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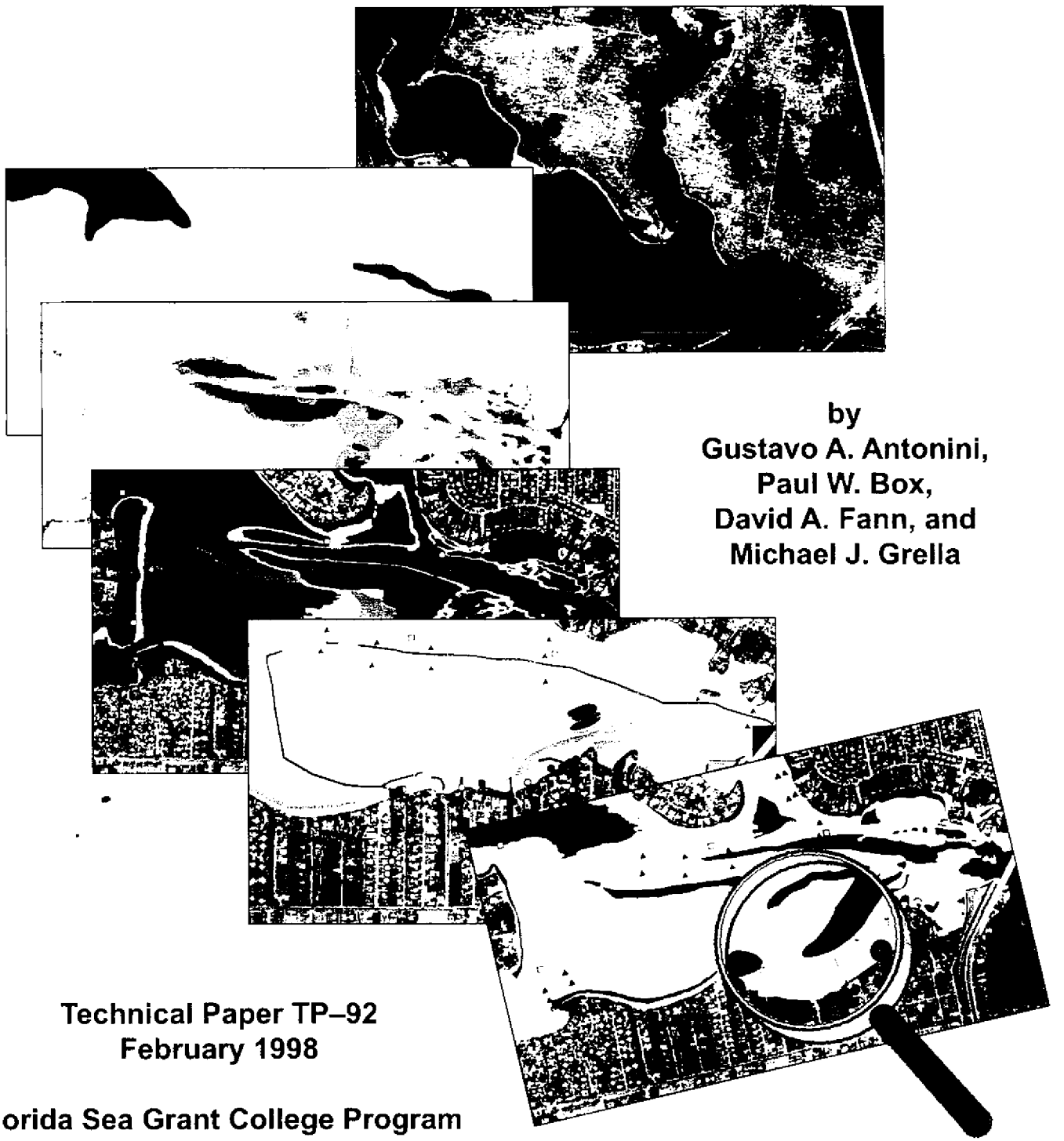

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Technical Paper TP–92
February 1998

Florida Sea Grant College Program
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Acronyms

ATM	Applied Technology & Management, Inc.
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FIND	Florida Inland Navigation District
FSG	Florida Sea Grant Program
ICW	Intracoastal Waterway
LEI	Law Environmental, Inc.
JID	Jupiter Inlet District
M&E	Morgan & Eklund, Inc.
mhw	mean high water
mllw	mean lower low water
mlw	mean low water
msl	mean sea level
NOS	National Ocean Service

Abstract

This report presents a geographic information system (GIS)-based method for planning and managing boating activities on the Central Embayment waterways of the Loxahatchee River in southeast Florida. The evaluation accomplishes this mission by fitting access channel maintenance to boat draft requirements, minimizing impacts on surrounding habitats using signage and boat traffic management, and encouraging environmental awareness and stewardship by providing boaters with accessibility maps and nature-tourism information. The boat traffic analysis focuses on five dredged canals and access routes to the main navigation channel. The resource management interpretations, and historic-environmental analyses, cover the larger area of the Central Embayment.

A boater survey is used to obtain information on boat location, boat type, draft, use patterns, boating destinations, and boater opinions concerning access problems and piloting strategies. Large-scale, historic (1967) and current (1996) bathymetry surveys are used to characterize present conditions and analyze the type and magnitude of changes in bathymetry that have occurred over the period. Current information on habitat and signage are evaluated as well.

The waterway (access channel) analysis uses a 'least-cost' path analysis procedure to simulate the most likely route a boat would follow from trip origin to a destination based on utilizing best (deepest) water and avoiding wherever possible sensitive bay habitats. The evaluation includes: overlaying the boat paths and bathymetry, determining the relation between the draft of each boat and the depth of water under each segment of the route, and indexing boat accessibility and channel restriction by the depth of the shallowest access channel segment. Boat accessibility and channel restriction are determined by comparing the index value with boat draft and center-line controlling depth.

The regional boating accessibility analysis uses the relation of boat draft to water depth to determine where and when recreational boating can occur within the Central Embayment. For a boat of a given draft: all areas that are deeper than the vessel's draft are freely navigable; areas shallower than the draft are inaccessible; and areas where boat draft equals water depth (within the 1 ft resolution of the data), are navigable on mid- or higher tide conditions (tidal range is 2 ft).

Three types of large-scale (1:6,000) photomaps are used to disseminate project results: resource inventory photomap, accessibility photomaps (tailored for each boat draft (1,2,3,4 ft), and nature-tourism maps.

Preface

The Jupiter Inlet District (JID), in 1996, entered into a contract with the University of Florida Sea Grant Program (FSG) to conduct a waterway evaluation of the navigation access needs of boaters living on canals along the south shore of the Central Embayment of the Loxahatchee River. The channels providing access from these canals to the navigable portion of the river have shoaled over the years, requiring boats to accelerate to planing speed in order to enter or exit the canal system. This procedure degrades the surrounding habitat and increases the potential risk of personal injury and property damage. The overall goal of the waterway management evaluation is to recommend management actions that will ensure safe, environmentally sustainable access to the water for residents living along these canals within a non-regulatory framework.

The groundwork for this FSG project was laid with the signing of a management agreement between the JID and the Florida Department of Environmental Protection (FDEP) for a portion of the Loxahatchee River - Lake Worth Creek Aquatic Preserve. This agreement provides the District with the ability to continually meet its charge while protecting resources for the public. It requires JID to develop and distribute a navigation chart, to restore four oxbows in the Northwest Fork of the Loxahatchee River, and to fund the placement of public awareness signs for environmental resource protection, preservation and safe usage at river access parks and ramps. Each of these management actions has been implemented by the District. Other initiatives currently underway or under consideration include the maintenance dredging of authorized navigation channels within the aquatic preserve, and the environmental enhancement of Sims Creek, a tributary to the Loxahatchee River. The recommendations in this FSG study fulfill the spirit and intent of the JID-FDEP management agreement.

The District is an independent special taxing authority, established in 1921 by the Florida Legislature, encompassing 92 square miles in northern Palm Beach County. It is responsible for maintaining and preserving both the Jupiter Inlet (with a special emphasis on navigability) and the Loxahatchee River system. District-wide ad valorem property taxation provides support for these JID programs.

1. Problem

The Loxahatchee River's Central Embayment has experienced dramatic increases in waterway use and waterfront development. These changes are in marked contrast to its slow evolution from a pristine turn–of–the–century palmetto upland, mangrove, salt marsh, and estuarine environment (Figure 1) to a rural, agricultural landscape with dispersed citrus groves and winter vegetable farms in the pre–World War II years (Figure 2). Five canals—Penn, Turner Quay, Pompano, Dolphin, and Marlin—were dredged from east to west along the south shore during the 1950–70 period (Figures 3 and 4) to provide south shore residents boating access to the Loxahatchee River and the Intracoastal Waterway (ICW). Aside from boat docks situated within the canals, 28 docks have been built along the south shore. Many extend well over 100 feet out into the Central Embayment. There are 212 south shore residents who live along the canals and docks in this locale.

The scale of development experienced along the south shore is also in evidence over much of the lower Loxahatchee basin. It was in response to these shorefront and waterway use pressures that the Loxahatchee River was designated an aquatic preserve in 1984. The river is also listed as an Outstanding Florida Water. There is great concern that the natural qualities of this water body be preserved, especially its extensive sea grass habitat.

The Central Embayment is situated at the confluence of three major tributaries, the North, Northwest, and Southwest Forks (Figure 4). The area waters funnel boat traffic upstream to boating and fishing locales and downstream to the ICW and Jupiter Inlet. A major boating attraction within the Central Embayment is a shoal (locally referred to as the Sandbar) between the south shore and the improved navigation channel. Hundreds of boaters use this shoal on weekends for anchoring, swimming, picnicking, fishing, and socializing. The Central Embayment has been posted as a "slow speed/no wake zone" (with the main channel being exempt) to address on–the–water safety and manatee protection. Congestion is a concern shared by boaters, residents, and public agencies alike.

South shore boaters face a dilemma: While the canals were dredged originally from 4 to 8 feet below mean low water (NOS, 1967), no access channels were provided at the time of canal development to ensure safe passage from the canal entrances to deep water (Figure 5). Boaters have been using several unimproved routes. One important route is northeast from Marlin canal–passing east or west of the mangrove islands ("a" or "b" in Figure 6)–to join the improved navigation channel. Another is west, parallel to the south shore, to a point midway between Penn canal and the mouth of the Southwest Fork, then north to the improved navigation channel ("c" in Figure 6).

These natural (unimproved) access routes from the residential canals to the dredged, main channel have shoaled in recent years. Boater options are either to limit entering/exiting their berths to mid– and higher tide conditions, or to accelerate to

planing speed to transit the shallow water portion of the access routes. These boat handling procedures are hazardous to people and the environment: Boaters caught out in inclement weather may not be able to return to safe harbor, increasing the risk of personal injury and property damage, and a speeding boat is less able to avoid running over sensitive habitats, which may degrade live bottom conditions by prop–scarring. Properly sited and maintained channels are needed to ameliorate such hazardous conditions and to reduce traffic and congestion on this Outstanding Florida Water body.

2. Goals and Objectives

The overall goal of the project is to ensure safe, environmentally sustainable access to the water for south shore residents within a non–regulatory framework. This can be achieved by:

a. Fitting access channel maintenance to boat draft requirements,

b. Minimizing impacts on surrounding habitats using signage and boat traffic management,

c. Encouraging environmental awareness and stewardship by providing boaters with accessibility maps and nature–tourism information,

d. Working with the south shore community and the regulatory agencies to develop a management strategy that will harmonize boat traffic with marine resource protection.

3. Study Design

The components of the waterway evaluation for the south shore of the Central Embayment, Loxahatchee River, Jupiter, Florida, are diagrammed in Figure 7. The steps link data sources, geographic data management, waterway traffic analysis, and output products (such as reports on existing conditions and recommendations for decision–making, nature–based tourism maps for promoting stewardship, and accessibility maps for improving boat traffic).

The evaluation focuses on determining the functionality of the access routes from the south shore canals to the main navigation channel. The relation between boat draft and water depth determines the functionality of the waterway system. Where draft exceeds depth (at mllw, the navigation datum), the access route is considered dysfunctional and boat access from trip origin (south shore canals) to destination (main navigation channel) is impaired. A dysfunctional traffic system not only increases safety and piloting risks, but, in a shallow water area containing ecologically sensitive habitats, such as the Central Embayment, also creates management problems. Boaters seek alternate routes around restrictions in access channels, and in the process, prop–

dredge 'Yankee–tracks' in sea grasses and soft bottom sediments. A fully functional waterway system, one that includes suitably marked access channels with controlling depth maintained to satisfy existing boat draft requirements, can provide the infrastructure needed to create a sustainable recreational boating environment.

The study design also includes developing and disseminating boater guide and map products showing waterway accessibility and describing nature–based tourism opportunities throughout the Central Embayment. These materials are essential elements—instruments of persuasion—of the program's public education, non–regulatory approach. Such an approach implies that boaters can make wise choices on boating practices, with minimum negative impact on the waterways and shore communities. Choice is a decision process based on selection of alternative options. A wise choice can be made, only if (1) information on waterway resources and facilities is available, and (2) the boater is aware of the negative impacts a poor use choice has on the quality of the recreational experience. A better understanding of the environmental history and boating geography of this popular recreation locale, it is reasoned, will assist boaters—residents and transients alike—to develop a sense of stewardship, and thus, sustain water quality, contribute to safer boating and encourage better resource use practices. The publication of accessibility maps and nature–based tourism maps are designed to provide the boating public with wise choice options that can make the non–regulatory approach a realistic management option.

4. Data Sources

The traffic analysis focused on the five dredged canals on the south shore and access routes to the main navigation channel of the Loxahatchee River. The mapped resource management interpretations, and historic–environmental analyses, cover a larger area (Figure 4) bounded by the A1A bridge (east), Anchorage Point (north), and Pennock Point (west). Black and white vertical aerial photography, taken in February 1995 by the Florida Department of Transportation (FDOT), was used as the plotting base for the photomap. The original 1:24,000 photography was enlarged to 1:2,400 and scanned for cartographic analysis purposes. The boating accessibility photomaps and the nature–tourism photomaps are compiled at a 1:6,000 scale (1 in = 500 ft).

The following information was used to operationalize the waterway traffic analysis: boats; bathymetry; sea grass; and signage. These are discussed below and presented in Figure 8.

a. Boats

A boater questionnaire was developed by Florida Sea Grant (FSG) and administered by the Jupiter Inlet District (JID) to survey all boaters residing along the five canals and south shore area, in order to obtain information on boat location, boat type, draft, use patterns, boating destinations, and boater opinions concerning access problems and piloting strategies.

All 212 shorefront residents were contacted and sent a questionnaire (see Appendix A). Of these, 153 responded (72 percent). Thirty–six individuals (24 percent of the respondents) who were non–boaters responded, but did not complete the survey. Boating statistics presented in this report are based on 117 completed questionnaires. A copy of this Loxahatchee Central Embayment Data Base is found in Appendix B.

b. Bathymetry and Shoreline

Morgan & Eklund, Inc. (M&E) mapped the Central Embayment in 1996. Soundings were collected at 0.1 ft resolution and referenced to mean sea level (msl) datum. M&E provided these data in a digital file that included the shoreline. FSG staff converted the depths from msl to mllw in order to be consistent with national charting standards which use mllw as the navigation datum.[1] Soundings were rounded to the nearest foot. Computer GIS models were used to transform the bathymetry point coverage into a contour map. The accessibility analysis was based on the 1.0 ft resolution (see map in Figure 9). This information was generalized into 2 ft depth classes for presentation purposes (Figure 8).

The US Department of Commerce (National Ocean Service) mapped the bathymetry in 1967, as point data, at 1 ft resolution (mlw datum), and at 1:10,000 (1 in = 800 ft approx.) scale (Figure 5). Contours were manually interpolated and digitized to produce a GIS coverage. Figure 10 shows bathymetry as color–shaded 2 ft depth zones and characterizes pre–development (1967) conditions in the waters of the Central Embayment. Note that the Loxahatchee River main navigation channel at this time was in a natural (pre–dredging) state. The NOS 1967 bathymetric chart was used to analyze changes in water depth over the 1967–1996 period.

c. Sea Grass

Applied Technology & Management, Inc. (ATM) mapped the Central Embayment in 1996 at 1:9,000 scale. ATM provided a digital polygon data file. This information is presented in Figure 8.

d. Signage

Law Environmental, Inc. (LEI) mapped the navigation aids in 1993 at 1:16,000 scale (approximate). The information for 21 aids to navigation was updated by JID in 1997. There are four Manatee protection and speed restriction signs, which are maintained by the Florida Inland Navigation District (FIND). The map in Figure 8 shows the location of the 21 aids to navigation and four manatee/slow speed signs in the region.

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[1] Tidal datums for the Central Embayment are: mean high water (mhw) = 2.14 ft; mean tide level or mean sea level (msl) = 1.15 ft; mean low water (mlw) = 0.16 ft; mean lower low water (mllw) = 0.00 ft.

5. Boater Survey

Profiles can be constructed from the survey of the south shore boaters, their boats, trips, activities, accessibility issues, and piloting strategies used to cope with the issues. Since this information is georeferenced, individual boaters and boat locations can be positioned on specific canals or docks, or these data can be aggregated in order to describe canal–by–canal conditions, as well as overall south shore conditions. A discussion follows of the boater survey results. Appendix C tables C–1 through C–14 explain the survey population characteristics.

a. South Shore Boaters

One–hundred and eight boaters (with 124 boats) and 36 non–boaters participated in the survey (Table C–1). These 144 individuals are 68 percent of the south shore residents. The dominant age cohorts of the boating population are 45–64 years (46.6 percent) and 25–44 years (39.8 percent) (Table C–2). There are few boaters ≥65 years old (13.6 percent) and none <25 years of age. Over 80 percent are in the work–force: sales/service account for 31.5 percent, followed by construction/engineering (28.7), and medical (11.1 percent) (Table C–3). The retired population is 14.8 percent. South shore boaters are a mature–aged, actively–employed population.

b. Boats

Recreational fishing (56.5 percent) and power cabin (25.0 percent) types of boats account for over 81 percent of the south shore boats (Table C–4). There are small numbers of speed boats (6.5 percent) and rowboats and canoes (4.8 percent). These boats are unevenly distributed in the canals along the south shore (Table C–5): 75 percent are located at the eastern end, in Dolphin (25) and Marlin (50) canals; 18 percent at the western end (Penn canal), 7 percent in the middle (Turner Quay and Pompano).

Boat draft—the water depth required by the boat to float—is a critically important factor in determining boat accessibility, since it defines what is the limiting (controlling) channel depth. Recreational boat draft may be expressed in terms of idle–speed, cruising–speed, or planing–speed conditions, each of which may require different water depths, based on boat design and performance characteristics. Idle–speed draft is used in this study since the Central Embayment is a posted "slow speed/no wake zone" where idle speed is warranted. The average idle–speed draft for south shore boats is 2.3 ft. Boat draft ranges from 0.5 ft to 4.0 ft: 11 percent have a draft ≤1.0 ft; 11 percent have a draft ≥3.5 ft; and 78 percent have a draft >1.0 and <3.5 ft. The deepest draft boats are situated in the easternmost canals (Dolphin [4], Marlin [5], Figure 3). Penn (1) canal—at the extreme west end—has some deeper draft boats, while those in Turner Quay (2) and Pompano (3) are relatively shallow and very shallow draft by comparison (Figure 8, Table C–5).

c. Boating Trips

When do south shore residents go boating? Survey results show that these boaters overwhelmingly go out on half–day trips either in the morning or the afternoon. Penn canal residents (18 percent of all boats) differ in that almost three–quarters of them are all–day trippers (Table C–6). On the average a south shore resident will boat 10 times per year. The peak boating season is the summer (30 percent of all trips) and the low season is the winter (20 percent) with one–third less activity.

An understanding of the origin–destination travel pattern is essential in determining the boat traffic pattern, and ultimately, the need for access channel placement in the Central Embayment. Since all boats are georeferenced to specific locations, it was possible to determine the relative numbers of boat trips originating from each of the five canals. Destinations were based on survey responses in which each boater listed, in order of importance, the #1, #2, and #3 destination locations. Tallies for each destination were ranked by their frequency of occurrence. Rank–weighted values were assigned to each count: 1st rank = 1.0; 2nd rank = 0.66; 3rd rank = 0.33. The frequency–rank weighted values were summed to obtain the destinations by order of importance.

Table C–7 summarizes this origin–destination analysis. The ranked destinations (highest to lowest) are: ICW/Ocean; river (Loxahatchee); Sandbar; followed by other locations off the river. Note the differences are orders of magnitude: ICW accounts for two–thirds of the destinations; there is a drop down to about 15 percent accounted for by the 'river', and about 10 percent by the Sandbar as boating destinations. Trips to the North, Northwest, and Southwest Forks of the Loxahatchee River make up less than 10 percent of south shore boating destinations. Marlin (5), Dolphin (4), Turner Quay (2), and Penn (1) boaters have the same trip destination characteristics (Figure 4); they represent 95 percent of the boats. Pompano (3) boaters (5 percent) travel to the Sandbar (#1 destination), ICW/Ocean (#2) and the North Fork (#3) (Table C–8). Shallow (1 ft) draft boats favor the river as the #1 destination, while deeper (≥2 ft) draft boats favor the ICW/Ocean (Table C–9).

d. Boating Activities

Boaters were asked to list their #1, #2, and #3 boating activities. Their responses were weighted (#1 = 1.00, #2 = 0.66, #3 = 0.33) in order to derive a composite score which ranked the activities in order of importance. Table C–10 summarizes the results of this analysis.

Ranked activities, from highest to lowest, are: fishing (42 percent), leisure (21 percent), cruising (17 percent), diving/swimming (12 percent), and speed boating/skiing (7 percent). Note that there are orders of magnitude of difference among the top four activities.

e. Access Problems

Is access an issue for south shore boats? And if so, is it a major or minor one? According to the boater survey, access is a problem for 91 percent of the boats in this region; it is a 'major' problem for 86 percent of the total boat population (Table C–11) and for all boats except rowboats, canoes, pontoon boats, and sailboats (7.2 percent of the total, see Table C–12). On a canal basis, boaters on all canals except Pompano consider access a major problem. For Pompano boaters (6 total), it is a minor problem or non–existent; their average boat draft is 1.2 ft, half the draft of all other south shore residents.

f. Solution Strategies

How do south shore boaters deal with the access problems? Marlin and Dolphin canal boats face the greatest access problem (Table C–11). Over half of these boats limit going out or returning to mid– or higher tide conditions, and rely on reducing their draft to a minimum by navigating shoal waters at planing (high) speed (Table C–13). Marlin boaters (50 percent of the total) have the greatest anxiety level: Two–thirds of them 'chew nails' (Table C–13). They also have ten times the number of vessels with ≥3.0 ft draft of all other canals. These are predominantly recreational fishing and power cabin types of boats (Table C–14).

g. Survey Summary

Most of the boats are in the three easternmost canals, which also have the largest concentration of 'deeper draft' boats. The majority (two–thirds) of all boaters head east to the ICW/Ocean; relatively few south shore boaters use the river as their boating locale.

A boating management objective should be to facilitate traffic flow from the areas of greatest boat concentrations (originating in the Dolphin and Marlin canals) to the primary destinations (ICW/Ocean), in order to minimize waterway congestion and reduce impacts on the environment. Results from this boater survey argue in favor of improving the channel northeast from Dolphin/Marlin canals, past the mangrove islands, to the main navigation channel.

6. Environmental Conditions

a. Bathymetry

An analysis was undertaken to determine the type and magnitude of changes in bathymetry that have occurred since 1967 in the Central Embayment (Figure 11). The dredged main channel is illustrative of the deepening process and the adjacent Sandbar reflects shoaling during this period. Shoaling has occurred, by 2 to 4 ft, along the south flank of the main channel between markers #5 and #11, and north of the main

channel between markers #10 and #12. Shoaling has occurred along the south shoreline, and has created obstructions to navigation at the mouths of Penn, Pompano and Dolphin canals. Deepening has occurred between the mangrove islands and the south shore east of Marlin canal. The 1967 NOS chart (Figure 5) shows a shoal, less than 2 ft deep, extending from the mainland shore to the mangrove island. Over the period, a northeast/southwest–trending trough, 4 ft deep, has developed, perhaps a result of boat traffic.

Table 1 shows bathymetry changes from 1967 to 1996 in 1 ft increments, as shoaling (-), no change (0), and deepening (+) conditions. These relations are reported in ft^2, mi^2, and percent. The area of the Central Embayment is 0.6 mi^2. Forty–two percent has experienced no change in water depth, 45 percent has shoaled, and 12 percent has deepened. Overall, the area has become shallower: 43 percent has shoaled by 1–3 ft. This corresponds with a 12 percent deepening in the 1–3 ft range.

b. Sea Grass

The map in Figure 8 shows the distribution of sea grass in the Central Embayment. Sea grass covers approximately 5 percent of the water area: it is found fringing the shoreline; as extensive beds southwest of the 'Sandbar' and in shoal waters at the mouth of the North Fork; and as patches between Dolphin and Marlin canals and between the mangrove islands and the Alt. A–1–A bridge. The access routes most frequently used by south shore boaters traverse sea grass beds, 288 ft on the westerly route and 765 ft on the easterly one.

c. Improved Channels and Signage

The main river channel is the only improved access channel in the Central Embayment. There are 11 aids to navigation marking this channel, five flank the lower segment of the North Fork, and four are situated at the mouth of the Southwest Fork. There are no aids for any of the unimproved access channels (Figure 8).

The manatee signs are located at the junction of the main channel and North Fork, south of Anchorage Pt and north of the Sandbar, at the north end of Pennock Pt, and at the south end of Pennock Pt where the Southwest Fork enters the Central Embayment (Figure 8). These signs indicate slow speed, minimum wake, manatee zone conditions, which prevail within 300 ft of the shoreline between November 15 and March 31. The authorized navigation channel is speed exempt.

7. Waterway Traffic Analysis

The waterway traffic analysis system is diagrammed in Figure 12 . The four data sources used to operationalize this analysis are: (1) M&E, Inc. bathymetry point (soundings) file, (2) ATM sea grass polygon file, (3) LEI and FIND signage data, and (4) JID boater survey. Each data source was incorporated into the analysis as a geographic information system (GIS) layer (coverage). The bathymetric coverage

served as the cartographic base to plot boats, signs, and sea grass, and to construct a boat traffic route network.

a. Boat Routes

There are five potential origins of boating trips (Penn, Turner Quay, Pompano, Dolphin, and Marlin canals) and six potential destinations (North Fork, Northwest Fork, Southwest Fork, River [Loxahatchee], Sandbar, and ICW/Ocean). A trip from an origin to a destination may include a route along a marked channel, as well as along open areas with no defined channel. Precise information about an individual's choice of route from origin to destination was not available from the boater surveys. Therefore, an estimate of the most likely route a boat would follow from origin to a destination was derived using a least–cost path method developed by one of the authors in a boat traffic study of Sarasota Bay (Box, 1997). The technique assumes that boats will use the most efficient, or 'least cost' path in transiting between two locations. 'Least cost' means (a) utilizing best (deepest) water and (b) avoiding sea grasses where possible.

A 'least–cost' path was determined for each boat. When all paths were plotted, it was found that many routes overlapped; i.e., many boats use a common route to reach a common destination. For example, the least–cost path for boats heading for the ICW or Atlantic Ocean invariably led east along the south shore past Marlin and northeast, passing south of the mangrove islands, to the main river channel. If, for a given boat, that route presented a depth restriction due to the vessel's draft, the least–cost path would take the boat by the westerly route around the west end of the Sandbar and then east along the main river channel. The most typical easterly and westerly routes determined by this procedure, shown in Figures 13 and 14, represent a composite of the individual paths. These paths are the basis of the subsequent boat accessibility and channel restriction analyses.

b. Boat Accessibility

This evaluation included: (1) overlaying the boat paths and bathymetry, (2) determining the relation between the draft of each boat and the depth of water under each segment of the route, (3) indexing boat accessibility by the depth of the shallowest access channel segment. Comparing the resulting index value with boat draft determined the accessibility of each boat: (a) unrestricted access is where segments are deeper than vessel draft; (b) restricted from low tide transit occurs where segments are equal to draft (this is within the resolution of the input data on draft and depth); (c) mid–tide access occurs where segments are 1 ft shallower than boat draft; and (d) high tide–only access is where segments are 2 ft shallower than draft.

c. Channel Restrictions

This analysis was performed by comparing the draft of each boat to the depth of each channel segment. Restrictions occur where channel segments are shallower than boat draft. Unrestricted channel segments are 4 ft or greater in depth, allowing access by the deepest draft boats in the south shore traffic system. Restricted segments occur in 2 ft and 3 ft water depths. (Neither the easterly nor the westerly access route has 1 ft shoals.)

d. Maintenance Dredging

A 4 ft controlling depth will provide access for all boats on the south shore of the Central Embayment. This depth was used to estimate maintenance dredging requirements. Thus, a channel segment with a 2 ft depth requires a 2 ft deep cut, and a 3 ft channel depth requires a 1 ft dredge cut. A 20 ft channel width is used, as it allows for two–way crossing traffic. Dredging volumes are determined by multiplying the length of the segment by the depth of the required dredge cut by the channel width. Channel lengths are reported in feet and dredging volume in cubic yards.

e. Boating Zones

The relation of boat draft to water depth can be used to determine where and when recreational boating can occur within the Central Embayment. The areas where boating can take place vary with vessel draft. For a boat of a given draft: (1) all portions of the Central Embayment that are deeper than the vessel's draft are freely navigable; (2) areas shallower than the draft are inaccessible; and (3) areas where boat draft equals water depth (within the 1 ft resolution of the data) are navigable on mid– or higher tide conditions. Maps showing the three accessibility zones were compiled for each boat draft (1,2,3,4 ft) class (Figures 15, 16, 17, 18).

8. Results

The traffic analysis was carried out at two geographic levels. First, the major focus was on evaluating the functionality of access channels, which is of critical concern to the south shore residents. However, this study also provided information on accessibility of the Central Embayment. This second level, regional evaluation of where and when recreational boating can occur outside the access channels is included herein to satisfy the need for such information by all boaters—from other localities as well as from the south shore—who use these waters.

a. Access Channels

For each boat situated along the south shore of the Central Embayment, the analysis evaluated the relationship between boat draft and channel depth from trip

origin to the main river channel, in order to determine boat accessibility and channel restrictions. Results of the boat accessibility and channel restrictions analyses and maintenance dredging estimates are presented for the two important access channels, the Easterly Route and the Westerly Route. These results provide a basis for improving the functionality of the access channels by identifying where selective maintenance dredging is required and where efforts are needed to minimize impacts on surrounding habitats.

A summary comparative listing of boat and channel accessibility characteristics is presented in Table 2 and mapped in Figures 13–14. The Westerly Route (11,923 ft) is two times longer than the Easterly Route (5,866 ft). However, 60.48 percent of the boats are restricted using the Westerly route, as opposed to 88.71 percent restricted to the Easterly channel. To offer unrestricted access to all south shore boats requires an estimated 3,598 cu yd of dredging from the Easterly Route or 3,358 cu yd from the Westerly Route. Approximately 765 ft of the Easterly Route crosses sea grass, compared to 288 ft on the Westerly Route.

Specific counts of restricted boats in each of the accessibility categories (somewhat restricted, restricted, and severely restricted) are given in Appendix D, Tables D–1 and D–2. The estimated lengths of restricted channels of 2 ft and 3 ft depths are reported in Table D–3. Tables D–4 and D–5 list the absolute (yd^3) and relative amounts of dredging required to bring each route into full compliance with boat access needs. The maps in Figures 13 and 14 show major shoaling at the mouths of the canals, which affects boats transiting either route. The Easterly Route shoals east of the mangrove islands near its junction with the main river channel.

b. Central Embayment

The Loxahatchee Central Embayment is a shallow water region. Over 50 percent of this area is less than 2 ft deep (Table 3). It is of no surprise that over two–thirds of the south shore residents' boating destinations are ICW and Ocean–bound (Table C–7), as 89 percent of their boats have draft deeper than 2 ft (Table C–9). The Sandbar is an attractive destination within the Embayment mainly because it is 'accessible' to boats of all draft classes.

Figures 15–18 show the accessible zones for each boat draft class, and Table 4 compares the relative areas in each zone (anytime, mid– and higher tide, at no time) in the Central Embayment for each boat draft. For south shore boaters, the statistics in these tables and the maps graphically illustrate the boating reality of this region: 86 percent of the area is accessible at some time for boats with a 1 ft draft; 42 percent is accessible for a 2 ft draft, 33 percent is accessible for a 3 ft draft, and only 21 percent is accessible for a 4 ft draft boat. Residents with boats of 3+ ft draft have extremely restricted use of the Embayment outside of the access and main river channels.

9. Boater Education Products

The project has produced three map products for boaters: (1) resource inventory photomap; (2) accessibility photomaps; and (3) nature–tourism maps. These products are specifically designed to provide a better understanding of the natural resources available to boaters in the Central Embayment and to instill stewardship which will encourage better resource use practices and contribute to safer boating. The flow chart in Figure 19 describes the elements of each product.

a. Resource Inventory Photomap

The 1995 aerial photograph is the compilation base. The map portion covers the water area while the photo portion covers the land. All boating facilities (e.g., docks) are shown in the photo element. The photomap scale is approximately 1:6,000 (1" = 500'). Map information includes: bathymetry at 1 ft increments, shown as depth areas and as centerline controlling depths for the easterly and westerly routes; sea grass as shaded areas; and signs as point features (Figure 20).

b. Accessibility Photomaps

Four photomaps have been compiled to show the accessible areas for boats of 1, 2, 3, and 4 ft draft (Figures 15–18). Each map shows areas that are: freely navigable; navigable at mid– or higher tides; and not navigable. For the novice boater or tourist the accessibility photomap is an easy–to–use guide to boating conditions in the Central Embayment. Sea grass areas are highlighted, and boaters are cautioned to exercise care in these habitat areas.

c. Nature–Tourism Maps

These maps include historical (1928) aerial photographs (Figure 21) and survey data on water and shoreline conditions of the Central Embayment (Figures 3,5,10, and 11). They portray elements of the environmental history that affect the current boating geography of the region and encompass depth changes, shoreline development, and the need to boat in harmony with the natural surroundings.

10. Conclusions

The dilemma facing boaters on the south shore of the Central Embayment is an endemic problem of many waterfront communities in Florida, where widespread canal construction occurred with inadequate access channels (or with no channels at all) to link residential canals and basins to arterial waterways, such as the Loxahatchee River and ICW. This is because in the 1950s and 1960s—the heydays of Florida's waterfront development—dredging of residential canals was driven almost entirely by the need to provide fill material to make land. The original dredged depth of canals and basins

depended upon the amount of fill needed by the developer to build waterfront parcels, and during dredging developers perceived little need for recreational boat access channels.

The south shore canals on the Central Embayment—from west to east, Penn, Turner Quay, Pompano, Dolphin, and Marlin—were dredged originally from 4 to 8 ft. below mean low water. With no access channels to ensure safe passage from the canal entrances to deep water, boaters have been using several unimproved routes: northeast from Marlin, passing east of the mangrove islands, to join the improved navigation channel; and west, parallel to the south shore, then north to the improved navigation channel. These natural (unimproved) access routes from the residential canals to the dredged, main channel, have shoaled in the past 30 years.

There are 124 boats in this area of the Central Embayment, and they are unevenly distributed: 75 percent are located at the eastern end, in Dolphin (25 percent) and Marlin (50 percent) canals; 18 percent at the western end (Penn canal), 7 percent in the middle two waterways (Turner Quay and Pompano). Boating destinations are: ICW/Ocean (67 percent); the Loxahatchee River (14 percent); the Sandbar (9 percent). Trips to the North, Northwest, and Southwest Forks make up less than 10 percent of south shore boating destinations. Summer is the peak boating season with 30 percent of the trips, and winter is the low season (20 percent). On average, boaters go out ten times per year. The major activities are fishing (42 percent), leisure (21 percent), and cruising (12 percent).

The average idle–speed draft is 2.3 ft; and boat draft ranges from 0.5 ft to 4.0 ft: Eleven percent of the boats have a draft $\leq$ 1 ft and 11 percent have drafts $\geq$ 3.5 ft, with the remainder, 78 percent, in between. Three–quarters of all boaters consider that they have a major access problem. Only Pompano boaters (6 total) consider it is minor or non–existing. Marlin and Dolphin canal boats are faced with the greatest access problems, and over half limit going out or returning to mid– or higher tide conditions. Marlin boaters have the greatest anxiety level, and they also have ten times the number of deeper draft vessels than all other canals. The greatest number of boats are situated in the easternmost canals; this coincides with the largest concentration of deeper draft boats. The majority (two–thirds) of all boaters head east to the ICW/Ocean; relatively few south shore boaters use the river as their boating locale.

The waterway traffic analysis examined the relationship between boat draft and channel depth for all boat trips in order to compare boat accessibility and channel restrictions for the westerly and easterly access routes. Sixty percent of the boats encounter some depth restriction using the westerly route, while 89 percent are restricted to some degree on the easterly route. The westerly route is 11,923 ft in length (about twice as long as the 5,866 ft easterly route); 3,595 ft of the westerly route channel restrict boat traffic and require some dredging. By comparison, 3,816 ft on the easterly route are restricted. The westerly route will require the removal of an estimated 3,358 cu yd of dredge, while the easterly one will need 3,598 cu yd to be removed in order to provide unrestricted access to all boats. Approximately 288 ft of the westerly

route traverse sea grass beds, while the easterly channel crosses 765 ft of this sensitive habitat.

A boating management objective should be to facilitate traffic flow from the areas of greatest boat concentrations (originating in the Dolphin and Marlin canals) to the ICW/Ocean, in order to minimize waterway congestion and reduce impacts on the environment. The results of the boater survey and traffic analysis argue in favor of improving the easterly route northeast from Dolphin/Marlin past the mangrove islands to the main navigation channel.

Another boating management objective should be to educate boaters—not just the south shore residents, but others, as well, who recreate on the Central Embayment—as to the shallow nature of this region and of the location and extent of its sensitive marine habitat. Over 50 percent of this area is less than 2 ft deep. The attractiveness of the Sandbar as a destination within the Embayment is in large measure due to its accessibility to all draft class boats since it lies adjacent to the dredged main river channel. As a boating region, the Embayment is ideally suited to boats with a 1 ft draft, since 86 percent of the area is accessible at some time. In contrast, a boat with a 3+ draft would have extremely restricted access outside the main channel. The navigability photomaps offer a useful boating management tool since suitable boating areas are identified for boats with different draft.

11. Recommendations for Managing Boat Traffic

1. Establish an 'improved' navigation access channel along the Easterly Route to route boat traffic flow from south shore canals to the Loxahatchee River. There should be a maintenance–dredging provision for this 'improved' channel with a controlling depth set at 4 ft. This will provide all boats presently berthed along the south shore area with reasonable access, by fitting the access channel's controlling depth to boat draft requirements. It will also discourage south shore residents from berthing deeper draft (larger) boats in this area, which will minimize future boating impacts on surrounding marine habitats.

2. Mark the proposed, 'improved', easterly access channel with aids to navigation: (a) at the junctions of the five canals with the easterly access connector channel; (b) along the south flank of the connector channel, from Penn to Dolphin canals; and (c) at strategic locations on both sides of the connector channel, north of Dolphin and between Marlin Drive and the mangrove islands.

3. Designate the major sea grass area south of the main navigation channel for rehabilitation, in part to mitigate the habitat lost by creating the 'improved' easterly route, and to offset encroachment from intensive boating uses on the Sandbar along its northern fringe. Establish a habitat restoration program for this area that includes both site enhancement and public education elements. Monitor habitat conditions and report changes to the appropriate management authority.

4. Launch a public education program to advise residents and visitors on the boating potentialities and limitations of the Central Embayment, based on its environmental conditions. Publish and distribute copies of the Resource Inventory Photomap (Figure 20) to all shorefront residents; it provides information on bathymetry, channel controlling depths, sea grass, navigation aids and manatee/speed zone signs. Publish and distribute copies of the Boating Accessibility Photomaps (Figures 15–18) to residents and visitors. These photomaps designate, for a given draft vessel, specific areas of the Embayment where unrestricted access is available or where restricted or limited conditions prevail. Use of these maps will promote stewardship through a better understanding of the region's environmental conditions.

12. Executive Summary

a. Background

The Jupiter Inlet District entered into a contract with the University of Florida Sea Grant Program (FSG) in 1996 to evaluate the navigation access needs of boaters living on five canals along the south shore of the Central Embayment of the Loxahatchee River. The unimproved routes providing access from these canals—identified from west to east as Penn, Turner Quay, Pompano, Dolphin, and Marlin—to the navigable portion of the river have shoaled over the years, requiring boats to accelerate to planing speed in order to enter or exit the canal system. This procedure degrades the surrounding habitat and increases the potential risk of personal injury and property damage.

The overall goal of the waterway management evaluation is to recommend non–regulatory management actions that will ensure safe, environmentally sustainable access to the water for residents living along these canals. The project evaluation proposes to accomplish this by: (a) fitting access channel maintenance to boat draft requirements; (b) minimizing impacts on surrounding habitats by using signage and boat traffic management; and (c) encouraging environmental awareness and stewardship by providing boaters with accessibility maps and nature–tourism information. This report presents a geographic information system (GIS)–based method for planning and managing the Central Embayment waterways.

b. Data Sources

A questionnaire survey of south shore boaters obtained information on boat location, boat type, draft, use patterns, boating destinations, and boater opinions concerning access problems and piloting strategies. Seventy–two percent of the residents responded to the survey.

Computer GIS models used bathymetry data for 1967 and 1996 to determine changes in water depth and to analyze the present conditions of the study area.

c. Boater Survey

South shore boaters are a mature, actively–employed population. On the average, they go boating ten times per year. The peak boating season is the summer (30 percent of all trips) and the low season is the winter (20 percent) with one–third less activity. Ranked boating activities, from highest to lowest, are: fishing (42 percent), leisure (21 percent), cruising (17 percent), diving/swimming (12 percent) and speed boating/skiing (7 percent).

The principal types of boats owned are recreational fishing (56.5 percent) and power cabin (25.0 percent). These are unevenly distributed in the canals along the south shore: 75 percent are located at the eastern end, in Dolphin (25) and Marlin (50) canals; 18 percent at the western end (Penn canal): and 7 percent in the middle (Turner Quay and Pompano canals).

Boat draft ranges from 0.5 ft to 4.0 ft. The deepest draft boats are situated in the easternmost canals (Dolphin and Marlin). Penn canal—at the extreme west end—has some deeper draft boats, while those in Turner Quay and Pompano are relatively shallow and very shallow draft by comparison.

The origin–destination travel route determines the boat traffic pattern, and ultimately, the need for access channel placement in the Central Embayment. The ranked destinations (from highest to lowest) are: ICW/Ocean; river (Loxahatchee); Sandbar; followed by other locations off the river. The ICW accounts for two–thirds of the destinations; there is a drop down to about 15 percent accounted for by the 'river', and about 10 percent by the Sandbar as boating destinations. Trips to the North, Northwest and Southwest Forks of the Loxahatchee River make up less than 10 percent of south shore boating destinations.

Access is a problem for 91 percent of the boats in this region; it is a 'major' problem for 86 percent of the total boat population. Marlin and Dolphin canal boats face the greatest access problem. Over half of these boats limit going out or returning to mid– or higher tide conditions and rely on reducing their draft to a minimum by navigating shoal waters at planing (high) speed. Marlin boaters have ten times the number of vessels with ≥3.0 ft draft, compared with boaters in all other canals.

Most boats are situated in the easternmost canals, which also contain the largest concentration of 'deeper draft' boats. The majority (two–thirds) of all boaters head east to the ICW/Ocean; relatively few south shore boaters use the river as their boating locale. A boating management objective should be to facilitate traffic flow from the areas of greatest boat concentrations (originating in the Dolphin and Marlin canals) to the primary destinations (ICW/Ocean), in order to minimize waterway congestion and reduce impacts on the environment. Results from this boater survey argue in favor of improving the channel northeast from Dolphin/Marlin canals, past the mangrove islands, to the main navigation channel.

d. Environmental Boating Conditions

The area of the Central Embayment is 0.6 mi^2. Over the 1967–1996 period, 42 percent has experienced no change in water depth, 45 percent has shoaled, and 12 percent has deepened. The dredged main channel is illustrative of the deepening process, and the adjacent Sandbar reflects shoaling during this period. Shoaling has occurred, by 2 to 4 ft, along the south flank of the main channel between markers #5 and #11, and north of the main channel between markers #10 and #12. Shoaling has occurred along the south shoreline, and has created obstructions to navigation at the mouths of Penn, Pompano and Dolphin canals. Deepening has occurred between the mangrove islands and the south shore east of Marlin canal; this may be the result of boat traffic.

Sea grass covers approximately 5 percent of the Central Embayment water area. It is found fringing the shoreline; as extensive beds southwest of the Sandbar and in shoal waters at the mouth of North Fork; and as patches between Dolphin and Marlin canals and between the mangrove islands and Alt. A–1–A bridge. The access routes most frequently used by south shore boaters traverse sea grass beds, 288 ft on the westerly route and 765 ft on the easterly one.

The main river channel is the only improved access channel in the Central Embayment. There are eleven aids to navigation marking this channel, five flank the lower segment of the North Fork and four are situated at the mouth of the Southwest Fork. There are no aids for any of the unimproved access channels.

The manatee signs are located at the junction of the main channel and North Fork, south of Anchorage Pt and north of the Sandbar, at the north end of Pennock Pt, and at the south end of Pennock Pt where the Southwest Fork enters the Central Embayment. These signs indicate slow speed, minimum wake, manatee zone conditions, which prevail within 300 ft of the shoreline between November 15 and March 31. The authorized navigation channel is speed exempt.

e. Waterway Analysis

Five potential trip origins (Penn, Turner Quay, Pompano, Dolphin, Marlin canals) and six potential destinations (North Fork, Northwest Fork, Southwest Fork, River [Loxahatchee], the Sandbar, and ICW/Ocean) were used to generate boating trips, which may include a route along a marked channel as well as along open areas with no defined channel. Precise information about an individual's choice of route from origin to destination was not available from the boater surveys. Therefore, an estimate of the most likely route a boat would follow from trip origin to a destination was derived by using a 'least–cost' path approach which assumes that boats will use the most efficient path in transiting between two locations. 'Least cost' means (a) utilizing best (deepest) water, and (b) avoiding sea grasses wherever possible.

A least–cost path was determined for each boat. When all paths were plotted, it was found that many routes overlapped; in other words, many boats use a common route to reach a common destination. The most typical easterly and westerly routes determined by this procedure are the basis of the boat accessibility and channel restriction analyses.

The boat accessibility evaluation included: (1) overlaying the boat paths and bathymetry, (2) determining the relation between the draft of each boat and the depth of water under each segment of the route, (3) indexing boat accessibility by the depth of the shallowest access channel segment. The accessibility of each boat was determined by comparing the index value with boat draft: (a) unrestricted access is where segments are deeper than vessel draft; (b) restricted from low tide transit occurs where segments are equal to draft (this is within the resolution of the input data on draft and depth); (c) mid–tide access occurs where segments are 1 ft shallower than boat draft; and (d) high tide–only access is where segments are 2 ft shallower than draft.

The channel restrictions analysis was performed by comparing the draft of each boat to the depth of each channel segment. Restrictions occur where channel segments are shallower than boat draft. Unrestricted channel segments are 4 ft or greater in depth. This case allows access by all boats, including the deepest draft of boats in the south shore traffic system. Restricted segments occur in 2 ft and 3 ft water depths (there are no 1 ft shoals on either of the easterly and westerly access routes).

A 4 ft controlling depth will provide access for all boats on the south shore of the Central Embayment. This depth was used to estimate maintenance dredging requirements. Thus, a channel segment with a 2 ft depth requires a 2 ft deep cut, and a 3 ft channel depth requires a 1 ft dredge cut. A 20 ft channel width is used since it allows for two–way crossing traffic. Dredging volumes are determined by multiplying the linear length of the segment by the depth of the required dredge cut by the channel width. Channel lengths are reported in feet and dredging volume is in cubic yards.

The relation of boat draft to water depth can be used to determine where and when recreational boating can occur within the Central Embayment. The areas where boating can take place vary with the draft of each vessel. For a boat of a given draft: (1) all portions of the Central Embayment that are deeper than the vessel's draft are freely navigable; (2) areas shallower than the draft are inaccessible; and (3) areas where boat draft equals water depth (within the 1 ft resolution of the data), are navigable on mid– or higher tide conditions. Maps showing the three accessibility zones were compiled for each boat draft (1,2,3, and 4 ft) class.

f. Results

Results presented for the two access channels—Easterly Route and Westerly Route—provide a basis for improving the functionality of the access channels by identifying where selective maintenance dredging is required and where efforts are needed to minimize impacts on surrounding habitats.

The Westerly Route (11,923 ft) is two–times longer than the Easterly Route (5,866 ft). However, 60.48 percent of the boats are restricted using the Westerly as opposed to 88.71 percent in the case of the Easterly channel. To offer unrestricted access to all south shore boats requires an estimated 3,598 cu yd of dredging from the Easterly Route or 3,358 cu yd from the Westerly Route. Approximately 765 ft of the Easterly Route crosses sea grass in comparison to 288 ft on the Westerly Route.

Specific counts of restricted boats in each of the accessibility categories (somewhat, restricted, and severely restricted) are presented. The report provides estimated lengths of restricted channels of 2 ft and 3 ft depths as well as amounts of dredging required to bring each route into full compliance with boat access needs. The mapped results show major shoaling at the mouths of the canals, which affects boats transiting either route.

The regional evaluation of the Central Embayment shows where and when recreational boating can occur outside the access channels. Over 50 percent of this area is less than 2 ft deep. It is of no surprise that more than two–thirds of the south shore residents' boating destinations are ICW and Ocean–bound since 89 percent of their boats have a 2+ ft draft. The Sandbar is an attractive destination within the Embayment mainly because it is 'accessible' to all draft class boats.

g. Boater Education Products

Three types of boater map products were produced: (1) a resource inventory photomap; (2) accessibility photomaps; and (3) nature–tourism maps. These products provide a better understanding of the natural resources available to boaters in the Central Embayment and foster stewardship which will encourage better resource use practices and contribute to safer boating.

h. Conclusions

Boaters have been using two unimproved routes: the easterly one, passing east of the mangrove islands, to join the improved navigation channel; and the westerly one, paralleling the south shore, then turning north to the improved navigation channel. These natural (unimproved) access routes from the residential canals to the dredged main channel have shoaled in the past 30 years.

The greatest number of boats are situated in the easternmost canals; this coincides with the largest concentration of deeper draft boats. The majority (two–thirds) of all boaters head east to the ICW/Ocean; relatively few south shore boaters use the river as their boating locale. Sixty percent of the boats encounter some depth restriction using the westerly route; 89 percent are restricted to some degree on the easterly route. The westerly route is 11,923 ft in length (about twice as long as the 5,866 ft easterly route); 3,595 ft of the westerly route channel restrict boat traffic and require some dredging. By comparison, 3,816 ft on the easterly route are restricted. The westerly route will require the removal of an estimated 3,358 cu yd of dredge, while the

easterly one will need 3,598 cu yd to be removed in order to provide unrestricted access to all boats. Approximately 288 ft of the westerly route traverse sea grass beds, while the easterly channel crosses 765 ft of this sensitive habitat.

A boating management objective should be to facilitate traffic flow from the areas of greatest boat concentrations (originating in the Dolphin and Marlin canals) to the ICW/Ocean, in order to minimize waterway congestion and reduce impacts on the environment. The results of the boater survey and traffic analysis argue in favor of improving the easterly route northeast from Dolphin/Marlin past the mangrove islands to the main navigation channel.

Another boating management objective should be to educate boaters—not just the south shore residents, but others as well, who recreate in the Central Embayment--as to the shallow nature of this region and of the location and extent of its sensitive marine habitat. Over 50 percent of this area is less than 2 ft deep. The attractiveness of the Sandbar as a destination within the Embayment is in large measure due to its accessibility to all draft class boats since it lies adjacent to the dredged main river channel. As a boating region, it is ideally suited to boats with a 1 ft draft since 86 percent of the area is accessible at sometime. In contrast, a boat with a 3+ draft would have extremely restricted access outside the main channel. The navigability photomaps offer a useful boating management tool since suitable boating areas are identified for boats with different drafts.

i. Recommendations

1. Establish an 'improved' navigation access channel along the Easterly Route to route boat traffic flow from south shore canals to the Loxahatchee River. There should be a maintenance–dredging provision for this 'improved' channel with a controlling depth set at 4 ft. This will provide all boats presently berthed along the south shore area with reasonable access, by fitting the access channel's controlling depth to boat draft requirements. It will also discourage south shore residents from berthing deeper draft (larger) boats in this area which will minimize future boating impacts on surrounding marine habitats.
2. Mark the proposed, 'improved', easterly access channel with aids to navigation: (a) at the junctions of the five canals with the easterly access connector channel; (b) along the south flank of the connector channel, from Penn to Dolphin canals; and (c) at strategic locations on both sides of the connector channel, north of Dolphin and between Marlin Drive and the mangrove islands.
3. Designate the major sea grass area south of the main navigation channel for rehabilitation, in part to mitigate the habitat lost by creating the 'improved' easterly route and also to offset encroachment from intensive boating uses on the Sandbar along its northern fringe. Establish a habitat restoration program for this area that includes both site enhancement and public education elements.

Monitor habitat conditions and report changes to the appropriate management authority.

4. Launch a public education program to advise residents and visitors on the boating potentialities and limitations of the Central Embayment based on its environmental conditions. Publish and distribute copies of the Resource Inventory Photomap to all shorefront residents; it provides information on bathymetry, channel controlling depths, sea grass, navigation aids and manatee/speed zone signs. Publish and distribute copies of the Boating Accessibility Photomaps to residents and visitors. These photomaps designate, for a given draft vessel, specific areas of the Embayment where unrestricted access is available or where restricted or limited boating conditions prevail. Use of these maps will promote stewardship through a better understanding of the region's environmental conditions.

Reference

Paul W. Box, 1997, *Bottom-Up Simulation for Evaluation of Recreational Boat Traffic Monitoring*, Ph.D. Dissertation, Department of Geography, University of Florida, Gainesville, Fl.

Depth Change (ft)	Area of ft^2	Central mi^2	Embayment Percent
–7	16,800	0.001	0.097
–6	1,600	0.000	0.009
–5	54,000	0.002	0.312
–4	288,400	0.010	1.665
–3	696,000	0.025	4.019
–2	1,571,200	0.056	9.073
–1	5,240,000	0.188	30.260
0	7,266,000	0.261	41.959
1	1,293,600	0.046	7.470
+2	496,000	0.018	2.864
+3	256,000	0.009	1.478
+4	96,800	0.003	0.559
+5	28,000	0.001	0.162
+6	8,400	0.000	0.049
+7	2,400	0.000	0.014
+8	800	0.000	0.005
+9	800	0.000	0.005
Total	17,316,800	0.621	100.000

Table 1. Bathymetry changes between 1967 and 1996

Evaluation Criteria	Easterly	Route	Westerly	Route
Boats	(#)	(%)	(#)	(%)
Unrestricted	14	11.29	49	39.52
Restricted	110	88.71	75	60.48
Total	124	100.00	124	100.00
Channel Length	(ft)	(%)	(ft)	(%)
Unrestricted	2,050	34.95	8,328	69.85
Restricted	3,816	65.05	3,595	30.15
Total	5,866	100.00	11,923	100.00
Dredging	(yd^3)		(yd^3)	
Volume	3,598		3,358	
Sea Grass Intersect	(ft)		(ft)	
Length	765		288	

Table 2. Comparative analysis of the easterly and westerly access routes

Water Depth (ft)	Area in 1996 (%)
<1	13.91
1	43.73
2	9.00
3	12.11
4	9.29
5	5.48
≥6	6.48

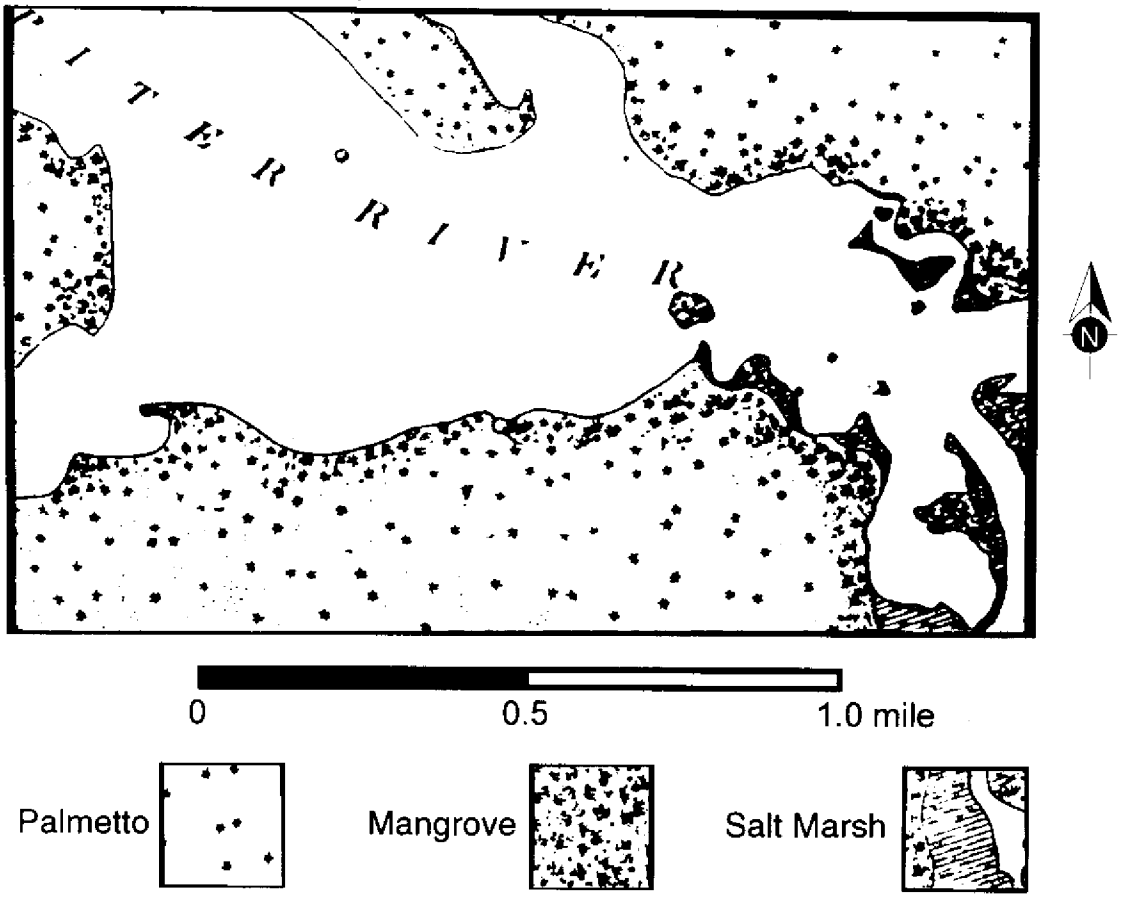
Table 3. Central Embayment area water depth in 1996 (%)

Boat Draft (ft)	Accessibility (% of Embayment)				South Shore Boats (%)
	Anytime	Mid – High Tide	Sometime	At No Time	
1	42.36	43.73	86.09	13.91	11.30
2	33.36	9.00	42.36	57.64	32.30
3	21.25	12.11	33.26	66.64	46.00
4	11.95	9.30	21.25	78.75	10.50
Wgt. Avg.	26.59	14.40	40.94	59.11	

Table 4. Relative numbers of south shore boats and accessible areas in the Central Embayment

Central Embayment, Loxahatchee River
Jupiter, Florida

Land Use/Land Cover, 1883



Bathymetry, 1884

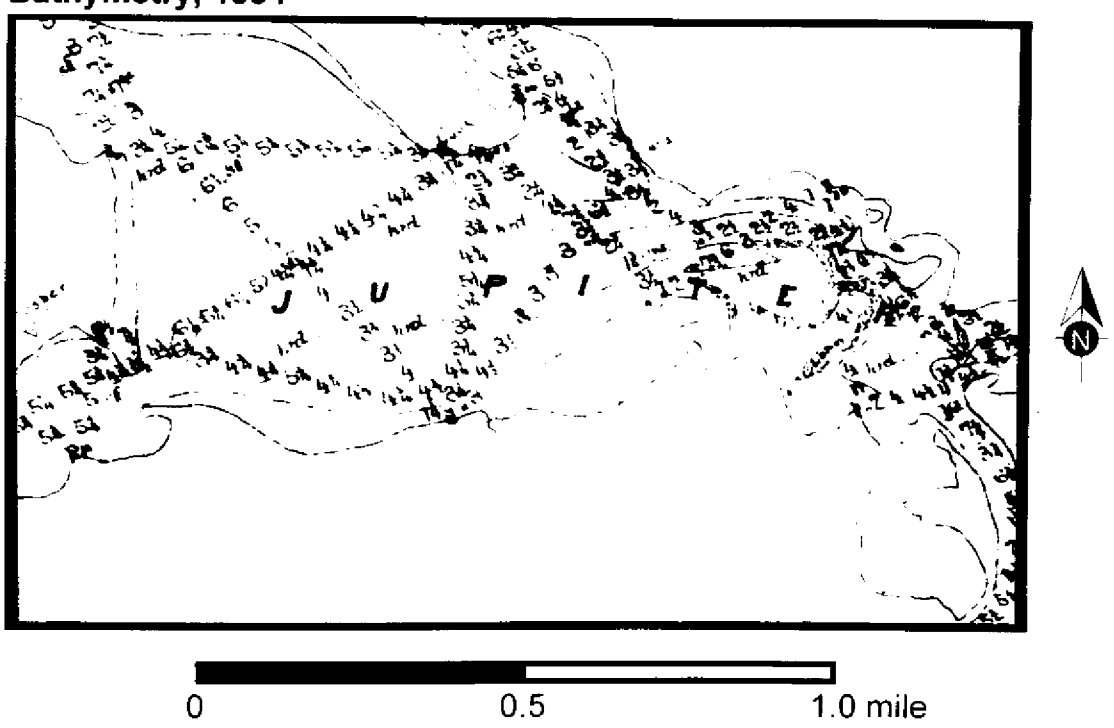


Figure 1. Central Embayment land use/land cover (1883) and bathymetry (1884)

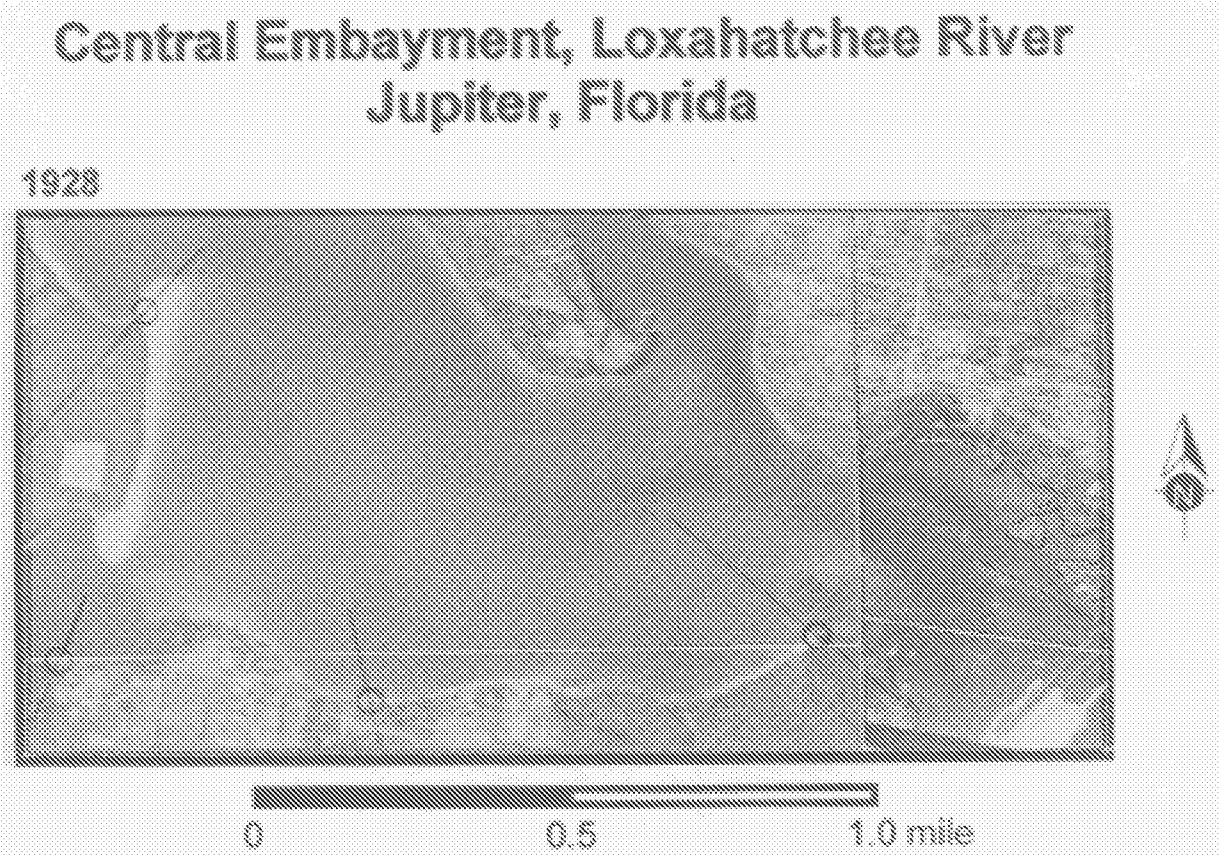


Figure 2. Trimetrigon aerial photograph taken in 1928, from NGS archives

Central Embayment, Loxahatchee River
Jupiter, Florida

June, 1954

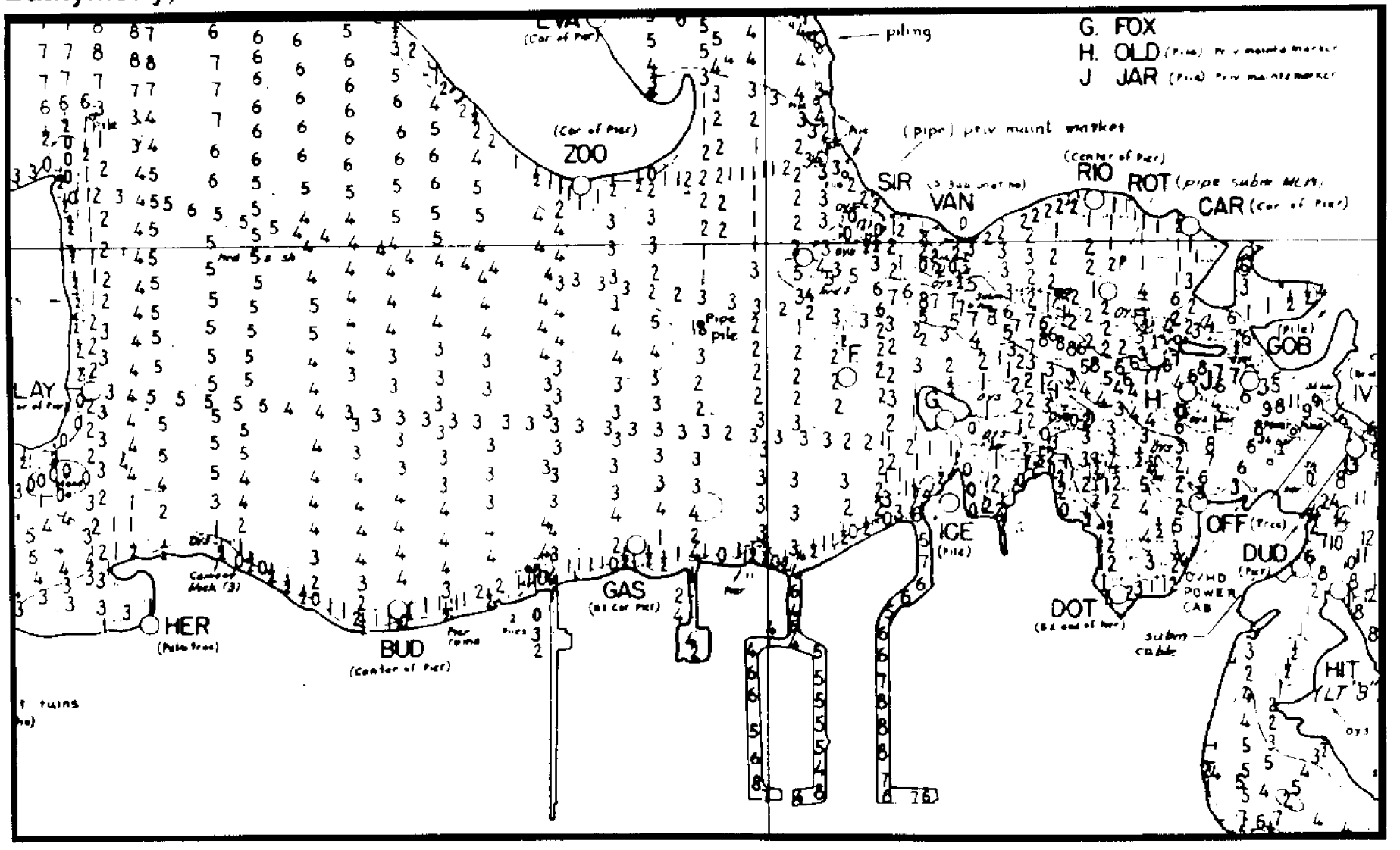
January, 1958

Figure 3. Central Embayment aerial photographs, June 1954 and January 1958

Figure 4. Central Embayment, Loxahatchee River, Jupiter, Florida

Central Embayment, Loxahatchee River
Jupiter, Florida

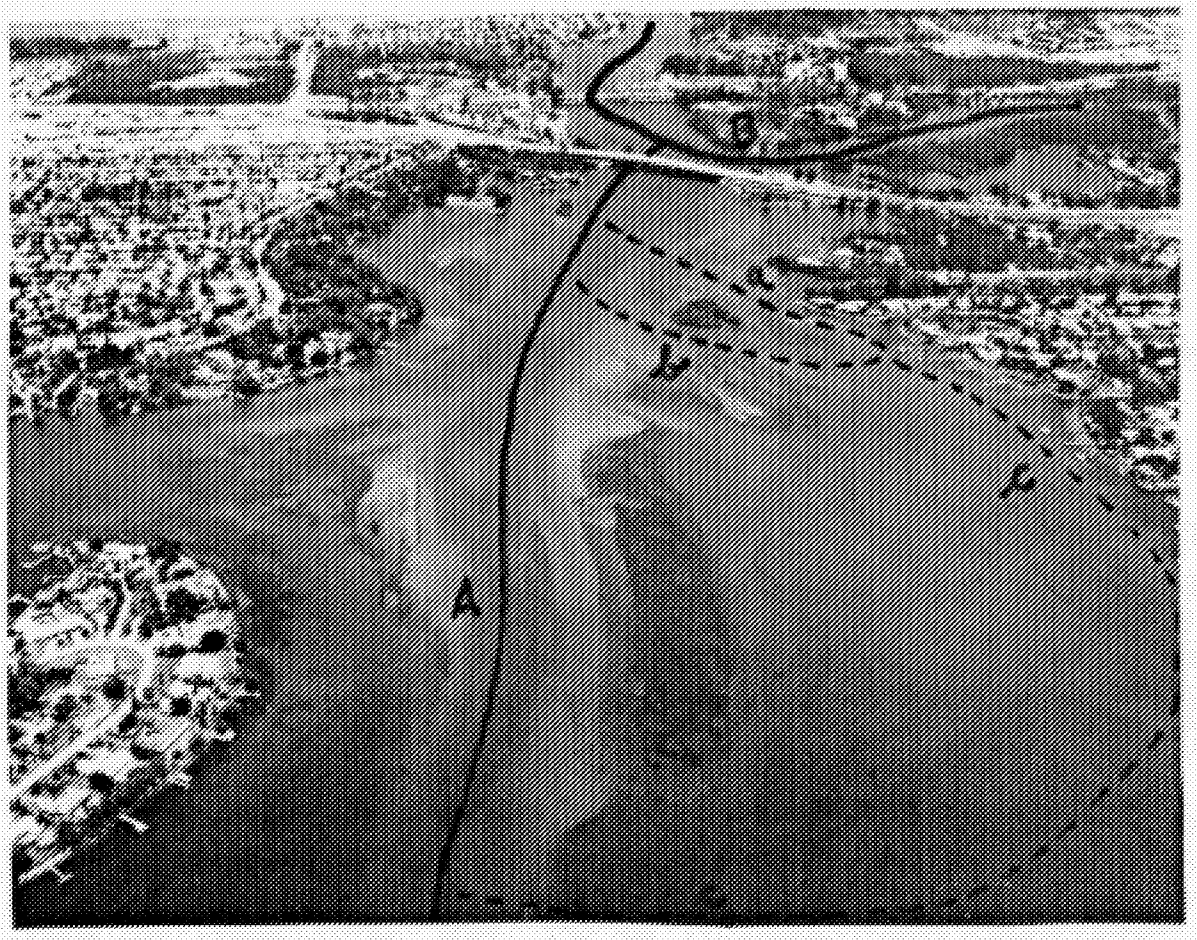
Bathymetry, 1969



Soundings in feet (Mean Low Water)

0 0.25 0.5 mile

Figure 5. Bathymetric survey, NOS Chart 9007, 1967, 1:10,000 scale



Unimproved Routes

a East of mangrove islands

b West of mangrove islands

c West loop paralleling south shore

Improved Routes

A Loxahatchee River

B Intracoastal Waterway

Figure 6. Oblique aerial taken May 1984, showing unimproved boat routes from south shore canals to improved navigation channel

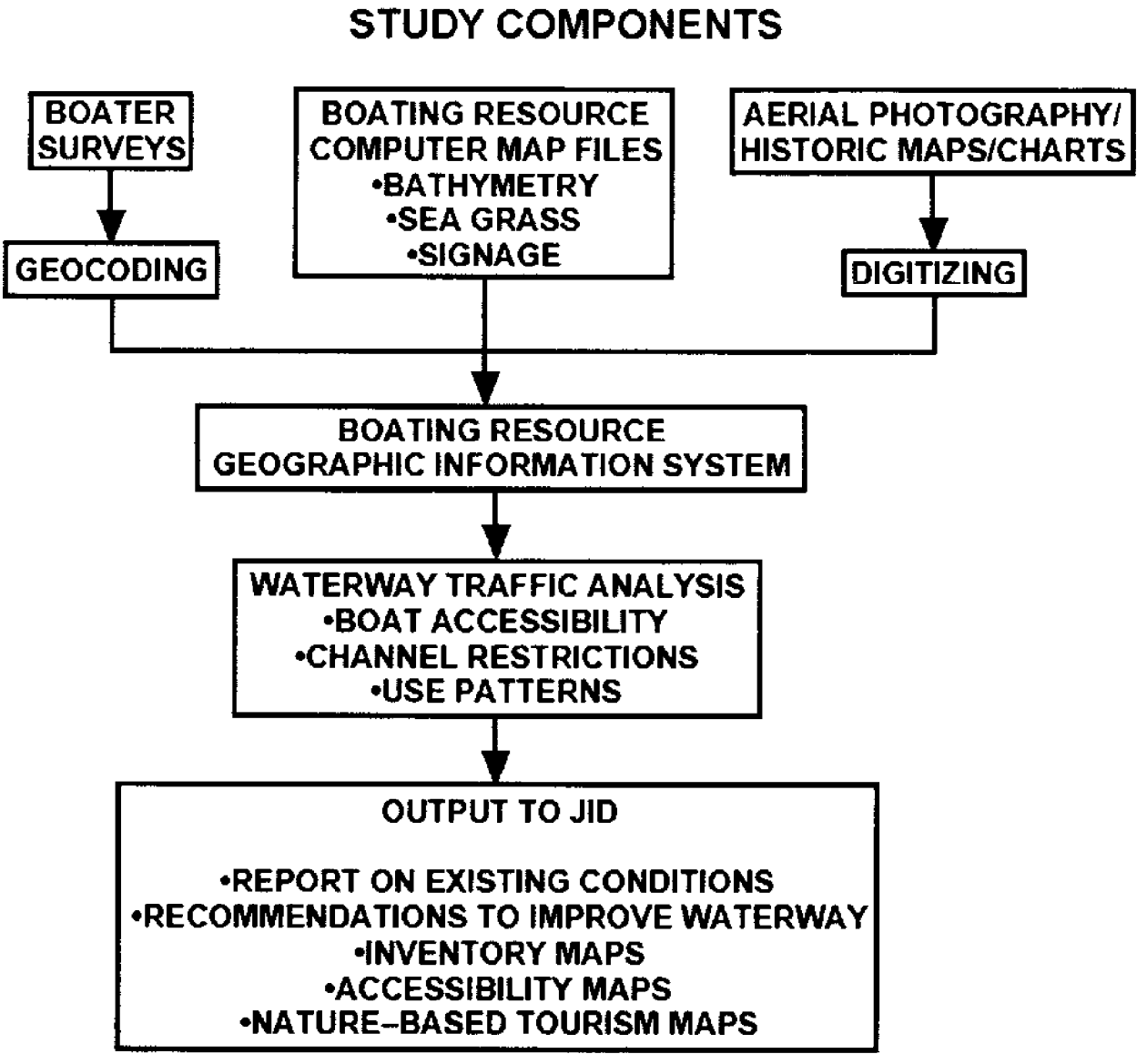


Figure 7. Flow chart of study components

Sea Grant
Florida

Manatee Sign

Navigation Aids
- Red Mark
- Green Mark
- Sea Grass

Boat Idle Draft
- 1 foot
- 2 feet
- 3 feet
- 4 feet

Bathymetry (feet, mllw)
- 2 or less
- >2 to 4
- >4 to 6
- >6 to 8
- >8

0 500 1000
Feet

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Data Sources

Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Boat distribution: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

This photomap was prepared in February 1998 by the Florida Sea Grant College Program. Its purpose is to help boaters identify sensitive marine habitats and shoal areas where traffic and anchoring should be avoided. **All sea grass beds should be considered non-navigable and not suitable for boating activities. Mariners must bear all responsibility for seamanship, piloting, and navigation.**

Figure 8. Photomap of bathymetry, sea grass, signage, and distribution of boats in South Shore canals

Bathymetry (feet)

1 3 5 7 9 11 13 15 17

2 4 6 8 10 12 14 16

Source: Morgan & Ecklund, Inc., 1996 field survey

Datum: Mean lower low water (mllw)

1000 500 0 1000

Feet

N

Figure 9. Chloropleth bathymetric map, at 1 foot resolution, showing 1996 conditions

Bathymetry (feet, mllw)

2 or less >4 to 6 >8

>2 to 4 >6 to 8

Source: NOS H-Sheet 9007

1000 500 0 1000

Feet

N

Figure 10. Chloropleth bathymetric map showing 1967 conditions

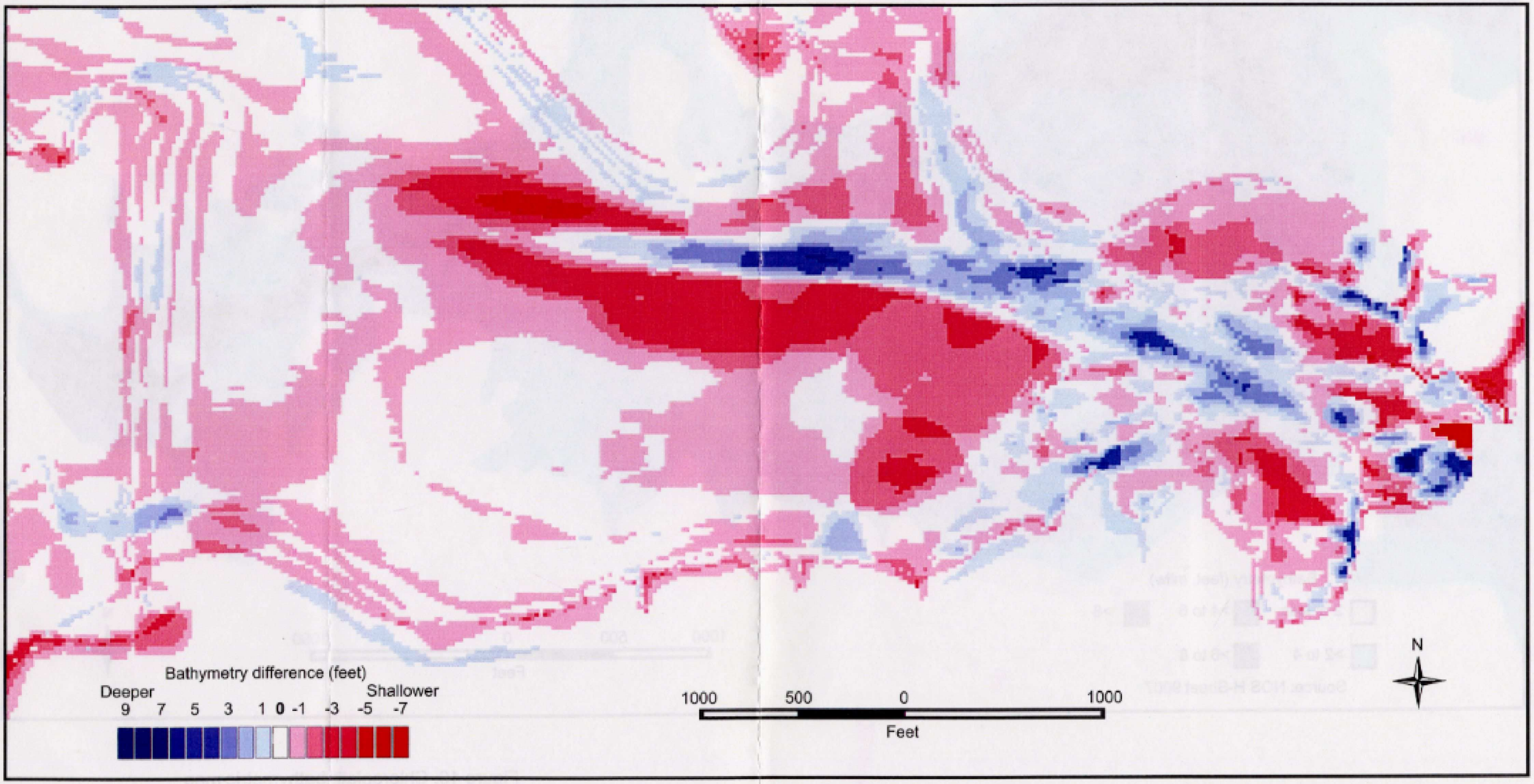

Figure 11. Bathymetry changes between 1967 and 1996

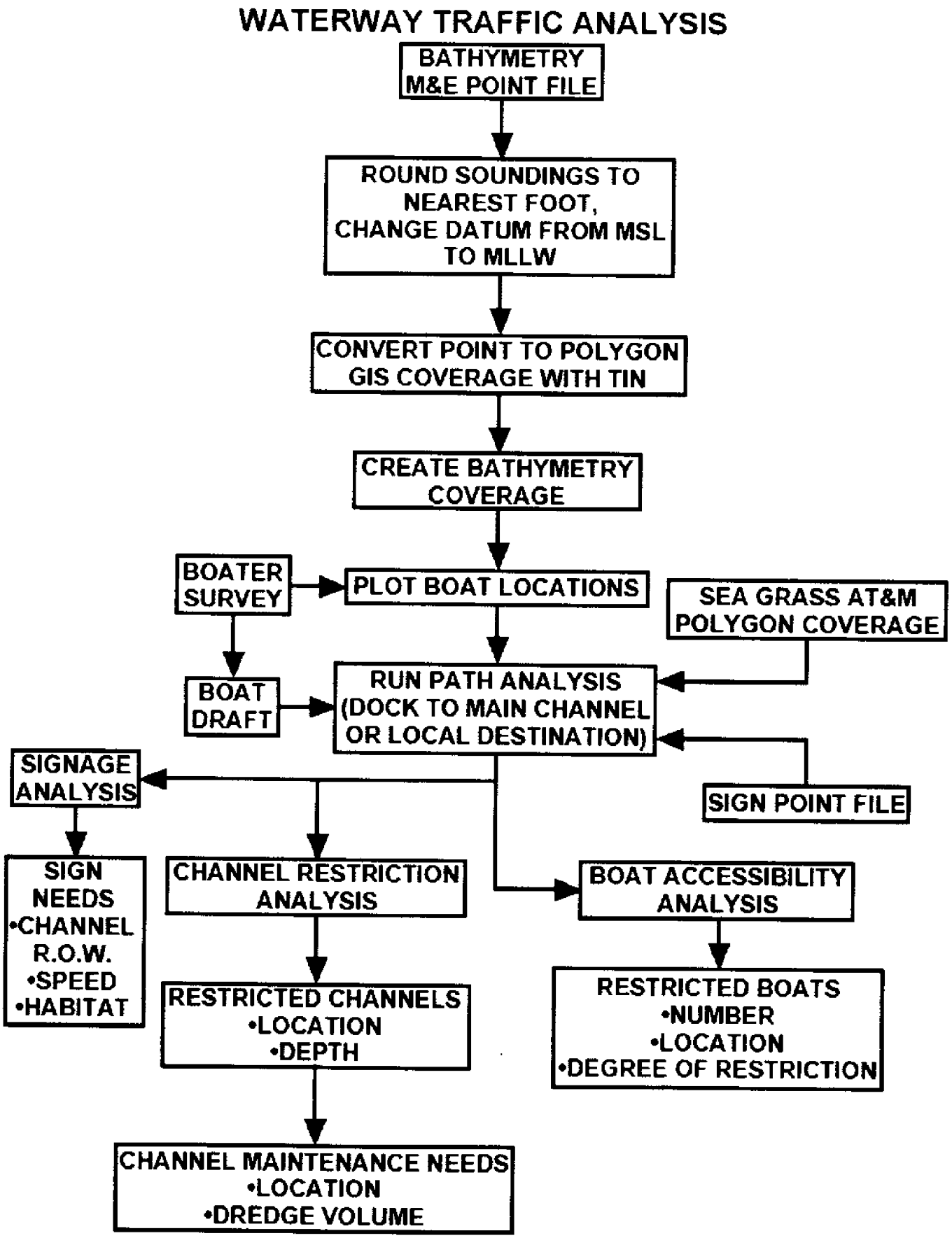

Figure 12. Flow chart of waterway traffic analysis

Sea Grant
Florida

Boat blockage
- Not blocked
- Medium tide
- High tide

- M Manatee Sign

Navigation Aids
- Red Mark
- Green Mark
- Sea Grass

Dredging required to provide access for deepest (4-foot draft) boats
- None
- 1 foot
- 2 feet

1000 500 0 1000
Feet

Data Sources
Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Boat distribution: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

N
Loxahatchee River

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Figure 13. Easterly route photomap

Sea Grant
Florida

Boat blockage
- Not blocked
- Medium tide
- High tide

- M Manatee Sign

Navigation Aids
- Red Mark
- Green Mark
- Sea Grass

Dredging required to provide access for deepest (4-foot draft) boats
- None
- 1 foot
- 2 feet

Data Sources
Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Boat distribution: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

1000 500 0 1000
Feet

N

Loxahatchee River

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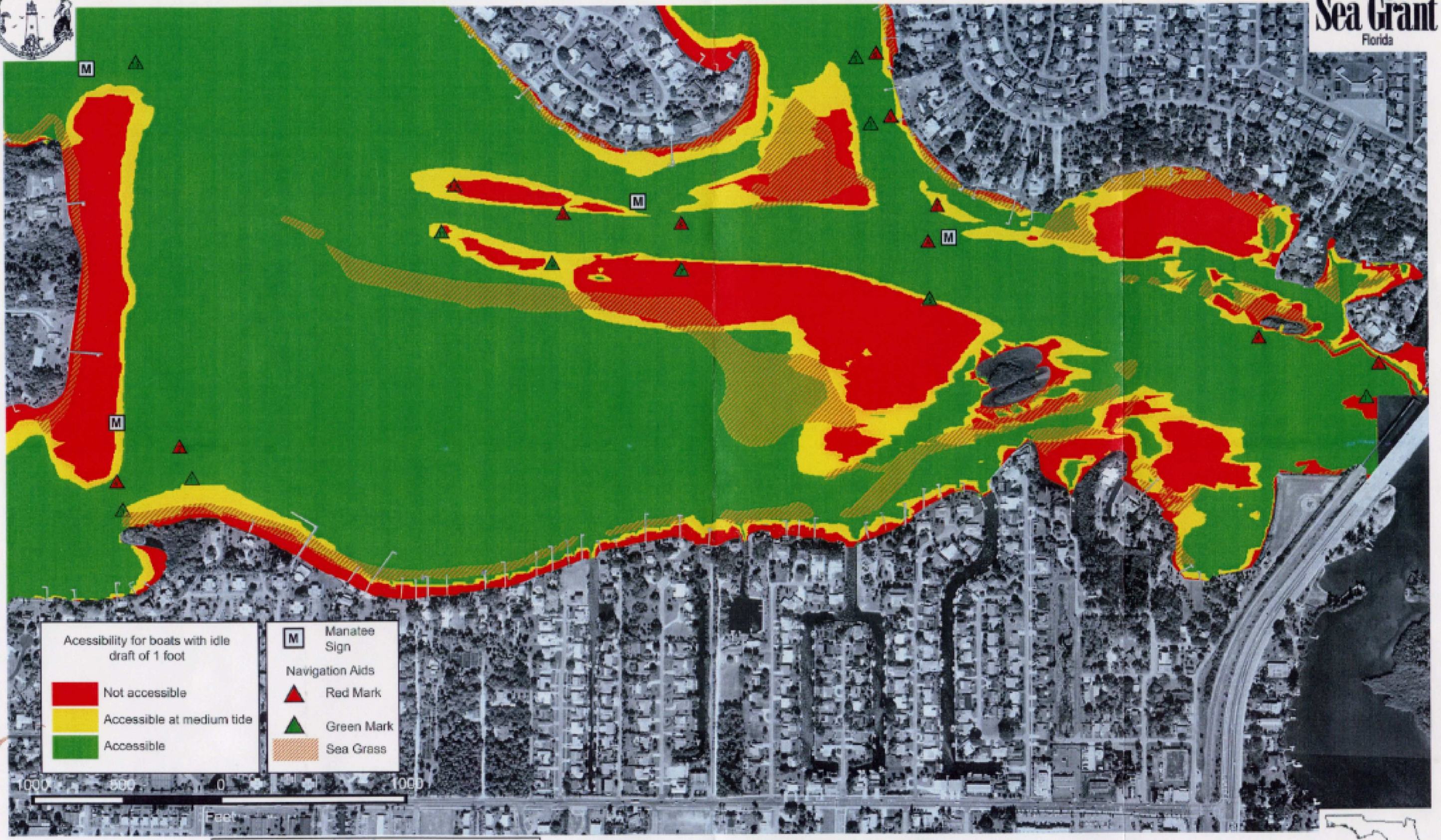
Figure 14. Westerly route photomap

Sea Grant
Florida



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Data Sources
Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Accessibility: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

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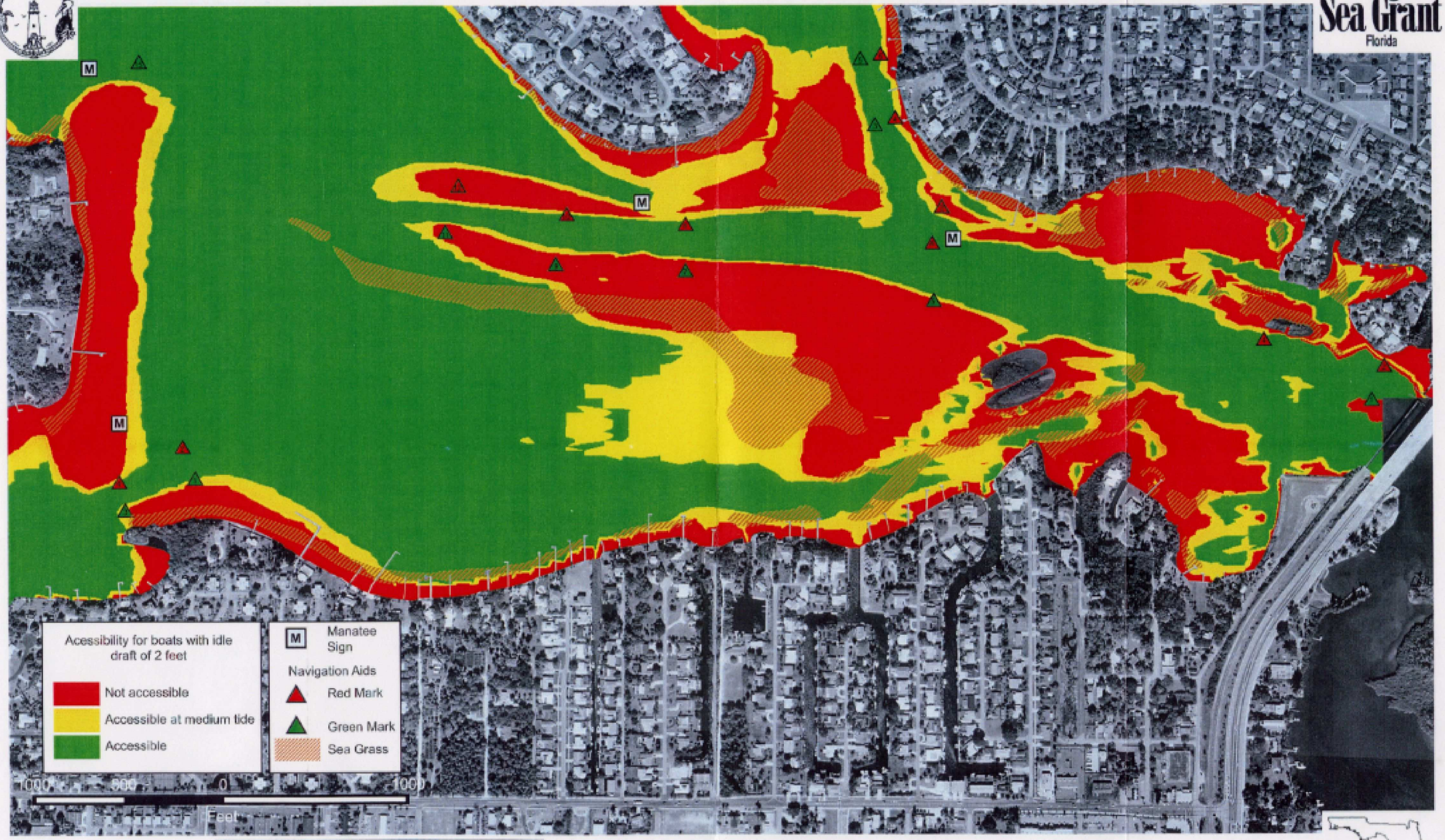
Figure 15. Boating accessibility zones for 1-foot draft boats

Sea Grant
Florida



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Data Sources

Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Accessibility: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
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Figure 16. Boating accessibility zones for 2-foot draft boats

Sea Grant
Florida

Acessibility for boats with idle draft of 3 feet

- Not accessible
- Accessible at medium tide
- Accessible

- M Manatee Sign

Navigation Aids

- Red Mark
- Green Mark
- Sea Grass

1000 500 0 1000 Feet

Data Sources

Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Accessibility: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

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Figure 17. Boating accessibility zones for 3-foot draft boats

N

Loxahatchee River

Sea Grant
Florida

Acessibility for boats with idle draft of 4 feet

- Not accessible
- Accessible at medium tide
- Accessible

- M Manatee Sign

Navigation Aids

- Red Mark
- Green Mark
- Sea Grass

1000 0 500 0 1000 Feet

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Data Sources

Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Accessibility: From waterway analysis by Florida Sea Grant
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

This photomap was prepared in February 1998 by the Florida Sea Grant College Program. Its purpose is to help boaters identify sensitive marine habitats and shoal areas where traffic and anchoring should be avoided. **All sea grass beds should be considered non-navigable and not suitable for boating activities. Mariners must bear all responsibility for seamanship, piloting, and navigation.**

Figure 18. Boating accessibility zones for 4-foot draft boats

N

Loxahatchee River

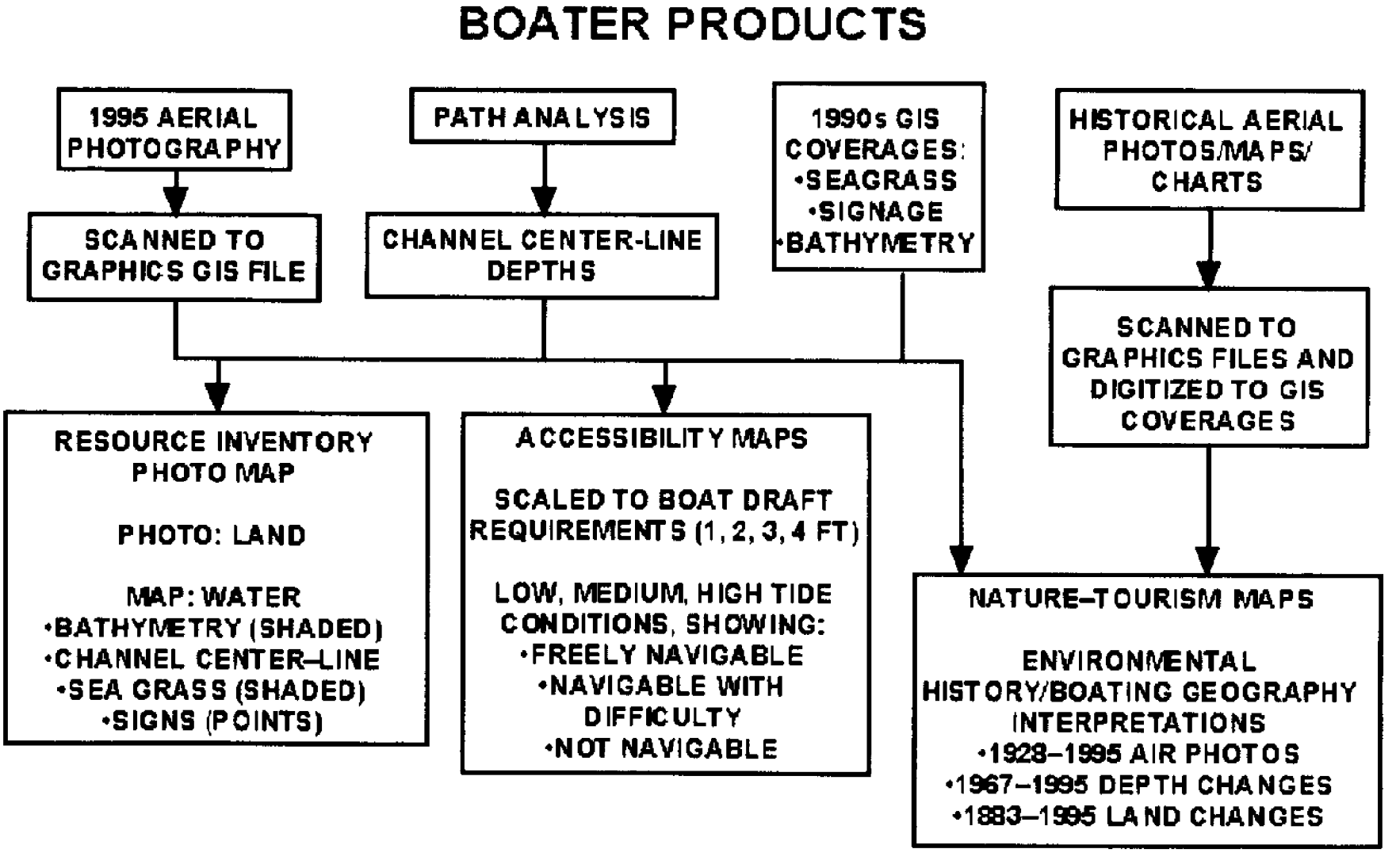

Figure 19. Boater products develop by this project

Sea Grant
Florida

Manatee Sign

Navigation Aids

Red Mark

Green Mark

Sea Grass

Controlling depth

4 feet

3 feet

2 feet

Bathymetry (feet)

1 3 5 or more

2 4

1000 500 0 1000

Feet

Data Sources

Bathymetry: Morgan & Eklund, Inc., 1996 field survey (mllw datum)
Sea grass: Applied Technology & Management, 1996 field survey
Aids to Navigation: Law Environmental, Inc. (1993 source updated by Jupiter Inlet District in 1997)
Manatee signs: Florida Inland Navigation District

This photomap was prepared in February 1998 by the Florida Sea Grant College Program. Its purpose is to help boaters identify sensitive marine habitats and shoal areas where traffic and anchoring should be avoided. **All sea grass beds should be considered non-navigable and not suitable for boating activities. Mariners must bear all responsibility for seamanship, piloting, and navigation.**

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N

Loxahatchee River

Figure 20. Resource inventory photomap

Appendices

Appendix A Waterway Evaluation Boater Questionnaire

Waterway Evaluation
of the
Central Embayment, Loxahatchee River
Jupiter, Florida

Waterway Resident and Boater

We are asking you to participate in a study being carried out to determine the channel access needs of boaters on the south shore of the Central Embayment. We hope that you will provide us with information concerning your boat and recreational boating activities so that we may evaluate them in relation to safety and environmental conditions in the river.

After we have gathered this information, we will study it to determine the best method of ensuring safe, environmentally sustainable access to the water to residents within a non-regulatory framework. We intend that this study will offer baseline information for a management strategy that will balance boat traffic with marine resource protection.

We want to be sure that the conclusions reached in this study are realistic. We place great importance on your willingness to participate and provide us with responses to the questions.

We would be pleased to answer any questions you have concerning the study procedures. All information is absolutely confidential.

If you are not a boat owner, we still ask that you return the questionnaire so that we may be assured that our response rate is as close to one hundred percent (100%) as possible.

Thank you for your cooperation.

Sincerely,

Michael J. Grella, AICP
Executive Director

Section 1: Information About Boat and Owner

1: Name _____

2: Occupation: _____

3: Age (optional): _____

4a: Street Address where boat is berthed: _____
(IF you are not a boat owner, you may skip the remaining questions)

4b: Indicate boat berth location with an X on the enclosed map.

5: Kind of Boat (circle one): Sail Power Cabin Speed

Recreational Fishing Row/Canoe Houseboat Pontoon

Other (specify) _____

6a: Boat make: _____

6b: Boat model: _____

6c: Year Built: _____

7: Draft (to nearest half foot) under the following conditions.

(a) Idle/No-Wake: _____ (b) Normal Operation: _____ (c) Planing: _____

Section 2: Information About Boat Use:

8: How often do you take your boat out (answer for all of the following seasons):

(a) summer _____ (time per week) (b) fall _____ (times per week)

(c) winter _____ (times per week) (d) spring ____ (times per week)

9: What time of day do you normally take your boat out? _____

10: Where do you usually take your boat out? List by name, and also kindly indicate the direction with a "D" on the enclosed map.

_____

_____

11: Indicate on the attached map the route(s) you *usually* take from your dock to the boating destinations:

Most frequent destination

1) _____

2) _____

3) _____

Least frequent destination

12: What do you typically do when you take your boat out (List your preferred boating activities in order of importance)

More Important

1) _____

2) _____

3) _____

Least Important

13: How long is a typical boating trip?

_____ hours

_____ days

Section 3: Questions About Potential Problems

14: Is the depth of the access channel a cause of concern? (Circle one)

Major concern Minor concern No concern

Please mark on the enclosed map the areas of greatest concern with a letter "A"

15: If the access channel depth is a cause of concern, how do you deal with it? (Circle ones that apply)

Only take the boat out on a medium tide or better

Only take the boat out on a high tide

Enter/exit canal at idle speed with lower unit or centerboard up

Enter/exit canal on a plane

Chew on fingernails

Appendix B . Loxahatchee River Central Embayment Data Base

Appendix B
Explanation of Information Fields in
Loxahatchee Central Embayment Data Base

(1) Boaters

Column	Explanation
R_IDNO	questionnaire identification number assigned by Jupiter Inlet District (*this is an identifier unique to each respondent; since one respondent may have more than one boat, the IDNO is repeated in the data base to capture multiple listings by each boat owner*)
B_INDO	boat identification number assigned by Florida Sea Grant (*this is an identifier unique to each vessel*)
SHEDNUM	refers to the canal in which the boat is berthed. Five canals are numbered from west to east, and correspond to the following names: (1) Penn; (2) Turner Quay; (3) Pompano; (4) Dolphin; (5) Marlin
OCCUPATION	boat owners include employment in: construction (contractor, equipment operator, inspector, trades), engineering (mechanical, network, nuclear), government (customs, parks/recreation, utilities), legal (attorney), medical (dentist, hospital administration, nursing, pharmacist, physician, professional), sales and service (administration, airlines, computer, distribution, food, hotels, insurance, investment, landscaping, management, marketing, planning, retail, tourism), retired
AGE_COHORT	respondents' age is grouped into: 0-14 (years old) = 1, 15-24 = 2, 25-44 = 3, 45-64 = 4, ≥65 = 5, no response = 6
AGE	respondents' age as reported in questionnaire

(2) Boats

Column	Explanation
KIND_OF_BOAT	classified as: houseboat, other, pontoon, power cabin, recreational fishing, row/canoe, sail, speed
BOAT_MAKE	includes the following manufacturers: Aqua Sport, Avon, Bayliner, Beehive, Bertram, Boston Whaler, Caprice, Chris Craft, Cobia,

	Contender, Donzi, Dusky, Egg Harbour, Force 5, Frost, Gheenoe, Gemini, Glastron, Goldline, Grady White, Hobie, Intrepid, Key West, Lake & Bay, Lumas, Mako, Manatee, Maverick, MTX, Ocean, Pacemaker, Phoenix, Ranger, Robalo, Rybovich, Sabreline, Sea Ray, Sea Vee, Seacraft, Seapro, Starline, Stratos, Sunbird, Sylvan, T-Craft, Thunderbird, Topaz, Uniflite, Wahoo, Wellcraft
BOAT_MODEL	may be verbal descriptor, as Bahiamar (Bertram), Cierra (Bayliner), Walkaround (Grady White), or length designation, as 26.5 (ft Robalo), 17 (ft Boston Whaler), or a combination, as 21 Open (Ocean)
YEAR	refers to year of boat manufacturer

(3) Boat Draft

Column	Explanation
IDLEDFT	water depth (to nearest foot) required by vessel at idle (no-wake) speed
NORDFT	water depth (to nearest foot) required by vessel at normal operating speed
PLANDFT	water depth (to nearest foot) required by vessel at planing (high) speed

(4) Trip Frequency

Column	Explanation
R_HOURS	boating period during day or night, described as: morning; afternoon; evening; morning, afternoon; afternoon, evening; morning, afternoon, evening; all day; varies; tides dictate
TRIPHOURS	number of hours in typical boating trip
TRIPDAYS	number of days in typical boating trip
SUM-FREQ	number of times/week boat taken out during summer (June, July, August), e.g., 4 = 4 trips/week, 0.25 = 1 trip/month
FALL_FREQ	number of times/week boat taken out during fall (September,

October, November), e.g., 4 = 4 trips/week, 0.25 = 1 trip/month

WIN_FREQ	number of times/week boat taken out during winter (December, January, February), e.g., 4 = 4 trips/week, 0.25 = 1 trip/month
SPR_FREQ	number of times/week boat taken out during spring (March, April, May), e.g., 4 = 4 trips/week, 0.25 = 1 trip/month

(5) Boating Activities

Column	Explanation
ACT1, ACT2, ACT3	boating activities, where ACT1 = primary (most preferred), ACT2 = secondary, ACT3 = tertiary (less preferred). Activities have been grouped into: cruising, diving/swimming, fishing, leisure (i.e., social, restaurant, pleasure, idle around, relax, sightseeing), speedboating/skiing, sailing

(6) Boating Destinations

Column	Explanation
DEST1,DEST2,DEST3	boating destinations, where DEST1 = primary (most frequent), DEST2 = secondary, DEST3 = tertiary (least frequent). Six destinations are noted: ICW (Intracoastal Waterway) and (Atlantic) Ocean; (Loxahatchee) River; North Fork; Northwest Fork; Southwest Fork; Sandbar

(7) Accessibility Issue and Piloting Strategies

Column	Explanation
AXMAJ	water depth in the entrance channel is a major access problem
AXMIN	water depth in the entrance channel is a minor access problem
AXNO	water depth in the entrance channel is not an access problem
MEDTIDE	boater enters/exits entrance channel on a medium tide or better to deal with access problem
HITIDE	boater enters/exits entrance channel on a high tide to deal with access problem

IDLETIDE	boater enters/exits entrance channel at idle speed (with lower unit up on vessels with variable draft capability)
PLANTIDE	boater enters/exits entrance channel on a plane (at planing speed)
NAILTIDE	boater trusts in 'divine providence [chews on nails] when entering/exiting entrance channel

Loxahatchee River Central Embayment Data Base

R_IDNO	B_INDO	SHEDNUM	OCCUPATION	AGE_COHORT	AGE	KIND_OF_BOAT	BOAT_MAKE	BOAT_MODEL	YEAR	IDLEDFT	NORDFT	PLANDFT	HOURS	TRIPHOURS	TRIPDAYS	SUM_FREQ	FALL_FREQ	WIN_FREQ	SPR_FREQ
103	103	1	PROPERTY MANAGER	6		SPEED	CHRISCRAFT	STINGRAY	1990	2	2	1	all day	4.00	5.00	2.00	1.00	0.50	1.00
104	104	1		3	44	RECREATIONAL FISHING	MAKO	DEEP VEE	1977	2	2	2	tides dictate	4.00	0.50	3.00	3.00	2.00	3.00
105	105A	1	NUCLEAR ENGINEER	3	44	RECREATIONAL FISHING	RYBOVICH		1984	2	2	2	all day	12.00	1.00	2.00	2.00	1.00	2.00
105	105B	1	NUCLEAR ENGINEER	3	44	SPEED	AQUASPORT		1972	2	2	2	all day	6.00	1.00	2.00	2.00	1.00	2.00
105	105C	1	NUCLEAR ENGINEER	3	44	PERSONAL WATERCRAFT	YAMAHA		1987	1	1	1	all day	2.00	1.00	2.00	2.00	1.00	2.00
106	106	1	NETWORK ENGINEER	3	35	POWER CABIN	AQUASPORT/WHALER	250/SPORT	1982	3	3	2	afternoon	4.00	0.50	3.00	1.00	1.00	2.00
107	107	1	BIOCHEMIST	6		POWER CABIN	SEACRAFT	SEAFARI	1979	2	2	2	morn, aft, even	5.00	0.50	2.00	2.00	1.00	2.00
108	108	1	NURSE	6		OTHER	HOBIE	SKIFF	1988	2	2	1	tides dictate	4.00	0.50	2.00	2.00	2.00	2.00
110	110	1	DENTAL TECHNICIAN	4	54	RECREATIONAL FISHING	LAKE&BAY	20'	1991	2	2	1	all day	3.00	0.50	2.00	2.00	2.00	2.00
111	111	1	DENTAL TECHNICIAN	3	39	RECREATIONAL FISHING	GRADY WHITE	DOLPHIN	1991	2	2	2	morning	7.00	4.00	3.00	2.00	2.00	3.00
122	122	5	PHYSICIAN	3	43		MAKO	231	1991	3	3	2	morn, aft	3.50	0.50	4.00	3.00	1.00	3.00
123	123	4	ENGINEER	4	57	RECREATIONAL FISHING	MAKO	CENTER	1979	2	2	2	morning	6.00	0.50	2.00	1.00	1.00	2.00
124	124	4	PHYSICIAN	4	46	RECREATIONAL FISHING	SEACRAFT		1985	3	3	3	morn, aft	3.00	0.50	1.00	1.00	1.00	1.00
125	125	4	RETIRED	5	70	RECREATIONAL FISHING	BERTRAM	BAHIAMAR	1971	3	3	2	morn, aft	7.00	0.50	0.00	3.00	3.00	3.00
127	127	4	CONTRACTOR	3	32	RECREATIONAL FISHING	GOLDLINE	OPEN	1987	3	3	3	morning	12.00	1.00	3.00	3.00	3.00	3.00
128	128A	4	NURSERY OWNER	6		RECREATIONAL FISHING	SEACRAFT	23'	1979	3	2	1	morning	5.00	0.50	5.00	3.00	2.00	3.00
128	128B	4	NURSERY OWNER	6		RECREATIONAL FISHING	CAPRICE	16'	1990	3	2	1	morning	5.00	0.50	5.00	3.00	2.00	3.00
129	129	4	MRI TECHNICIAN	4	50	POWER CABIN	SEARAY	34'EXPRESS	1987	3	2	2	morning	9.00	0.50	2.00	2.00	2.00	2.00
131	131	4	INDEPENDENT DISTRIBUTOR	3	42	RECREATIONAL FISHING	CHRIS CRAFT	SCORPION	1980	3	2	2	no data	4.00	0.50	2.00	2.00	1.00	2.00
132	132	4	RETIRED	6		RECREATIONAL FISHING	GRADY WHITE	OVERNITE	1994	1	2	1	morning	7.00	0.50	1.00	0.50	0.50	1.00
135	135	4	ENGINEER (RETIRED)	4	63	POWER CABIN	SEACRAFT	SPORT	1988	2	2	1	morning	6.00	0.50	2.00	2.00	2.00	2.00
136	136	4	CONTRACTOR	3	42	POWER CABIN	TOPAZ	28' EXPRESS	1980	3	3	3	tides dictate	6.00	0.50	2.00	2.00	1.00	2.00
137	137	4	SELF EMPLOYED-WELLDRILLING	3	41	POWER CABIN	EGGHARBOUR	SPORT	1988	4	4	3	tides dictate	12.00	1.00	3.00	2.00	1.00	3.00
138	138	4	GENERAL CONTRACTOR	4	47	RECREATIONAL FISHING	BEEHIVE	25'	1978	2	2	1	varies	4.00	21.00	4.00	2.00	2.00	4.00
139	139	4	FPL SUPERVISOR	4	51	OTHER	SPORT FISHERMAN	CATLIMBO	1984	4	4	3	morning	10.00	5.00	4.00	3.00	2.00	3.00
142	142	4	GENERAL CONTRACTOR	6		RECREATIONAL FISHING	SEA VEE		1989	2	1	1	varies	4.00	0.50	3.00	2.00	1.00	2.00
144	144	4	CONTRACTOR	3	38	POWER CABIN	MAKO	24'	1990	2	3	1	all day	8.00	4.00	4.00	4.00	4.00	4.00
145	145	4	SELF EMPLOYED	4	47	RECREATIONAL FISHING	AQUASPORT	OPEN	1988	2	2	2	morn, aft	4.00	0.50	3.50	2.00	1.00	2.00
147	147	4	ENGINEER	4	52	OTHER	SEAPRO	180CC	1994	3	2	3	afternoon	4.00	0.50	2.00	1.00	0.50	2.00
148	148	4	LIFEGUARD	4	55	RECREATIONAL FISHING	ANSWER	1/2 PINT	1981	2	2	2	afternoon	3.00	0.50	3.00	1.00	1.00	3.00
152	152	4	RETIRED	5	74	RECREATIONAL FISHING	PACEMAKER	26'WAHOO	1977	3	2	2	morning	6.00	0.50	2.00	2.00	1.00	2.00
154	154	4	RETIRED FROM PRATT & WHITNEY	4	58	RECREATIONAL FISHING	DUSKY	256	1995	3	3	2	morning	5.00	0.50	4.00	4.00	3.00	4.00
155	155	4	ATTORNEY	4	45	HOUSEBOAT	MTX			2	2	2	afternoon	4.00	0.50	1.00	1.00	1.00	1.00
156	156	4	ENGINEER	3	39	POWER CABIN		24'	1987	3	3	2	varies	3.00	0.50	7.00	4.00	3.00	4.00
157	157	4		6		RECREATIONAL FISHING	MAKO	CC	1991	2	3	3	morning	7.00	0.50	2.50	2.00	2.00	2.00
161	161	4	ENGINEER	4	58	RECREATIONAL FISHING	STARLINE	AGGRESSOR	1986	3	3	2	morning	2.00	0.50	0.25	0.50	0.50	0.50
162	162	4	RETIRED ENGINEER	5	65	RECREATIONAL FISHING	SEACRAFT	21'	1967	3	2	2	morning	4.00	0.50	3.00	3.00	3.00	3.00
163	163	4	SELF EMPLOYED	4	49	RECREATIONAL FISHING	SEACRAFT	CUTTCAB	1977	2	2	1	afternoon	5.00	0.50	1.50	1.00	2.00	1.50
166	166	4	ELECTRICAL SALES	3	43	RECREATIONAL FISHING	CHRISCRAFT	SCORPION	1981	3	2	2	all day	4.00	0.50	3.00	3.00	3.00	3.00
172	172	4	REAL ESTATE BROKERS	3	40	RECREATIONAL FISHING	FINISH LINE	22'	1977	3	2	2	varies	3.50	0.50	3.50	3.50	3.50	3.50
173	173	4	ELECTRICAL CONTRACTOR	6		RECREATIONAL FISHING		OPEN	1992	3	3	2	morn, aft	8.00	0.50	3.50	2.50	1.50	3.00
174	174	4	DENTIST	3	43	RECREATIONAL FISHING	BOSTON WHALER	SPORTS	1988	2	2	1	afternoon	1.50	0.50	3.00	1.00	1.00	2.00
178	178	1	RETIRED	5	69	POWER CABIN	T-CRAFT		1972	3	2	1	varies	4.00	0.50	3.00	3.00	1.00	3.00
180	180	1		4	49	RECREATIONAL FISHING	WELLCRAFT	SCARAB	1989	3	3	2	varies	4.50	0.50	2.00	2.00	2.00	2.00
182	182	1	RETIRED	6		POWER CABIN	LUMAS	SPORT	1990	4	4	3	morning	5.00	0.50	3.00	3.00	1.00	3.00
183	183	1	AIR CONDITIONING	3	39	RECREATIONAL FISHING	AQUASPORT	OSPEY	1996	2	2	1	varies	4.00	0.50	3.00	3.00	3.00	3.00

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R_IDNO	B_INDO	SHEDNUM	OCCUPATION	AGE_COHORT	AGE	KIND_OF_BOAT	BOAT_MAKE	BOAT_MODEL	YEAR	IDLEDFT	NORDFT	PLANDFT	HOURS	TRIPHOURS	TRIPDAYS	SUM_FREQ	FALL_FREQ	WIN_FREQ	SPR_FREQ
184	184	1	PHARMACIST	4	47	RECREATIONAL FISHING	AQUASPORT	OPEN	1976	3	2	2	afternoon	3.00	0.50	3.50	2.00	2.00	2.00
186	186	1	SALES AND SERVICE	3	40	RECREATIONAL FISHING	ROBALO	SPORT	1982	2	2	2	morn, aft	7.00	0.50	3.50	3.00	2.00	3.00
188	188	1	RADIOGRAPHER	4	52	OTHER	GRADY WHITE	BOWRIDER	1986	3	2	2	morn, aft	3.00	0.50	1.00	1.00	0.50	1.00
189	189	1	SENIOR PROCUREMENT ANALYST	4	52	RECREATIONAL FISHING	WAHOO	16'	1987	3	3	2	morning	3.00	0.50	1.00	1.00	1.00	1.00
190	190	1	CONSTRUCTION	3	42	POWER CABIN	35 CONTENDER		1994	3	3	3	morning	5.00	0.50	3.00	2.00	2.00	2.00
191	191	1	INSURANCE AGENT	3	44	RECREATIONAL FISHING	LAKE & BAY	20'	1995	2	2	1	varies	4.00	0.50	3.00	2.00	2.00	2.00
192	192	1	ENGINEER	4	55	RECREATIONAL FISHING	MAKO	CENTER	1968	3	2	2	morning	3.00	0.50	8.00	8.00	4.00	8.00
198	198A	3	FIREFIGHTER	3	41	RECREATIONAL FISHING	SYLVAN	PONT	1985	2	2	1	aft, even	4.00	24.00	18.00	12.00	12.00	12.00
198	198B	3	FIREFIGHTER	3	41	PONTOON	WHALER	SKIFF	1976	2	2	1	aft, even	4.00	0.50	18.00	12.00	12.00	12.00
203	203	3	GENERAL CONTRACTOR	3	44	RECREATIONAL FISHING	MAVERICK	16.5'	1993	2	2	1	varies	7.00	0.50	7.00	7.00	7.00	7.00
204	204A	3	BIOLOGIST	4	46	SAIL	SUNFISH			1	1	1	afternoon	5.00	0.50	1.00	0.50	1.25	0.50
204	204B	3	BIOLOGIST	4	46	ROW/CANOE	ROW/CANOE			1	1	1	afternoon	5.00	0.50	1.00	0.50	1.25	0.50
204	204C	3	BIOLOGIST	4	46	ROW/CANOE	KAYAK			1	1	1	afternoon	5.00	0.50	1.00	0.50	1.25	0.50
207	207	5	SELF EMPLOYED	6		POWER CABIN	OCEAN	48' SPORT	1988	4	4	4	morning	4.00	4.00	4.00	3.00	3.00	4.00
209	209A	5	RETIRED	4	54	POWER CABIN	MAKO	WALK	1990	3	3	3	tides dictate	3.00	7.00	4.00	3.00	3.00	3.00
209	209B	5	RETIRED	4	54	SPEED	BOSTON WHALER	SPORT	1985	3	3	3	no data	3.00	0.50	4.00	3.00	3.00	3.00
211	211	5	HOTEL OWNER	4	62	POWER CABIN	BAYLINER	CIERRA	1987	4	4	4	morning	5.50	0.50		3.50	2.50	3.50
212	212A	5	SENIOR NUCLEAR ENGINEER	4	54	SAIL	FORCE 5		1982	1	1	1	morn, aft, even	3.00	0.50	4.00	3.00	2.00	3.00
212	212B	5	SENIOR NUCLEAR ENGINEER	4	54	ROW/CANOE	GEENOE		1980	1	1	1	morn, aft, even	3.00	0.50	4.00	3.00	2.00	3.00
212	212C	5	SENIOR NUCLEAR ENGINEER	4	54	ROW/CANOE		AMF	1980	1	1	1	morn, aft, even	3.00	0.50	4.00	3.00	2.00	3.00
213	213	5	ENGINEER	4	62	POWER CABIN	PHOENIX	SPORT	1989	3	3	3	afternoon	2.00	7.00	3.00	2.00	2.00	3.00
214	214	5	U.S. CUSTOMS OFFICER	6		POWER CABIN	SEA RAY	SUNDANCER	1981	3	3	3	varies	2.00	0.50	2.00	2.00	2.00	3.00
215	215	5	DISTRIBUTION MARKETING MGR.	4	47	POWER CABIN	BERTRAM	SPORT	1976	3	3	3	varies	4.00	0.50	3.00	3.00	2.00	2.00
216	216	5	BUILDING CONTRACTOR	3	44	RECREATIONAL FISHING	MAKO	26'	1993	3	3	2	tides dictate	2.50	0.50	6.00	5.00	3.00	5.00
217	217	5		6		RECREATIONAL FISHING	MAKO	OPEN	1974	2	2	2	morning	5.00	0.50	1.00	1.00	1.00	1.00
218	218A	5	PRINT BROKER	4	52	POWER CABIN	CONTENDER 44'	CONTENDER	1996	3	4	3	no data	8.00	0.50	4.50	2.50	2.50	2.50
218	218B	5	PRINT BROKER	4	52	RECREATIONAL FISHING	CRUISER 35'	CRUISER	1996	3	4	3	no data	8.00	0.50	4.50	2.50	2.50	2.50
219	219	5	RETIRED	4	62	POWER CABIN	BERTRAM	SPORT FISHING	1968	4	4	5	morning	6.00	0.50	1.00	2.00	3.00	3.00
220	220	5	ENGINEER	3	36	RECREATIONAL FISHING	RAMPAGE/BOSTON WHALER	28'	1986	3	3	3	morn, aft	12.00	1.00	2.00	2.00	1.00	2.00
220	220	5	ENGINEER	3	36	RECREATIONAL FISHING	RAMPAGE/BOSTON WHALER	17'	1980	2	2	1	morn, aft	12.00	1.00	2.00	2.00	1.00	2.00
221	221	5	COMPUTER SYSTEMS ANALYST	3	35	POWER CABIN	UNIFLITE	28'	1972	3	3	3	tides dictate	5.00	0.50	2.00	2.00	2.00	2.00
222	222	5	SELF EMPLOYED	3	36	RECREATIONAL FISHING	INTREPID		1990	3	1	3	varies	4.50	0.50	5.00	4.00	4.00	4.00
223	223	5	CHEF	3	38	RECREATIONAL FISHING	MAKO	261	1990	3	3	2	tides dictate	12.00	1.00	5.00	5.00	4.00	5.00
224	224	5	PROJECT MANAGER	4	45	RECREATIONAL FISHING	ROBALO	20' CENTER	1980	2	2	2	morn, aft	5.00	3.00	4.00	2.00	1.00	3.00
225	225	5	RETAIL SALES	4	49	RECREATIONAL FISHING	INTREPID	30'	1986	3	3	2	tides dictate	6.00	0.50	3.00	2.00	1.00	3.00
226	226	5		6		RECREATIONAL FISHING	AQUA SPORT	OPEN	1972	3	2	2	varies	5.00	0.50	4.00	3.00	1.00	3.00
228	228	5	BUSINESS OWNER	6		RECREATIONAL FISHING	WELLCRAFT	OPEN	1996	2	2	1	aft, even	4.50	0.50	2.50	2.00	1.50	2.50
230	230	5	BUSINESS EXECUTIVE	6		SPEED	SEACRAFT	18' OPEN	1977	3	3	2	afternoon	6.00	0.50	2.00	2.00	1.00	2.00
234	234	5	BOAT BUILDER	3	37	RECREATIONAL FISHING		OPEN	1997	3	4	2	tides dictate	6.00	0.50	4.00	4.00	3.00	4.00
235	235	5	MARINE EXHAUST MANUF.	4	53	POWER CABIN	CUSTOM	48'	1978	4	4	3	morning	8.00	5.00	3.00	3.00	2.00	3.00
237	237	5	CONTRACTOR	5	75	POWER CABIN	SILVERTON	CRUISER	1994	3	3	2	morn, aft	5.00	0.50	0.00	3.00	3.00	0.00
238	238	5	ELECTRICIAN	3	35	POWER CABIN	THUNDERBIRD	FORMULA	1979	3	3	2	morn, aft	6.00	0.50	4.00	3.00	3.00	4.50
241	241	5	RETIRED	5	69	POWER CABIN	THUNDERBIRD	IROQUOIS	1968	3	3	2	morning	3.50	0.50	1.50	1.50	1.50	1.50
242	242	5	RETIRED	5	88	RECREATIONAL FISHING		OPENSKIFF	1980	2	2	1	no data						
243	243A	5	RANGER/J.D. PARK	4	46	SPEED	MANATEE			1	1	1	afternoon	2.00	0.50	7.00	7.00	3.00	3.00
243	243B	5	RANGER/J.D. PARK	4	46	ROW/CANOE				1	1	1	afternoon	2.00	0.50	7.00	7.00	3.00	3.00

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R_IDNO	B_INDO	SHEDNUM	OCCUPATION	AGE_COHORT	AGE	KIND_OF_BOAT	BOAT_MAKE	BOAT_MODEL	YEAR	IDLEDFT	NORDFT	PLANDFT	HOURS	TRIPHOURS	TRIPDAYS	SUM_FREQ	FALL_FREQ	WIN_FREQ	SPR_FREQ
244	244	5	ENGINEER	4	53	RECREATIONAL FISHING	MAKO	231 CUDDY	1987	3	3	3	morn, aft	5.00	0.50	1.50	2.00	2.00	2.00
245	245	5	FINANCIAL PLANNER	6		RECREATIONAL FISHING	KEY WEST		1994	3	2	2	varies	4.00	0.50	3.00	1.00	1.00	3.00
246	246	5	INSURANCE AGENCY OWNER	5	65	RECREATIONAL FISHING	COBIA/ROWING DORY	V HULL DECK	1996	4	3	2	tides dictate	1.00	1.00	6.00	2.00	1.50	4.50
247	247	5	RETIRED	5	74	RECREATIONAL FISHING	GEMINI	OUTBOARD	1972	1	2	1	morning	2.00	0.50	2.00	2.00	1.00	2.00
249	249	5	CPA	6		RECREATIONAL FISHING	MAKO	25'OPEN	1987	1	1	1	morn, aft	2.00	0.50	2.00	1.00	0.50	1.00
250	250	5	RETIRED	4	62	POWER CABIN	SABRELINE	TRAWLER	1989	4	4	4	tides dictate	8.00	0.50	2.50	1.50	1.50	2.50
254	254	5	AIRLINE PILOT	3	41	RECREATIONAL FISHING	MAKO	261	1988	3	3	2	no data	3.00	0.50	5.00	4.00	3.00	4.00
255	255	5	ENGINEER	5	66	POWER CABIN	BERTRAM	FLYBRIDGE	1984	4	4	4	tides dictate	5.00	0.50		4.00	4.00	4.00
256	256	5	RETIRED	5	70	POWER CABIN	GRADY WHITE	WALKAROUND	1992	3	2	2	morning	4.00	0.50	2.00	2.00	2.00	2.00
258	258	5	ATTORNEY	4	48	POWER CABIN	SEARAY	CUDDY CAB	1982	3	2	4	varies	5.00	0.50	1.00	1.00	0.00	0.50
259	259A	5	ENVIRONMENTAL INFO ADMIN.	3	38	RECREATIONAL FISHING	AVON	INFLATABLE	1984	1	1	1	afternoon	2.00	0.50	1.00	1.00	1.00	1.00
259	259B	5	ENVIRONMENTAL INFO ADMIN.	3	38	ROW/CANOE	ROWBOAT		1984	1	1	1	afternoon	2.00	0.50	1.00	1.00	1.00	1.00
261	261	5	DRIVER	4	60	RECREATIONAL FISHING	OCEAN	21' OPEN	1988	2	2	1	morning	6.00	0.50	3.00	2.00	2.00	2.00
262	262	5	LANDSCAPE	3	40	RECREATIONAL FISHING	FROST	22' CENTER	1990	3	2	2	tides dictate	8.00	2.00	5.00	2.00	2.00	4.00
264	264	5	BUILDING INSPECTOR	4	45	RECREATIONAL FISHING	MAKO	OPEN	1971	2	3	2	morning	8.00	0.50	2.00	1.00	0.00	2.00
265	265	5	HAIRDRESSER	3	39	SPEED	GLASTRON		1973	2	2	2	varies	4.50	0.50	1.00	0.25		0.50
267	267	5	RETIRED	5	68	RECREATIONAL FISHING	BOSTON WHALER	17'	1988	2	2	2	varies	4.00	0.50	5.00	5.00	5.00	5.00
271	271A	5	A&P MANAGER	3	34	POWER CABIN	"SEARAY"	25	1976	4	4	4	tides dictate	7.00	0.50	1.00	0.50	0.25	0.75
271	271B	5	A&P MANAGER	3	34	SPEED	"SEARAY"	18'	1977	4	4	4	tides dictate	7.00	0.50	1.00	0.50	0.25	0.75
271	271C	5	A&P MANAGER	3	34	POWER CABIN	"BERTRAM"	28'	1977	4	4	4	tides dictate	2.00	0.50	1.00	0.50	0.25	0.75
275	275	5	ARCHITECTURAL PROJECT MGT.	4	55	RECREATIONAL FISHING	LAKE&BAY"	21'	1988	2	2	1	morning	5.00	3.50	1.00	1.00	0.25	1.00
275	275	5	ARCHITECTURAL PROJECT MGT.	4	55	RECREATIONAL FISHING	"SEACRAFT	20'	1969	2	2	1	morning	5.00	3.50	1.00	1.00	0.25	1.00
280	280	5	CHIEF OPERATOR-WATER TREAT	3	42	RECREATIONAL FISHING	RANGER	OPEN	1995	2	1	1	morning	4.50	0.50	2.00	1.00	1.00	2.00
286	286	5	MECHANICAL ENGINEER	4	45	POWER CABIN	STRATOS		1988	3	2	2	varies	6.50	0.50	3.00	3.00	1.50	3.00
287	287	5	AVIONICS TECHNICIAN	3	37	RECREATIONAL FISHING	WELLCRAFT	OPEN	1983	3	1	1	varies	9.00	0.50	3.00	3.00	2.00	3.00
288	288	5	HEAVY EQUIPMENT OPERATOR	6		RECREATIONAL FISHING	OCEAN	CENTER	1987	2	2	1	morning	7.00	0.50	1.00	1.00	1.00	1.00
290	290	5	HOSPITAL ADMINISTRATOR	4	59	RECREATIONAL FISHING	WELLCRAFT	WALKAR.	1991	3	3	3	morn, aft	5.00	0.50	4.00	3.00	2.00	4.00
292	292	5	INVESTMENT SALES	3	42	RECREATIONAL FISHING	DONZI 33'		1989	3	2	4	morn, aft	3.00	0.50	4.00	2.00	1.00	2.00
295	295	2	RETIRED	6		SPEED	SUNBIRD	NEPTUNE	1996	3	3	2	morn, aft, even	1.50	0.50	3.50	3.50	1.50	3.50
299	299	2	SALES MANAGEMENT	4	55	RECREATIONAL FISHING	ROBALO	26.5'	1980	2	2	1	morn, aft, even	4.00	0.50	2.00	2.00	2.00	2.00
306	306	2	FPL/H.D. TRUCK MECHANIC	4	52	RECREATIONAL FISHING	PURSUIT	27 EXPRESS	1985	3	3	3	morning	7.00	3.00	2.50	2.50	2.50	2.50
312	312	1	ATTORNEY	6		RECREATIONAL FISHING	CHRIS CRAFT	SEAHAWK	1989	2	2	2	morning	6.00	0.50	2.00	1.50	1.00	1.00

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R_IDNO	ACT1	ACT2	ACT3	DEST1	DEST2	DEST3	AXMAJ	AXMIN	AXNO	MEDTIDE	HITIDE	IDLETIDE	PLANETIDE	NAILTIDE
103	SPEEDBOAT/SKIING	LEISURE	LEISURE	ICW AND OCEAN	NORTH FORK	RIVER		X		X		X		
104	FISHING	LEISURE		ICW AND OCEAN	SANDBAR		X			X			X	
105	FISHING			ICW AND OCEAN			X			X		X		
105		SPEEDBOAT/SKIING		RIVER			X			X		X		
105	SPEEDBOAT/SKIING						X				X		X	
106	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X		X		X
107	SPEEDBOAT/SKIING	DIVING/SWIMMING	FISHING	ICW AND OCEAN	NORTH FORK		X					X		X
108	DIVING/SWIMMING	LEISURE	FISHING	ICW AND OCEAN	ICW AND OCEAN		X			X				X
110	FISHING			SOUTHWEST FORK	NORTH FORK	ICW AND OCEAN		X						
111	FISHING	CRUISING		ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X			X		X		X
122	FISHING	CRUISING	SPEEDBOAT/SKIING				X			X		X	X	X
123	FISHING							X			X	X		
124	LEISURE	DIVING/SWIMMING	FISHING	ICW AND OCEAN	RIVER		X	X				X		X
125	FISHING	FISHING	CRUISING	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN		X				X		X
127	FISHING	DIVING/SWIMMING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X	X	
128	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	SANDBAR		X			X	X			X
128	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	SANDBAR		X			X	X			X
129	DIVING/SWIMMING	FISHING	CRUISING	RIVER			X			X		X		
131	DIVING/SWIMMING	FISHING	SPEEDBOAT/SKIING	ICW AND OCEAN	RIVER	ICW AND OCEAN	X			X		X	X	
132	FISHING	DIVING/SWIMMING	LEISURE	ICW AND OCEAN		NORTH FORK		X				X		X
135	FISHING	CRUISING		ICW AND OCEAN	ICW AND OCEAN		X					X		X
136	FISHING	CRUISING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X			X	X			X
137	FISHING	CRUISING		ICW AND OCEAN	ICW AND OCEAN		X			X				X
138	FISHING		CRUISING	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X					X		
139	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN			X			X				X
142	FISHING	CRUISING		ICW AND OCEAN		ICW AND OCEAN	X					X		
144	FISHING	LEISURE	CRUISING				X					X		
145	FISHING	LEISURE		SANDBAR	ICW AND OCEAN	ICW AND OCEAN		X				X	X	
147	CRUISING	SPEEDBOAT/SKIING	FISHING	ICW AND OCEAN	SANDBAR		X					X		
148	LEISURE	DIVING/SWIMMING	FISHING	ICW AND OCEAN	NORTHWEST FORK	ICW AND OCEAN	X					X		
152	FISHING		LEISURE	ICW AND OCEAN		ICW AND OCEAN	X			X				
154	FISHING	FISHING	CRUISING	ICW AND OCEAN	RIVER	ICW AND OCEAN	X					X	X	X
155	CRUISING			SANDBAR	ICW AND OCEAN	NORTHWEST FORK	X					X		
156	CRUISING						X					X		
157	FISHING	DIVING/SWIMMING	DIVING/SWIMMING	ICW AND OCEAN	RIVER	ICW AND OCEAN	X					X	X	
161	FISHING	SPEEDBOAT/SKIING	CRUISING	SOUTHWEST FORK	ICW AND OCEAN	RIVER		X				X		
162	FISHING	DIVING/SWIMMING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	NORTH FORK	X					X		
163	DIVING/SWIMMING	FISHING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN		X				X		
166	LEISURE	LEISURE	FISHING	ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X						X	X
172	LEISURE	FISHING	DIVING/SWIMMING	RIVER					X					
173	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	NORTHWEST FORK	ICW AND OCEAN	X					X	X	X
174	LEISURE	SPEEDBOAT/SKIING		ICW AND OCEAN	ICW AND OCEAN	NORTHWEST FORK		X		X				
178	FISHING	CRUISING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X					X		
180	CRUISING	FISHING	DIVING/SWIMMING	SANDBAR	ICW AND OCEAN	ICW AND OCEAN		X					X	
182	FISHING	CRUISING	CRUISING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X				X
183	LEISURE	FISHING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X		

Loxahatchee River Central Embayment Data Base

R_IDNO	ACT1	ACT2	ACT3	DEST1	DEST2	DEST3	AXMAJ	AXMIN	AXNO	MEDTIDE	HITIDE	IDLETIDE	PLANETIDE	NAILTIDE
184	CRUISING	FISHING		ICW AND OCEAN	RIVER	NORTH FORK	X			X		X		
186	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	SANDBAR		X					X		
188	FISHING	CRUISING	CRUISING	ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X					X		
189	FISHING	LEISURE	DIVING/SWIMMING	RIVER	ICW AND OCEAN	ICW AND OCEAN	X					X		
190	DIVING/SWIMMING	FISHING	LEISURE	ICW AND OCEAN	ICW AND OCEAN		X			X				
191	FISHING	SPEEDBOAT/SKIING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X		
192	LEISURE	LEISURE	SPEEDBOAT/SKIING				X					X		
198	LEISURE	FISHING	LEISURE	SANDBAR	SANDBAR	SANDBAR			X					
198	LEISURE	FISHING	LEISURE	SANDBAR	SANDBAR	SANDBAR			X					
203	LEISURE			ICW AND OCEAN	NORTH FORK			X				X		
204	SAILING							X		X	X	X		
204	FISHING							X		X	X	X		
204	LEISURE							X		X	X	X		
207	FISHING						X				X			X
209	FISHING	CRUISING		ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X				
209	FISHING			ICW AND OCEAN		RIVER	X			X				
211	CRUISING			ICW AND OCEAN	ICW AND OCEAN		X					X		
212	LEISURE			RIVER	RIVER	ICW AND OCEAN			X					
212	LEISURE			RIVER	RIVER	ICW AND OCEAN			X					
212	LEISURE		LEISURE	RIVER	RIVER	ICW AND OCEAN			X					
213	CRUISING	CRUISING	FISHING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X				
214	CRUISING	FISHING		ICW AND OCEAN	RIVER			X						X
215	CRUISING	DIVING/SWIMMING	CRUISING	RIVER			X			X			X	X
216	FISHING	SPEEDBOAT/SKIING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X		X	X	X
217	FISHING	SPEEDBOAT/SKIING		ICW AND OCEAN	RIVER			X		X				
218	LEISURE	CRUISING					X			X		X		X
218	FISHING	LEISURE					X			X		X		X
219	FISHING	CRUISING		ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X			X				
220	FISHING	CRUISING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X			X				X
220	FISHING	CRUISING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X			X				X
221	FISHING	DIVING/SWIMMING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X	X			X
222	FISHING	LEISURE	LEISURE	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X				
223	FISHING	DIVING/SWIMMING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X			X				X
224	DIVING/SWIMMING	FISHING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X		X		
225	CRUISING	FISHING		ICW AND OCEAN	RIVER		X			X				X
226	FISHING	LEISURE		SANDBAR	ICW AND OCEAN	ICW AND OCEAN	X					X		
228	LEISURE	SPEEDBOAT/SKIING		ICW AND OCEAN	ICW AND OCEAN				X					
230	CRUISING	FISHING					X			X		X		X
234	FISHING	LEISURE	SPEEDBOAT/SKIING				X			X				
235	CRUISING	LEISURE		ICW AND OCEAN	ICW AND OCEAN	RIVER	X			X				X
237							X				X			X
238	FISHING	LEISURE	SPEEDBOAT/SKIING	ICW AND OCEAN			X			X				
241	DIVING/SWIMMING	FISHING	CRUISING	ICW AND OCEAN	ICW AND OCEAN	NORTHWEST FORK	X					X	X	
242	FISHING						X			X				
243	LEISURE	LEISURE		SANDBAR	RIVER	ICW AND OCEAN	X					X		
243	LEISURE	LEISURE		SANDBAR	RIVER	ICW AND OCEAN	X					X		

Loxahatchee River Central Embayment Data Base

R_IDNO	ACT1	ACT2	ACT3	DEST1	DEST2	DEST3	AXMAJ	AXMIN	AXNO	MEDTIDE	HITIDE	IDLETIDE	PLANETIDE	NAILTIDE
244	FISHING	LEISURE	DIVING/SWIMMING	ICW AND OCEAN	RIVER		X			X		X		X
245	FISHING	SPEEDBOAT/SKIING		ICW AND OCEAN	NORTH FORK		X						X	
246	CRUISING	LEISURE	FISHING	ICW AND OCEAN	SANDBAR	ICW AND OCEAN	X			X		X	X	
247	FISHING			ICW AND OCEAN			X			X				
249	CRUISING	DIVING/SWIMMING	FISHING					X				X		
250	CRUISING	CRUISING	FISHING	ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN	X			X	X			X
254	DIVING/SWIMMING	FISHING	CRUISING	ICW AND OCEAN	ICW AND OCEAN		X					X		X
255	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN			X							
256	FISHING			ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN			X					
258	CRUISING	SPEEDBOAT/SKIING	FISHING	ICW AND OCEAN	ICW AND OCEAN	SANDBAR	X				X		X	X
259	LEISURE	FISHING		SOUTHWEST FORK	NORTH FORK	SANDBAR		X				X		X
259	LEISURE	FISHING		SOUTHWEST FORK	NORTH FORK	SANDBAR		X				X		X
261	FISHING	DIVING/SWIMMING	CRUISING	ICW AND OCEAN	SANDBAR	ICW AND OCEAN	X					X		X
262	FISHING	LEISURE		ICW AND OCEAN	RIVER		X			X		X	X	X
264	FISHING	LEISURE	LEISURE	ICW AND OCEAN	NORTH FORK	NORTHWEST FORK	X			X		X		X
265	SPEEDBOAT/SKIING			RIVER	ICW AND OCEAN				X					
267	FISHING	LEISURE		ICW AND OCEAN	ICW AND OCEAN		X					X	X	
271	CRUISING		DIVING/SWIMMING	ICW AND OCEAN	NORTHWEST FORK		X			X	X	X	X	X
271	SPEEDBOAT/SKIING		DIVING/SWIMMING	ICW AND OCEAN	NORTHWEST FORK		X			X	X	X	X	X
271		CRUISING	DIVING/SWIMMING	ICW AND OCEAN		ICW AND OCEAN	X			X	X	X	X	X
275	FISHING	CRUISING	LEISURE	NORTHWEST FORK	ICW AND OCEAN	ICW AND OCEAN			X					
275	FISHING	CRUISING	LEISURE	NORTHWEST FORK	ICW AND OCEAN	ICW AND OCEAN			X					
280	FISHING	CRUISING	SPEEDBOAT/SKIING	RIVER	ICW AND OCEAN	ICW AND OCEAN		X				X		
286	LEISURE	FISHING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X		X
287	FISHING	CRUISING		ICW AND OCEAN	SANDBAR		X			X	X	X		
288	FISHING			ICW AND OCEAN	ICW AND OCEAN	ICW AND OCEAN		X				X		
290	FISHING	LEISURE		ICW AND OCEAN	ICW AND OCEAN	NORTHWEST FORK	X					X	X	X
292	FISHING	LEISURE	LEISURE	ICW AND OCEAN		RIVER	X					X		
295	LEISURE	SPEEDBOAT/SKIING		RIVER	ICW AND OCEAN		X			X		X		
299	FISHING	CRUISING	LEISURE	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X		
306	FISHING	CRUISING	LEISURE				X							
312	FISHING	CRUISING	DIVING/SWIMMING	ICW AND OCEAN	ICW AND OCEAN	RIVER	X					X		

Appendix C Boater Survey Tables

Table C-1. Surveyed populations of boaters and boats

Survey Populations	Boaters	Boats
Individuals Contacted	212	
Respondents	153	
(Non-Boaters)	36	
Boaters with ≥1 boat	108	
One-boat owners	96	96
Two-boat owners	8	16
Three-boat owners	4	12
Total in survey	108	124

Table C-2. Age of boater population

Age Groups	Population	Percent 1	Percent 2
25–44	35	32.4	39.8
45–64	41	38	46.6
≥65	12	11.1	13.6
No response	20	18.5	
Total	108	100	100

Table C-3. Employment or occupation

Occupation	Population	Percent
Construction	16	14.8
Engineering	15	13.9
Public sector	7	6.5
Legal	3	2.8
Medical	12	11.1
Sales/service	34	31.5
Retired	16	14.8
No response	5	4.6
Total	108	100

Table C-4. Types of boats

Boat type	Count	Percent
Houseboat	1	0.8
Other	4	3.2
PWC	1	0.8
Pontoon	1	0.8
Power cabin	31	25
Rec. Fishing	70	56.5
Row/canoe	6	4.8
Sail	2	1.6
Speed	8	6.5
Total	124	100

Table C-5. Numbers of boats

	Penn (1)	Turner Quay (2)	Pompano (3)	Dolphin (4)	Marlin (5)	South Shore
Boats						
Counts	22	3	6	31	62	124
Percent	17.7	2.4	4.8	25.0	50.0	100.0
Idle Draft (ft)						
Average	2.1	2.2	1.2	2.5	2.5	2.3
Minimum	0.5	1.5	0.5	1.0	1.0	0.5
Maximum	4.0	2.5	2.0	4.0	4.0	4.0

Table C-6. Boating trips

	Penn (1)	Turner Quay (2)	Pompano (3)	Dolphin (4)	Marlin (5)	South Shore
Boating Period						
Morning	17.6	2.9		38.2	41.2	100
Afternoon	12.5		18.8	31.3	37.5	100
All day	71.4			28.6		100
Weekly Trips						
Year (count)	196.5	30	145.75	284.75	577.25	1234.25
Year (boater average)	8.9	10	24.3	9.2	9.3	9.6
Season (percent)						
Summer	30	26.7	31.6	30.1	30.5	30.4
Fall	25.7	26.7	22.3	23.5	25.7	24.8
Winter	17.8	20	23.8	19.5	19	19.5
Spring	26.5	26.7	22.5	26.9	24.8	25.3

Table C-7. Boating destinations based on weighted counts of boating trips

	North Fork	Northwest Fork	Southwest Fork	River	Sandbar	ICW/Ocean	Total
Raw Count	11	11	4	45	28	168	267
Weighted Count	(6.27)	(6.29)	(4.00)	(27.17)	(17.93)	(127.53)	(189.19)
Weighted Percent	3.31	3.32	2.11	14.36	9.48	67.41	99.99
Rank Order	5	4	6	2	3	1	

weights applied to frequency counts
primary = 1.00
secondary = 0.66
tertiary = 0.33

Table C-8. Ranked destinations from frequency weighted trip origins

	Destinations						Rank order
Trip Origins	North Fork	Northwest Fork	Southwest Fork	River	Sandbar	ICW/Ocean	(column)
Penn (1)							
Rank order (row)	4		5	2	3	1	3
Turner Quay (2)							
Rank order (row)				2		1	5
Pompano (3)							
Rank order (row)	3				1	2	4
Dolphin (4)							
Rank order (row)	6	4	5	2	3	1	2
Marlin (5)							
Rank order (row)	5	4	6	2	3	1	1

Table C-9. Ranked order of boating destinations based on frequency weighted trips by boats of different draft

	Percent of			Destinations			
Boat Draft	All Boats	North Fork	Northwest Fork	SW Fork	River	Sandbar	ICW/Ocean
'1 ft Draft	11.3						
Ranked order		5		4	1	3	2
2 ft Draft	32.3						
Ranked order		5	4	6	3	2	1
3 ft. Draft	46						
Ranked order		4a	4b	5	2	3	1
4 ft. Draft	10.5						
Ranked order			2		3a	3b	1

Table C-10. Primary, secondary and tertiary boating activities

Boating Activities	Raw Count	Weighted Count	Weighted %	Rank Order
Cruising	43	29.84	17.38	3
Diving/swimming	33	20.87	12.16	4
Fishing	83	72.86	42.45	1
Leisure	56	36.82	21.45	2
Speedboating/skiing	16	11.26	6.56	5
Total	231	171.65	100.00	

weights applied to frequency counts
primary = 1.00
secondary = 0.66
tertiary = 0.33

Table C-11. Degree of access problem by waterway

Location	Count	Percent	Degree of Problem (row %)		
			Major	Minor	None
Penn (1)	22	17.7	86.4	13.6	0
Turner Quay (2)	3	2.4	100	0	0
Pompano (3)	6	4.8	0	66.7	33.3
Dolphin (4)	31	25	71.9	25	3.1
Marlin (5)	62	50	75.8	11.3	12.9
Total	124	100	73.6	17.6	8.8

Table C-12. Degree of access problem by boat type

Type of Boat	County	Percent	Degree of Problem (row %)		
			Major	Minor	None
Houseboat	1	0.8	100	0	0
Other	4	3.2	100	0	0
PWC	1	0.8	100	0	0
Pontoon	1	0.8	0	0	100
Power Cabin	31	25	93.5	3.2	3.2
Rec. Fishing	70	56.5	70.4	22.5	7
Row/Canoe	6	4.8	16.7	50	33.3
Sail	2	1.6	0	50	50
Speed	8	6.5	75	12.5	12.5
Total	124	100	73.6	17.6	8.8

Table C-13. Piloting strategy by waterway

Location	Count	Percent	Med. Tide	High Tide	Idle-Speed	On Plane	Chew Nails
Penn (1)	22	17.7	18.2	5.8	20.5	13.0	10.9
Turner Quay (2)	3	2.4	1.8	0.0	2.7	0.0	0.0
Pompano (3)	6	4.8	5.5	17.6	5.5	0.0	0.0
Dolphin (4)	31	25.0	16.4	23.5	30.1	30.4	26.1
Marlin (5)	62	50.0	58.2	52.9	41.1	56.5	63.0
Total	124	100.0	100.0	100.0	100.0	100.0	100.0

Table C-14. Piloting strategy by boat type

Type of Boat	Count	Percent	Med. Tide	High Tide	Idle-Speed	On Plane	Chew Nails
Houseboat	1	0.8	0	0	1.4	0	0
Other	4	3.2	3.6	0	2.7	0	4.3
PWC	1	0.8	0	5.9	0	4.3	0
Pontoon	1	0.8	0	0	0	0	0
Power Cabin	31	25	30.9	47.1	17.8	21.7	39.1
Rec. Fishing	70	56.5	49.1	23.5	63	69.6	50
Row/Canoe	6	4.8	3.6	11.8	5.5	0	2.2
Sail	2	1.6	1.8	5.9	1.4	0	0
Speed	8	6.5	10.9	5.9	8.2	4.3	4.3
Total	124	100	100	100	100	100	100

Appendix D Boat and Channel Accessibility Tables

Table D-1

Boat accessibility by the easterly route

(Numbers reported are counts of boats)

Restriction Levels	Penn (1)	Turner Quay (2)	Pompano (3)	Dolphin (4)	Marlin (5)	Total
Unrestricted	1	0	3	1	9	14
Restricted	21	3	3	30	53	110
Somewhat Restricted (= vessel draft)	12	1	3	11	13	40
Restricted (=<1ft shallower than draft)	8	2	0	17	30	57
Severely Restricted (=<2ft shallower than draft)	1	0	0	2	10	13

Table D-2

Boat accessibility by the westerly route

(Numbers reported are counts of boats)

Restriction Levels	Penn (1)	Turner Quay (2)	Pompano (3)	Dolphin (4)	Marlin (5)	Total
Unrestricted	21	1	6	12	9	49
Restricted	1	2	0	19	53	75
Somewhat Restricted (= vessel draft)	1	2	0	17	13	33
Restricted (=<1ft shallower than draft)	0	0	0	2	30	32
Severely Restricted (=<2ft shallower than draft)	0	0	0	0	10	10

Table D-3. Channel restrictions

Characteristics	Westerly Route (length, ft)	Easterly Route (length, ft)
Unrestricted	8,328	2,050
Restricted	3,595	3,816
(2 ft depths)	(939)	(1,041)
(3 ft depths)	(2,656)	(2,775)
Total	11,923	5,866

Table D-4. Maintenance dredging requirements+

Required Dredge Depth of Cut (ft)	Westerly Route Amount (cu yds)	Easterly Route Amount (cu yds)
1**	1,967	2,056
2***	1,391	1,542
Total	3,358	3,598

+provides 4 ft water depth at mllw to ensure access to all boats on south shore
*assumes a 20 ft channel width
**3 ft depth channel segments require 1 ft cut
***2 ft depth channel segments require 2 ft cut

Table D-5. Relative amounts of dredging required

Required Dredge (ft)	Westerly Route (%)	Easterly Route (%)
1	58.58	57.14
2	41.42	42.86
Total	100.00	100.00

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