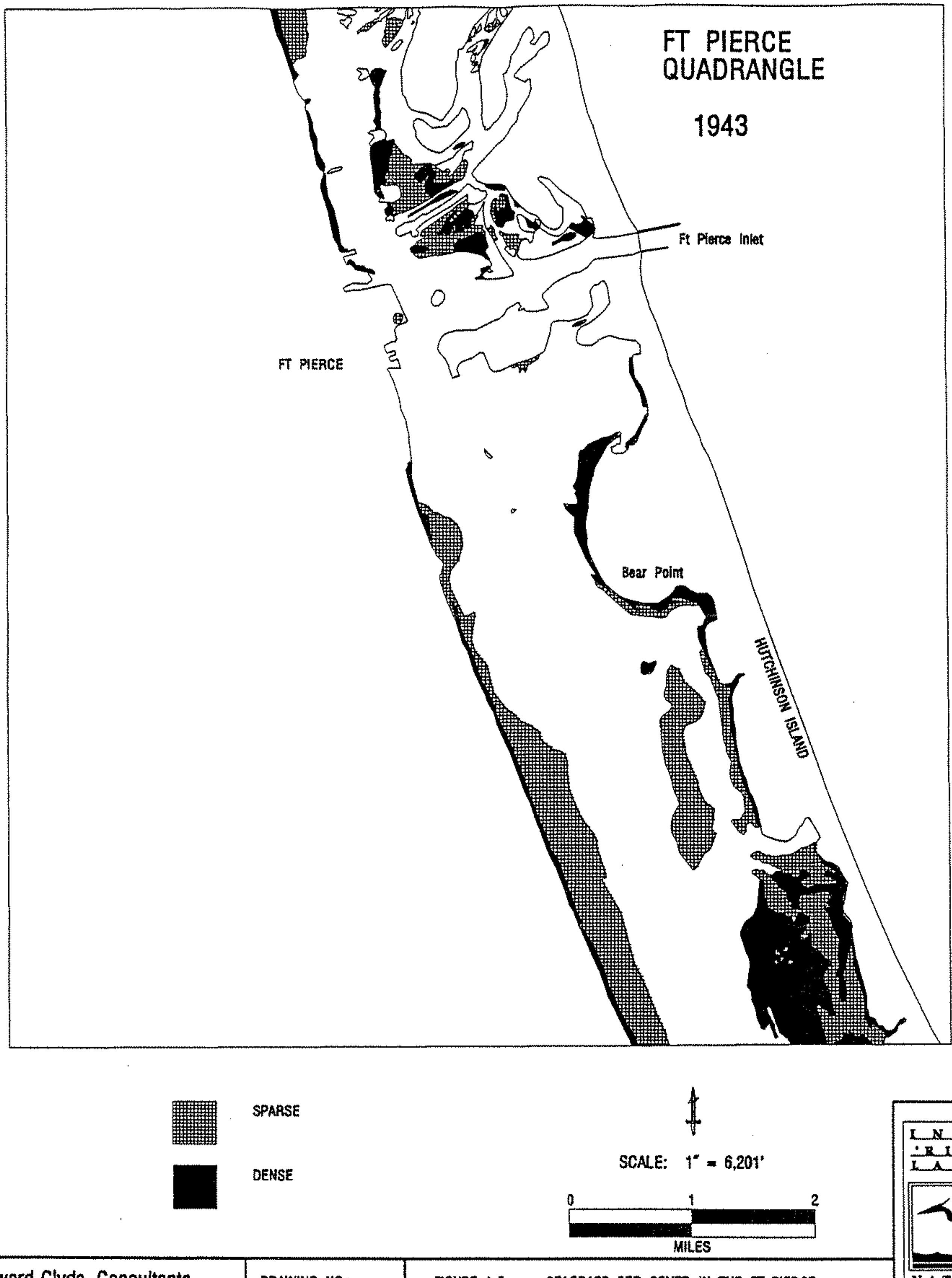

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FIGURE A-5. SEAGRASS BED COVER IN THE FT PIERCE QUADRANGLE FROM 1943 TO 1992.
a) 1943

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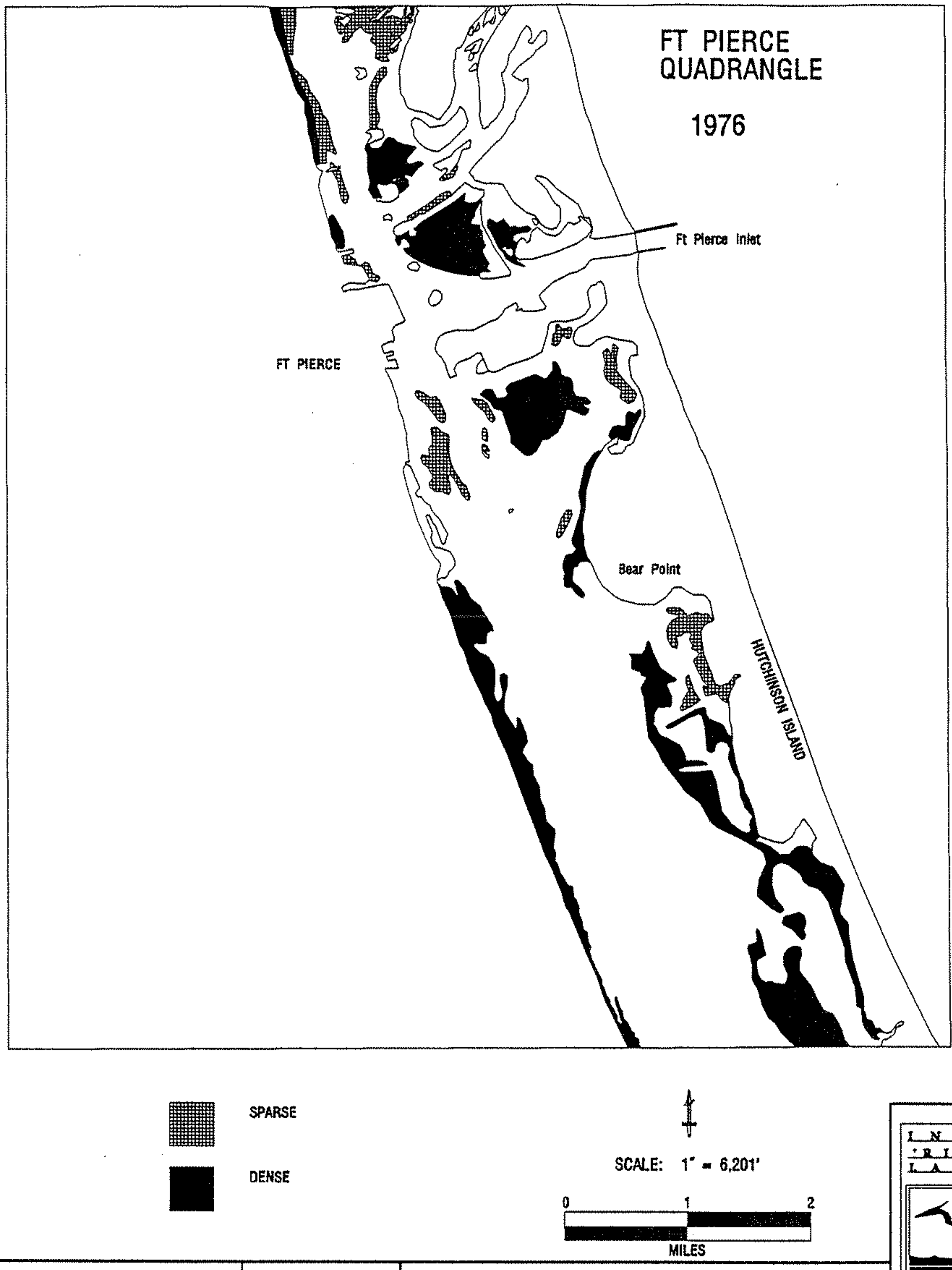

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FIGURE A-5. SEAGRASS BED COVER IN THE FT PIERCE QUADRANGLE FROM 1943 TO 1992.
b) 1976

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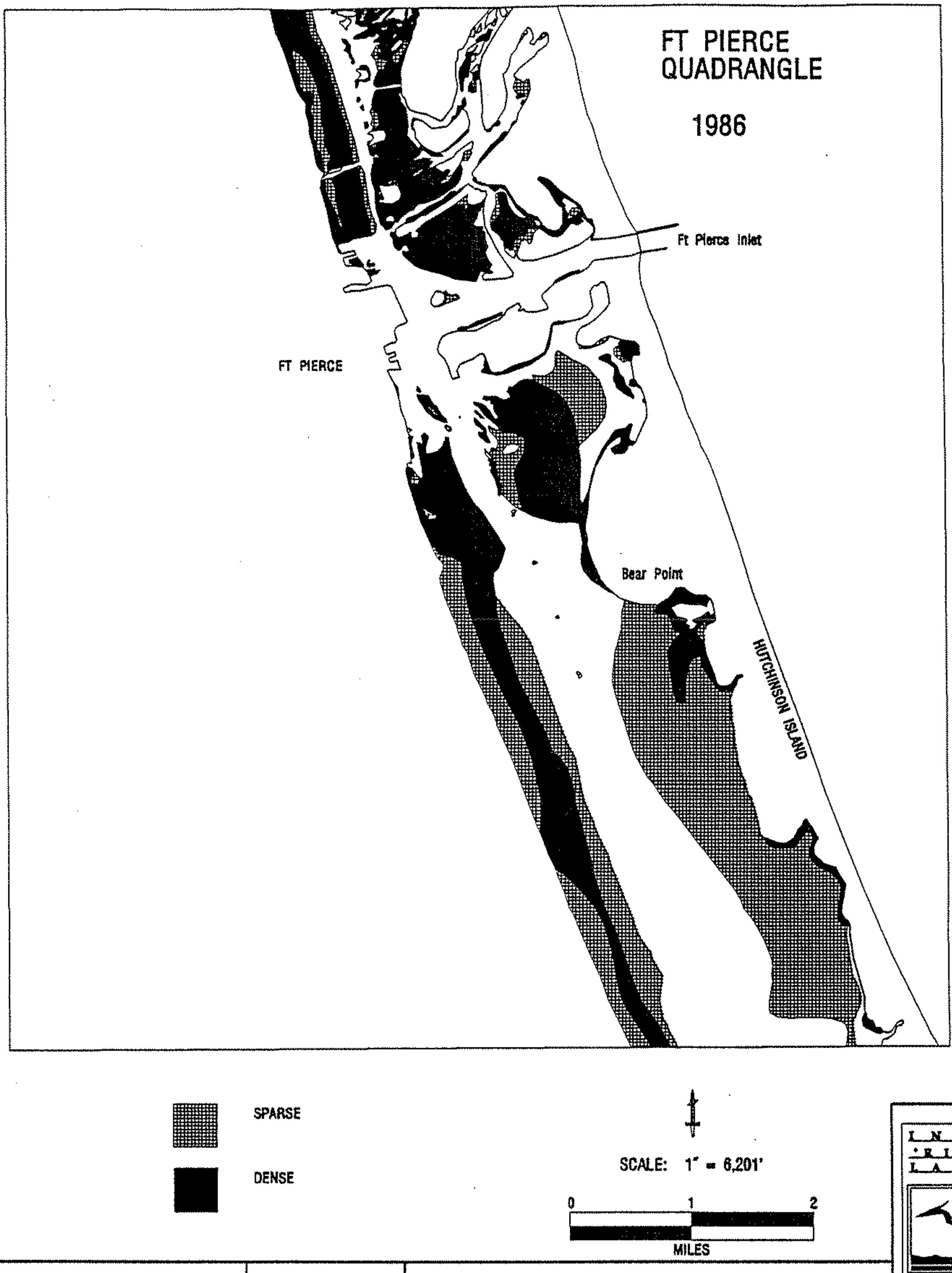

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FIGURE A-5. SEAGRASS BED COVER IN THE FT PIERCE QUADRANGLE FROM 1943 TO 1992.
c) 1986

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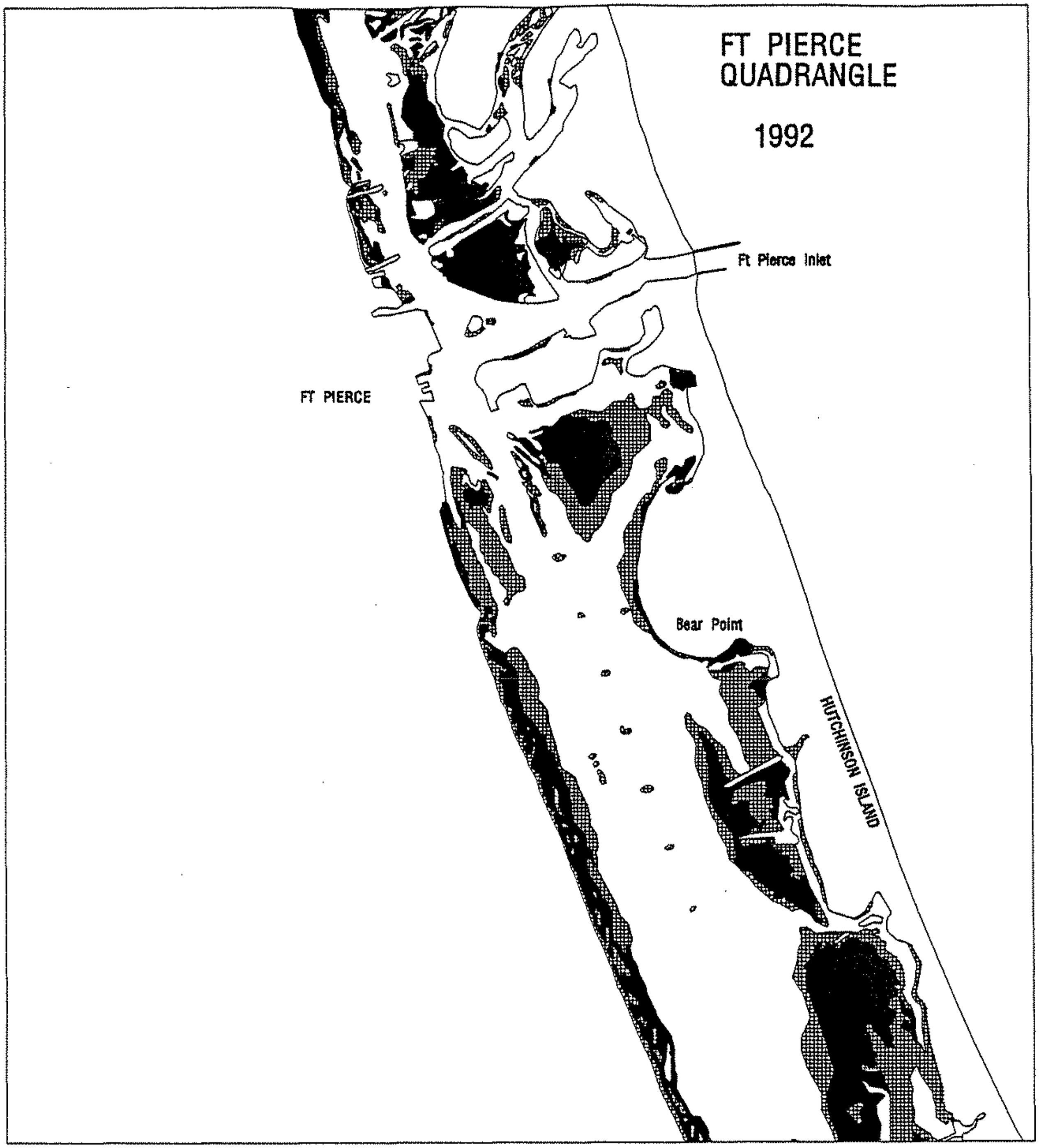

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FIGURE A-5. SEAGRASS BED COVER IN THE FT PIERCE QUADRANGLE FROM 1943 TO 1992.
d) 1992

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