Distribution, Density and Composition of Seagrasses in the Southernmost Reach of the Indian River Lagoon

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Introduction

Florida's Indian River Lagoon (Lagoon) extends through six coastal counties; from the Ponce de Leon Inlet in Volusia County south to the Jupiter Inlet and Loxahatchee River in Palm Beach County. A series of barrier islands separates the 155 mile long Lagoon from the Atlantic Ocean; and, this separation, combined with a series of inlets, creates a highly diverse and productive estuary. In 1991, the U.S. Environmental Protection Agency designated the Lagoon as an "estuary of national significance" and a plan for the comprehensive management and preservation of this resource was drawn. An integral part of that plan was the establishment of a series of studies designed to determine the abundance and distribution of seagrasses and macroalgae, cumulatively referred to as Submerged Aquatic Vegetation or SAV.

SAV is recognized as one of the most important habitats within the Lagoon, yet its' health and vitality are issues of continuing concern. Seagrass habitats play a critical role in providing sediment stabilization, nutrient cycling, detridal food sources and nursery grounds for many recreational and commercially important fisheries. However, over the last twenty years, significant amounts of SAV have been depleted or completely lost in certain areas of the Lagoon. This decline, most recently described in a 1993 report by the St. John's River Water Management District (SJRWMD), is attributed to adverse and declining water quality conditions, particularly water clarity.

The southernmost portion of the Lagoon consists of the Loxahatchee River estuary, the Jupiter Inlet and an approximate six-mile reach of the Intracoastal Waterway running from the Jupiter Inlet northward to Hobe Sound. Figure #1 presents a map of the entire Indian River Lagoon.

In the last twenty years, several studies of SAV distributions have been conducted near the western and northern limits of the. In the 1980's, the United States Geological Survey (USGS) and Vare & Klemm each conducted a study using aerial photography to create general spatial distribution maps of the seagrass beds observed in the Loxahatchee River Estuary. In 1990, the Jupiter Inlet District (JID) began a series of studies that included mapping of the seagrass distribution within the estuary. The JID studies are conducted every two years and based on aerial photography with limited ground-truthing to verify the presence of SAV. Each of these past research efforts concentrated on seagrass distribution in the central embayment of the Loxahatchee River and included little or no information on densities, species identification or the composition of the SAV communities.

Figure # 1: Indian River Lagoon and SJRWMD Seagrass Stations

Also in 1992, the SJRWMD initiated a long term SAV monitoring program throughout the entire Lagoon. The SJRWMD identified over seventy stations within the Lagoon and established transects that are monitored twice annually. Information from this ongoing study is used to establish spatial and temporal relationships of the SAV communities. Two of the SJRWMD stations are located in the southern portion of the Lagoon, one of which is immediately adjacent to the northern terminus of this study. Recently, a new technology, called stereo-graphic modeling was developed for seagrass analysis and is being employed by the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA) in concert with the ongoing SJRWMD research. This new process uses conventional aerial photographs to produce digital data with high spatial precision that creates 'new' photographs showing seagrass distributions. This modeling technique is currently being applied to areas within the Lagoon including the southernmost reaches. Like the earlier seagrass studies, the new NOAA study concentrates on the distribution of SAV and provides only limited information on densities or species composition. The SJRWMD long-term program includes information on seagrass densities and identification as well as SAV distribution.

The overall goal of the current research is to increase the base of information on seagrass communities in the southernmost portion of the Indian River Lagoon. Five distinct objectives were identified and used to define the scope of study. The first objective was to develop data on SAV communities for an area not previously studied, from the inlet to the eastern extent of the estuary and northerly along the Lagoon for approximately five miles. The second and third objectives were to develop and employ a more definitive scale characterizing the density of SAV and to record information on species identification and composition. The fourth objective was to document the new baseline information and create a digital map series for future comparative analyses. The final objective was to interface with the prior research conducted within the estuary and portions of the Lagoon.

Methodology

The study started in June of 1998 and data collection continued through September of 1998. There were four steps involved in the study: initial evaluation of aerial photographs, ground truthing, photo-interpretation and digital mapping.

Initial Photo-interpretation and Selection of Sampling Stations

The first part of the study entailed looking at 1996 aerial photographs taken by the SJRWMD. These 1:10,000 scale photos were reviewed to obtain an understanding of the study area and general presence or absence of SAV. From the knowledge gained from this photographic review and with the help of the SJRWMD researchers, fourteen representative stations were selected for the study. The stations were also grouped into four segments, each of which characterized a portion of the study area based predominantly on distance from the Jupiter Inlet.

Ground-Truthing

Given the limitations of aerial photographs in the determination of SAV coverage, density determinations and vegetative type, a program for extensive in-situ evaluation was established. For the study, a point transect method, one that generates accurate and useable information and is not too labor intensive, was selected. This technique involves the placement of a linear transect line perpendicular from the shore out to the deepest edge of the grass bed. Transects at the sampling stations varied in length due to water depth and interference with the main channel. Once the transect line was laid on the bottom, researchers swam the length of the line recording notes, every half meter, on what the line was hitting, either sand or vegetation. Where vegetation was encountered, the species was identified and recorded. Once the field runs of the transects were completed, all the information was entered into a computer database and analyzed to calculate densities and species composition of the seagrass community.

From one to four linear transects were established at each station and each transect was sampled a minimum of one time during the sixteen week study period. Sampling was conducted primarily at low tide, using a mask, fin and snorkel.

Advanced Photo-interpretation

Fourteen stations and thirty three transects represent a relatively small portion of the entire study area; however, the sampling technique employed and the information generated allows extrapolation of SAV coverage for the entire study area. Photo-interpretation involves looking at photographs and interpreting vegetation density for known areas and extending those densities into areas that appear similar in the photographs. Specifically, 1998 aerial photographs provided by the SJRWMD were studied and variations in the shading and colors of the seagrass beds were observed. The differences in shading and color correlates to different SAV densities. Distinct patterns were observed for the fourteen sampling stations where densities were known. Similar densities were then understood to exist in other portions of the study area displaying similar patterns.

Digital Mapping

Base GIS maps of the study area were developed and, using the field information obtained during the ground truthing phase and the advanced photo-interpretation procedure, spatial seagrass distribution and relative SAV densities were plotted on the base map. Densities were delineated into four categories: sparse, patchy, dense and dense continuous coverage. These drawings were then digitized and new maps, one for the general study area and one for each of the identified segments, were created.

Description of the Study Area and General Observations

Figure #2 presents a map of the study area showing the Jupiter Inlet, the eastern portion of the Loxahatchee River estuary and an approximate six mile reach of the Intracoastal Waterway extending northerly from the inlet channel. Figure #2 also shows the four segments into which the study area has been divided and the fourteen sampling stations selected for evaluation. At each station, multiple shore to channel transects were established for monitoring. Data is recorded for each transect and data from each suite of transects are composited and reported for the individual sampling station. Appendix 'A' presents this data in tabular form.

Environmental Description of the Study Area

The hydrology of the southernmost portion of the Lagoon is strongly influenced by tidal exchanges through the Jupiter Inlet. Prior research has shown that the incoming tide is diverted rather evenly with approximately 45 percent of the marine water flowing northerly into the Lagoon and a similar percentage moving inland into the Loxahatchee estuary. The remaining ten percent is channeled south to the Lake Worth Lagoon. This tidal influence assures that the waters of the entire study area are well flushed and the substrate is bathed with saline waters on a routine basis.

The 250 square mile watershed of the Loxahatchee River estuary, west of the Alt.A1A bridge, is substantially larger than the drainage basin for the lower Lagoon. Therefore, a greater freshwater influence is exerted on the water of the estuary. This influence varies seasonally and in other respects, but typically results in modified physical and qualitative characteristics of the water leaving the estuary on an outgoing tide. In contrast, the effect of tidal flushing along the Lagoon is much more constant.

Figure #3 summarizes the general water quality characteristics for four stations in the study area. Values shown represent the four year means of 24 sampling events from 1994 through 1997 and are believed to be representative of existing conditions. The WildPine Ecological Laboratory, as a part of its long term monitoring program, conducted the water quality sampling. A comprehensive expression of water quality is the Florida Water Quality Index (FWQI), which is a blended measure of water clarity, dissolved oxygen, organic demand, nutrients, bacteria and biological integrity. Index values range from 0 to 90 with lower values reflecting superior water quality conditions. The FWQI scale sets a value of less than 45 as reflecting 'good' water quality, values from 45 to 59 as indicators of 'fair' water quality and values above 60 as a 'poor' water quality measure. The Loxahatchee River District develops and publishes the FWQI values for the area twice annually. With infrequent exception during and after large rainfall events, the quality of water in the study area is consistently good.

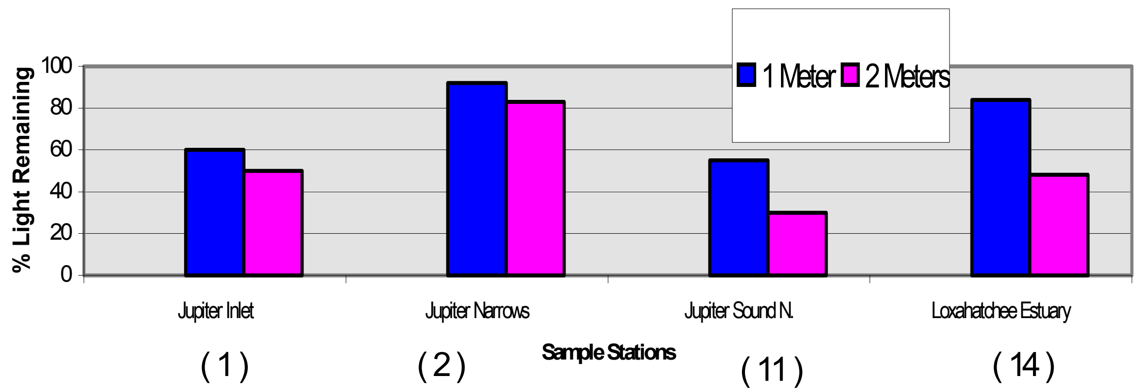
Figure # 3: General Water Quality Characteristics of the Study Area

Station	Inlet Station (1)	Narrows Station (2)	Sound N. Station (11)	Loxahatchee Estuary (14)
Temperature (C)	25.2	25.4	24.6	26.1
pH (standard units)	7.9	8.0	7.9	8.0
Alkalinity (mg/L)	112.0	115.0	117.0	112.0
Turbidity (NTU)	3.3	1.9	2.5	3.0
Transparency (m)	1.4	2.5	1.7	1.5
Color (Pt/Co units)	<25	<25	16.0	42.0
TSS (mg/L)	10.3	7.5	14.0	7.2
Salinity (ppt)	32.4	34.4	32.6	29.0
Conductivity (umho/cm)	49600	52100	49700	43300
Dis. Oxygen (mg/L)	6.81	6.86	6.73	6.85
Dis. Oxygen (% Sat)	81.6	82.5	79.2	83.6
B.O.D. (mg/L)	1.17	1.04	1.26	1.14
Total Nitrogen (mg-N/L)	1.10	1.01	1.06	1.17
Total Phos (mg-P/L)	0.042	0.039	0.032	0.039
CHL A (mg/L)	2.3	2.7	4.3	2.6
F-Coli (cfu/100ml)	16.0	6.0	5.0	29.0
Florida Water Quality Index	31	25	28	30
Shannon-Weiner log2	NA	3.54	3.45	3.16

In addition to water quality monitoring, three stations in the study area have been monitored for benthic macroinvertebrates since 1991. As with water quality, measures of biological health and diversity show good or very good conditions. A commonly used index to determine biological diversity is the Shannon-Weiner Biological Diversity Index. Values above 3.0, as are the great majority of readings from the study area, typically indicate high diversity and good biological health.

Another measure commonly used in SAV studies is light transmittance, or specifically the amount of photosynthetic active radiation available to the vegetation. An evaluation of how much light reaches various depths was conducted at four of the seagrass stations concurrent with several of the dates when researchers were recording the presence of SAV. On days without significant cloud cover, readings above 1,000 umols were observed just below the water surface. Figure #4 provides a review of the percent of surface light reaching various depths in the water column. Most stations near the inlet or areas least impacted by freshwater runoff showed only minimal reduction in the availability of light from one meter to 2 meters in depth. In general terms, the study area is subjected to extensive tidal flushing and exhibits good, often exceptional, water quality, healthy biological diversity and high levels of light penetration.

Figure # 4: Light Transmittance at Four Representative Stations



Density and Distribution

For the purpose of this study, the density of SAV is defined as the percent of seagrass or macroalgae observed along a defined linear transect. Researchers recorded either sand or SAV in one-half meter increments along each transect. Thus, a SAV density of 40 percent would indicate that vegetation was encountered at four out of ten sampling points along the transect and sand was recorded for the remaining points.

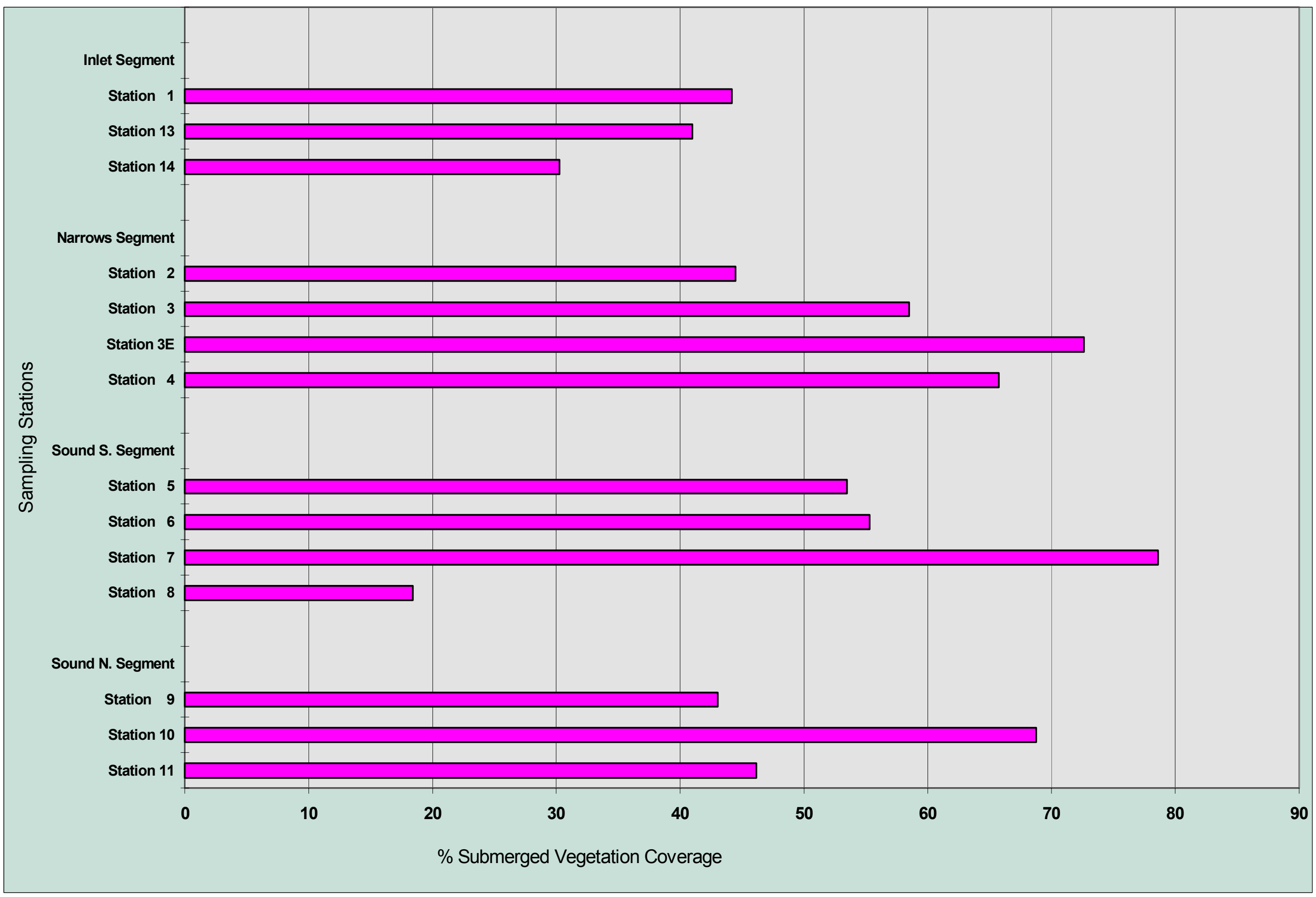
Prior seagrass studies in or near the current study area have included different scales in describing the densities of SAV. Early studies within the estuary of the river used greater than 10 percent coverage to define the presence of seagrasses. The SJRWMD research estimates percent SAV coverage using a two point scale with less than 50 percent referenced as patchy and greater than 50 percent considered dense continuous. The scope of this study described an expanded scale and this more precise scale was developed and shown below. It should be noted that this new scale remains comparable to the density distinctions employed by the SJRWMD.

Sparse	= less than 25 percent SAV
Patchy	= 26 to 50 percent SAV
Dense	= 51 to 75 percent SAV
Dense Continuous	= greater than 76 percent SAV

Figure #5 shows the presence of SAV as a percent of bottom cover at each of the fourteen sampling stations. In general, SAV is observed in densities from 30 to 70 percent, thus falling into either the patchy or dense category. Station #8 is the only station displaying sparse coverage, perhaps attributable to a nearby marina and the associated channel construction and boat traffic. Conversely, only station #7 has a dense continuous coverage of SAV. This station is less than one-half mile south of the marina at station #8; however, it is protected from recreational and other pressures by a natural sand bar.

Distribution is considered the spatial extent of SAV communities, regardless of density, and is described in a map series developed by the advance photo-interpretation method. Figures #6, #7, #8 and #9 are digitized maps that document the SAV distribution of the study area. These maps show the overall distribution of SAV in each of the four study segments and show the relative density of SAV. Distribution throughout the six-mile northern stretch of the Lagoon is nearly complete along both shorelines. The western shoreline shows more extensive spatial distribution possibly due to the shallower water depths. The western shoreline gradually slopes toward the main channel whereas the east shoreline has a steeper slope. Conversely, within the Loxahatchee estuary, SAV distribution is not complete with only limited areas of vegetative growth. Even less spatial area is covered by SAV within the Jupiter Inlet area where velocity and depth extremes appear to be limiting.

Figure # 5: SAV Densities as Percent of Bottom Cover



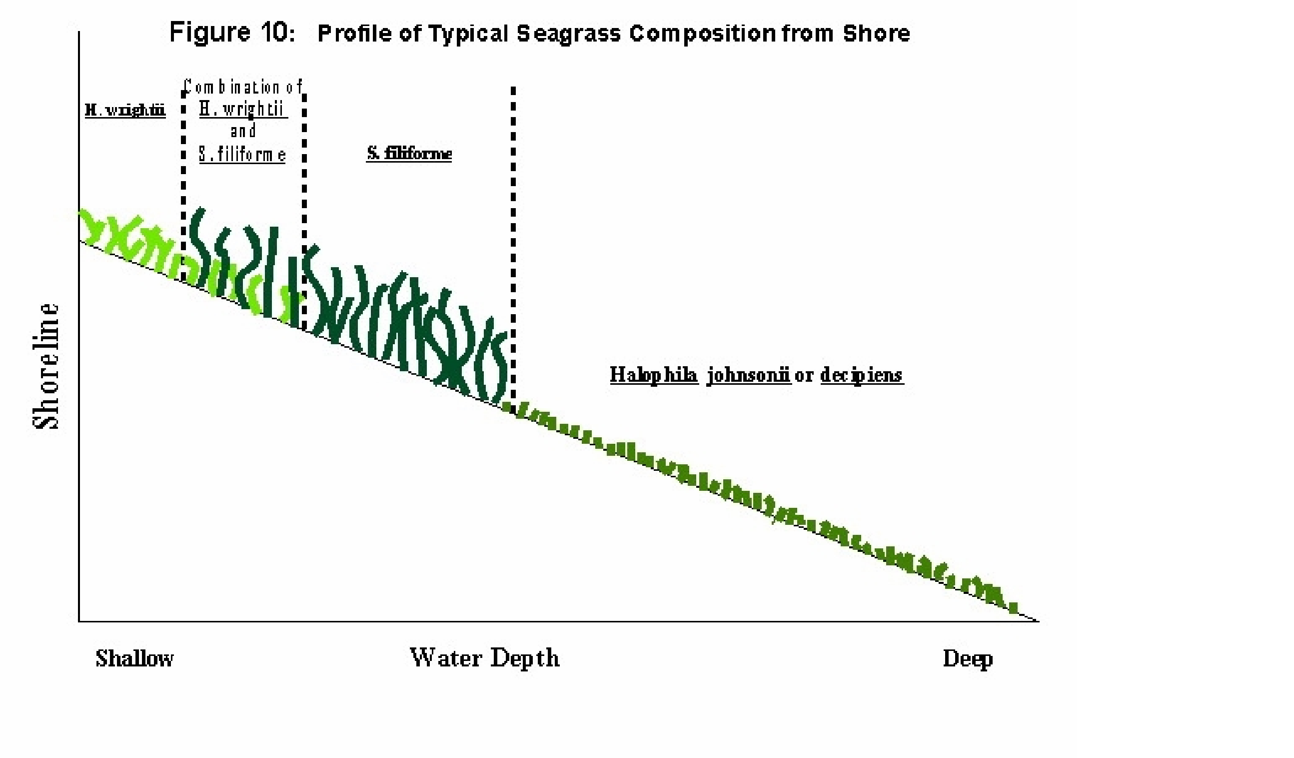
Species Identification and Community Composition

Five species of seagrasses are identified within the study area:

Syringodium filiforme	manatee grass
Halodule wrightii	shoal grass
Thallassia testudinum	turtle grass
Halophila johnsonii	Johnson's seagrass
Halophila decipiens	paddle grass

Also noted are species of macroalgae which, for this report, are all grouped and referred to as algae.

All SAV beds are made up of several species of seagrass or algae. The relative presence of one species to another can be used to describe the composition of the plant community. Figure #10 provides a simplified seagrass community profile from the shore out to the deepest edge of the grass bed. This basic profile is seen at many of the sampling stations monitored in this study, including station #2, #3, #3E, #4 and #5. Other stations have different profiles due to the presence of channels and sandbars. As seen in Figure #10, *H. wrightii* is typically observed in shallow areas where tidal fluctuations and wave dynamics make it difficult for other species to live. Further from the shoreline, there typically is a transitional zone where combinations of species are found, and, as the water deepens, *S. filiforme* becomes dominant given sufficient light. At greater depths, *S. filiforme* becomes sparse and *H. johnsonii* or *H. decipiens* become the dominant species.



In general terms, *S. filiforme* is the species found most often in the study area. This observation is encouraging because this species is associated with water of good quality and high light attenuation. In areas where water quality is variable or current velocities strong, *S. filiforme* is usually replaced by *H. wrightii*, a species that is more tolerant to such variations.

Another species of seagrass that is found in abundance at many stations is *H. johnsonii*. This particular species is currently considered threatened within the Indian River Lagoon. Nine of the fourteen stations have *H. johnsonii* as an integral part of the SAV community. At stations #1, #3, #4, #13 and #14, *H. johnsonii* represents from 14 to 43 percent of all SAV observed at the station.

Two species that have limited representation in the study area are *T. testudium* and *H. decipiens. T. testudinum* is found at eight stations in the study area, either in association with *S. filiforme* or occupying the deeper waters along a given transect. While both species tend to occupy similar depths, T. testudinum, generally less pollution tolerant and/or more light dependent, tends to grow only in waters of high clarity. *H. decipiens* is found in relatively small numbers at four sampling stations, three of which are in the northern segments of the study area.

It was observed that *H. decipiens* and *H. johnsonii* tend to occupy the same niche with only one or the other present at a given station. The presence of one species or the other may be related to the density of the SAV community. Stations with patchy, less than 50 percent, SAV coverage tended to support either species, however, only *H. johnsonii* was observed in beds with greater than 50 percent overall density.

Findings and Results

The following evaluation of the individual segments in the study area provides information on the environmental conditions and SAV communities observed during the study. The following paragraphs describe the physical, chemical and biological aspects of the four major segments of the study area and the fourteen sampling stations described in Figure #2. Reference can be made to Figures #6 through #9 for graphic representations of distribution and relative density and Figure # 5 for SAV density. Figures #11, #12, #13 and #14 display the relative abundance, in percent, of the individual species that make up the SAV communities observed in each of the four study segments.

Jupiter Inlet / Loxahatchee Estuary Segment ……… stations #1, #13 and #14

Three SAV monitoring stations are located in this segment of the study area. Station #1 is located on the south side of the Jupiter Inlet near DuBois Park. The three linear transects used for monitoring extend out from the shoreline a distance of 45 meters and terminate in 1.8 meters of water. Station #13 is one mile west of the inlet, located on the south shore between the U.S. Highway One bridge and the Alt. A1A bridge. At this station, three transects extend from a mangrove fringed shoreline out 40 meters and end in 2.3 meters of water. Station #14 is located one and a half miles west of the inlet on the west side of the Alt. A1A bridge and the FEC railroad bridge. The three transects at this station run from the north shore of the Loxahatchee estuary out to a depth of 1.5 meters. The transects are long, approximately 200 meters, and traverse a substantial sand bar and a channel.

In this segment stations #1 and #14 are also long-term water quality monitoring stations. The water quality characteristics recorded for these stations are believed to be representative of the entire segment. Salinity averages near 30 ppt, turbidity is above 3.0 mg/l, pH is at a value of 8.0 or slightly below and dissolved oxygen levels average 6.8 mg/l. One major difference between the inlet and the estuary is color with significantly higher levels observed in the estuary. The composite index for water quality, FWQI, is well within the good range at 30 and 31. Station #14 has also been monitored for macroinvertebrates throughout the 1990's. A representative index, the Shannon-Weiner Diversity Index, is above 3.0 for this station, demonstrating good species diversity and indicating healthy biological conditions. At station #1, light reduction from one meter to two meters is observed to be only 10 percent, demonstrating good light attenuation. Tests at station #14 however, show a 43 percent reduction in light from one meter to two meters. The higher color observed at this station may be part of the reason for the difference in available light.

All three of the inlet stations have patchy seagrass densities ranging between 30 percent and 44 percent, meaning that over half of the bottom is composed of sand. SAV distribution in this segment is not complete and dependent on environmental conditions, mainly water velocity and depth. The SAV communities found within this segment are associated with shallow waters protected from extreme tidal current velocities. Figure #11 shows the composition of the SAV community for these stations. *H. wrightii*, either by itself or in combination with another species, is prominent at stations #1 and #13. All stations have a substantial population of *H. johnsonii;* and, this threatened species is the primary seagrass type found at station #14. The relative presence of *H. johnsonii* in this segment tends to increase with distance from the inlet.

Jupiter Narrows Segment ……… stations #2, #3, #3E and #4

The Narrows segment is directly north of the Jupiter Inlet in the Lagoon portion of the Intracoastal waterway and contains four SAV monitoring stations. Station #2 is located on the east shore just north of the SR 707 bridge approximately one mile north of the inlet. The four transects established for monitoring are each 70 meters in length with an ending water depth of less than 2.0 meters. This station is subject to extensive recreational use. Also on the western shore of the Lagoon, station #3 is approximately one-half mile north of station #2. The two transects at this station start from a residential shoreline and extend out 100 meters to an ending depth of 2.5 meters. Station #3E is on the east shore diagonally across from station #3. This station is protected from the shore by a fringe of mangrove and two transects extend from the mangroves nearly 70 meters and end in 2.0 meters of water. Station #4 is a half-mile north of station #3 and located on the west side of the Lagoon. Each of the two transects at this station run 100 meters and concludes in 2.6 meters of water depth.

In this segment, station #2 is monitored for water quality and macroinvertebrates and the data are considered representative for the entire segment. The physical and chemical characteristics of this segment show average salinities of above 34 ppt, and very low turbidity, color and nutrients are observed. Dissolved oxygen levels are high, averaging above 6.8 and levels of organics are relatively low. The composite FWQI at station #2 is very good at 25, the lowest in the full area of study. Macroinvertebrates collected at this station exhibit an average diversity index of above 3.5, which is exceptional. It is also interesting to note that at station #4, many unique species of marine life were observed, including an octopus and a conch. Light transmittance through the waters at station #2 is very good with less than 10 percent reduction with depth. Visual observations on most sampling dates recorded very clear water allowing for significant amounts of light to reach depths of two or more meters.

Three out of the four stations in this segment have dense SAV, ranging between 58 and 73 percent coverage. The fourth station, station #2, had an average of 45 percent coverage that is described as patchy. Spatial distribution within this segment is complete along both the east and west shorelines with the exception of small areas immediately north of the SR 707 bridge. Along the western shore, the SAV grows out further from the shore primarily due to the greater extent of shallow water. Also, a sand bar running parallel to the western side of the channel serves as a protective barrier and deflects wave action from watercraft.

Seagrass composition at the sites within this segment is shown on Figure #12. *S. filiforme* is the primary vegetation cover at stations #3, #3E and #4 and is of equal composition with *H. wrightii* at station #2. While all stations support *H. johnsonii*, it is particularly observed at stations #3 and #4. These are the only two stations that support substantial populations of *T. testudinum.* One observed tendency worthy of future attention is that the percentage of *S. filiforme* appears to increase and the percentage of *H. wrightii* decreases as one moves north through this segment.

Jupiter Sound South Segment ……… stations #5, #6, #7 and #8

The stations of the southern half of Jupiter Sound are all located north of the Narrows segment and are all located on the western side of the Lagoon. Stations #5 and #6 are on opposite sides of a land jetty approximately two miles north of the Jupiter Inlet. Each station has two transects that extend out 100 meters and end in a water depth of 2.0 meters. Station #7 is located one-half mile north of station #6 and is situated behind a small sand bar, creating a protected cove. The two linear transects at this station run an average of 150 meters from a residential shoreline into 2.0 meters of water. Station #8 is located a quarter of a mile further to the north and is adjacent to a small marina. At this station, only one transect exists and it extends out approximately 100 meters and terminates in 3.0 meters of water. A deep channel, 10 to 20 meters in width, intersects the transect about halfway.

No long-term water quality, biological or light monitoring has been undertaken in this segment. However, water quality and macroinvertebrate information from the two neighboring segments indicates probable good water quality and healthy biological communities in this segment of the study area.

Stations #5 and #6 have dense coverage of SAV, slightly greater than 50 percent. As previously discussed, station #7 is the sole station in the study area with a dense continuous rating and station #8 is the sole station with a density rating of sparse. Similar to the Narrows segment, the SAV distribution in this segment is complete along both shorelines with larger distributions associated with the western shallows. Two land jetties in this segment effectively harbor portions of the substrate and allow expanded growth of SAV further east into the Lagoon. Figure #13 shows each of the four stations in this segment and provides a breakout of the composition of species at each station. At all stations, *S. filiforme* is the most prominent vegetative type observed and *H. wrightii* maintains a significant presence especially at the most northern station. *H. decipiens,* which is normally found in deeper water, is observed at station #8 where the SAV density is sparse.

Jupiter Sound North Segment ……… stations #9, #10 and #11

The three stations in this segment are the northernmost stations sampled in this study. All three stations have transects extending from the west side of the Lagoon. Station #9 is 3.7 miles north of the inlet near an upland that consists of low density commercial and residential land uses. The station is located in front of a jet ski rental business and the three transects extend an average of 80 meters and end in over 2.5 meters of water. Station #10 is located 4.5 miles north of the inlet and possesses two transects that are 50 meters in length and terminate in over 3.0 meters of water depth. The station is protected by a mangrove shoreline. Station #11 is the northernmost SAV sampling location and is approximately five miles north of the Jupiter Inlet, just south of the Hobe Sound Wildlife Refuge. This station is adjacent to one of the long-term seagrass stations sponsored by the SJRWMD. The two transects at station #11 extend out 75 meters and end in 2.5 meters of water. Each of the transects run parallel to a sand bar with fairly steep slopes.

Water Quality and macroinvertebrates are monitored at station #11 the results are believed to accurately portray the physical, chemical and biological characteristics of the northern half of the Jupiter Sound. Water quality is good with an average FWQI number of 30. Salinity values average above 30 ppt with only occasional drops below 20 ppt., turbidity is below 3.0 mg/l and pH levels and the mean concentration of dissolved oxygen are similar to other water quality observations in the study area. The Shannon-Weiner Diversity Index number for station #11 is 3.45, which demonstrates high species diversity. It should be noted that this station was used as a reference site for a report comparing benthic macroinvertebrates at several locations in the Lagoon and estuary. This selection was based on the consistently good water quality and high biological diversity observed at this station. However, station #11 does not receive as much of the clear saline water on in-coming tides as do stations closer to the inlet. Therefore, the light transmittance at station #11 drops 45 percent from one meter to two meters of depth.

As relates to density, station #10 is the most dense of the three stations in this segment with a coverage of SAV approaching 70 percent. The other two stations show patchy seagrass coverage, ranging from 40 percent to 50 percent. While SAV distribution is complete in this segment, the band of vegetation is narrower and concentrated along the shorelines. This segment is the furthest north and the water is more highly colored, limiting light penetration to relatively shallow depths. The presence of a sand bar at station #11 is associated with the greater spatial distribution in this limited area.

The composition of the SAV communities at the three northern stations is shown on Figure #14. As was observed at most other stations, *S. filiforme* is the primary species found at stations #9 and #10. *H. wrightii* made up over one-half of the seagrass community found at station #11. Small populations of either *H. decipiens* or *H. johnsonii* are found at each of the monitoring stations. Stations #9 and #11, as well as station #8 in the segment to the south, have patchy growths of SAV and include *H. decepiens*. The site where the growth was dense, station #10, included *H. johnsonii* as part of the SAV community.

Comparisons with Prior Studies and Future Research

The final objective of this study was to compare the results of this investigation with those of prior research. Two of the fourteen sampling stations were placed in close proximity to monitoring stations sponsored by others.

The first was in the Jupiter Inlet/Loxahatchee Estuary segment located in the northeast part of the estuary. The USGS, Vare and Kleem and the JID studies each evaluated the distribution of SAV in this area. A comparison of the distribution maps generated from the current study with the graphics presented in earlier works shows a general agreement with the coverage and location of seagrasses and indicates that there has been a small decrease in the spatial extent of SAV. No comparisons of the presence of species or the composition of the SAV communities can be drawn with the earlier studies. As relates to density, however, the prior JID reports concluded that the grassbeds in this part of the estuary were healthy with a density of greater than 10 percent. SAV density evaluations undertaken for the current study agree with the findings of greater than ten percent and were able to quantify the SAV coverage at this location as ranging between 28 and 37 percent. The most recent of the JID seagrass survey series reported that this is the only area of the estuary to support a population of *T. testudinum*. The current study identified limited growths of *T. testudinum* included within the SAV community at this site.

The second point of interface with previous research work is in the northernmost area sampled under this study. The long term SJRWMD program for SAV monitoring includes a transect immediately adjacent to station #11. Since 1992, the SJRWMD has been working within the Lagoon to monitor and record distribution, density and species composition information. This effort is now being assisted by the NOAA and its' new photo-imaging technology. Since the method of sampling for the long-term program differs from and is more complex than the methods used in the current study, no specific comparisons are drawn; however, general information seems to match relatively well.

Specific comparisons will be available in the coming months because the Loxahatchee River District has joined with the SJRWMD and established three new long-term stations. These stations were monitored this summer, using the advanced monitoring protocol and will continue to be monitored concurrent with over 70 other stations located elsewhere in the Lagoon.

Additionally, the Loxahatchee River District plans to return to the fourteen sampling stations used in this report and replicate the monitoring conducted this past summer. This future sampling is scheduled for the summer of 2000 and is intended to provide temporal comparisons and other observations.

KEEP SCROLLING TO VIEW SEAGRASS MAPS, FIGURES AND TABLES

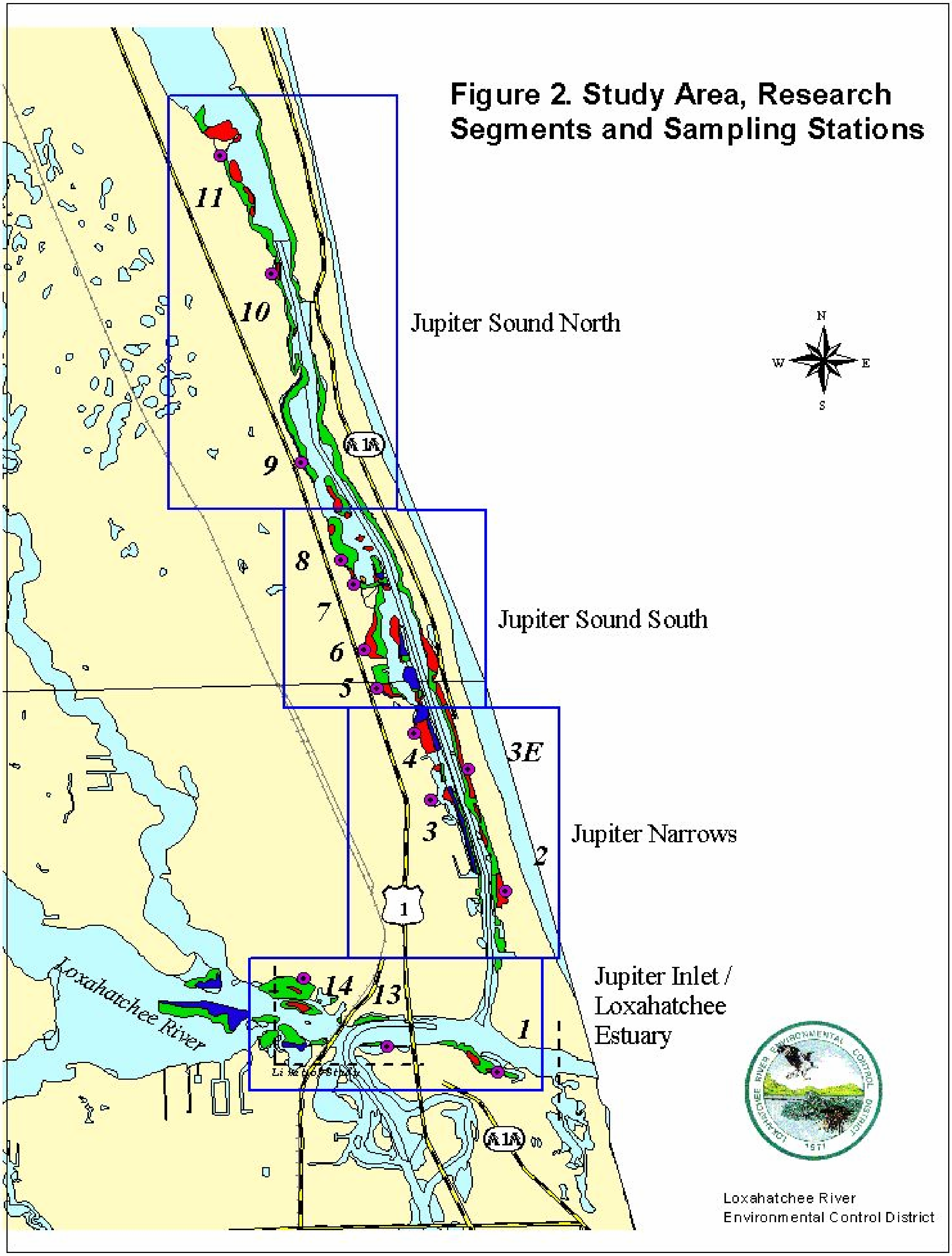


Figure 2. Study Area, Research Segments and Sampling Stations

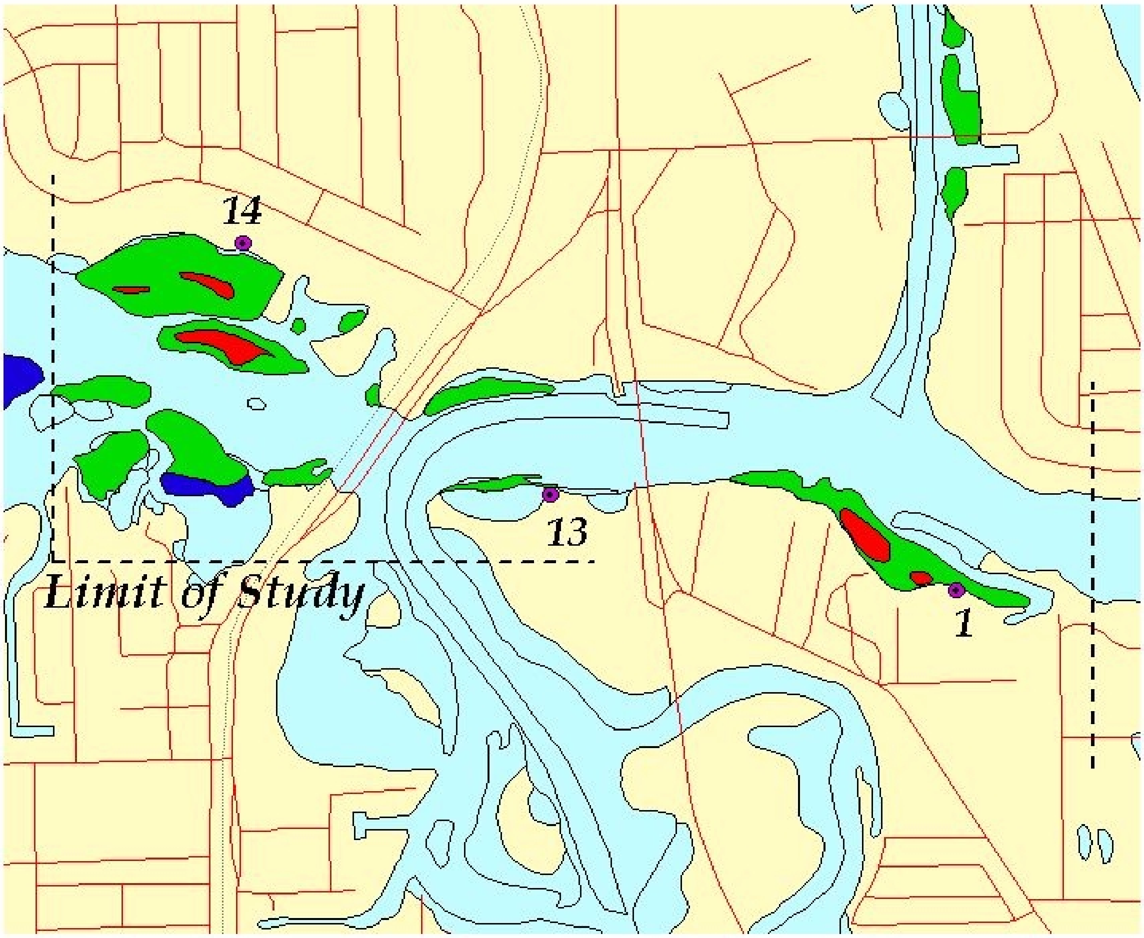


Figure 6. Inlet Stations: 1, 13, 14
Spatial Distribution and Relative Density of SAV

- Sampling Stations
- Roads
- Railroads
- Dense Continuous > 75%
- Dense 51% to 75 %
- Patchy 25% to 50%
- Sparse < 25%

Loxahatchee River
Environmental Control District

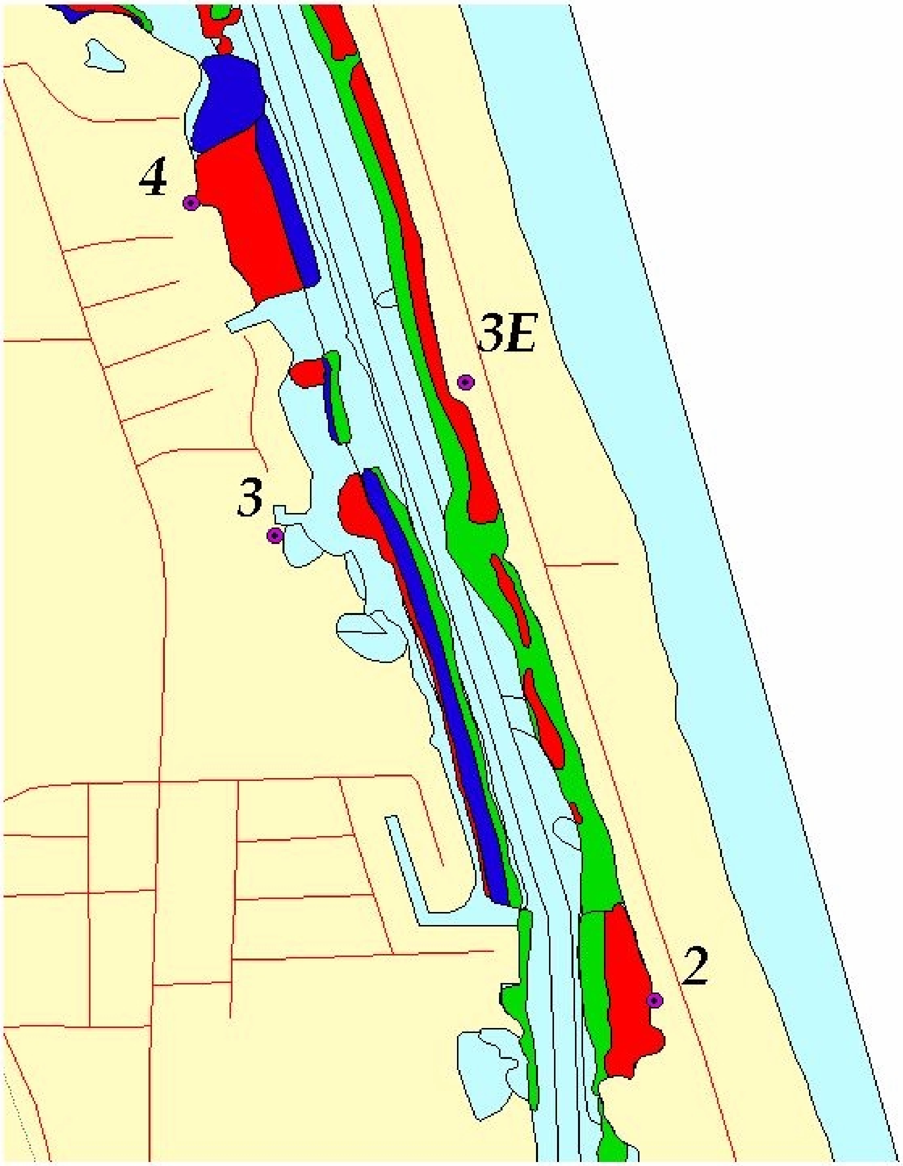


Figure 7. Jupiter Narrows: 2, 3, 3E, 4
Spatial Distribution and Relative Density of SAV

- Sampling Stations
- Roads
- Railroads
- Dense Continuous > 75%
- Dense 51% to 75 %
- Patchy 25% to 50%
- Sparse < 25%

Loxahatchee River
Environmental Control District

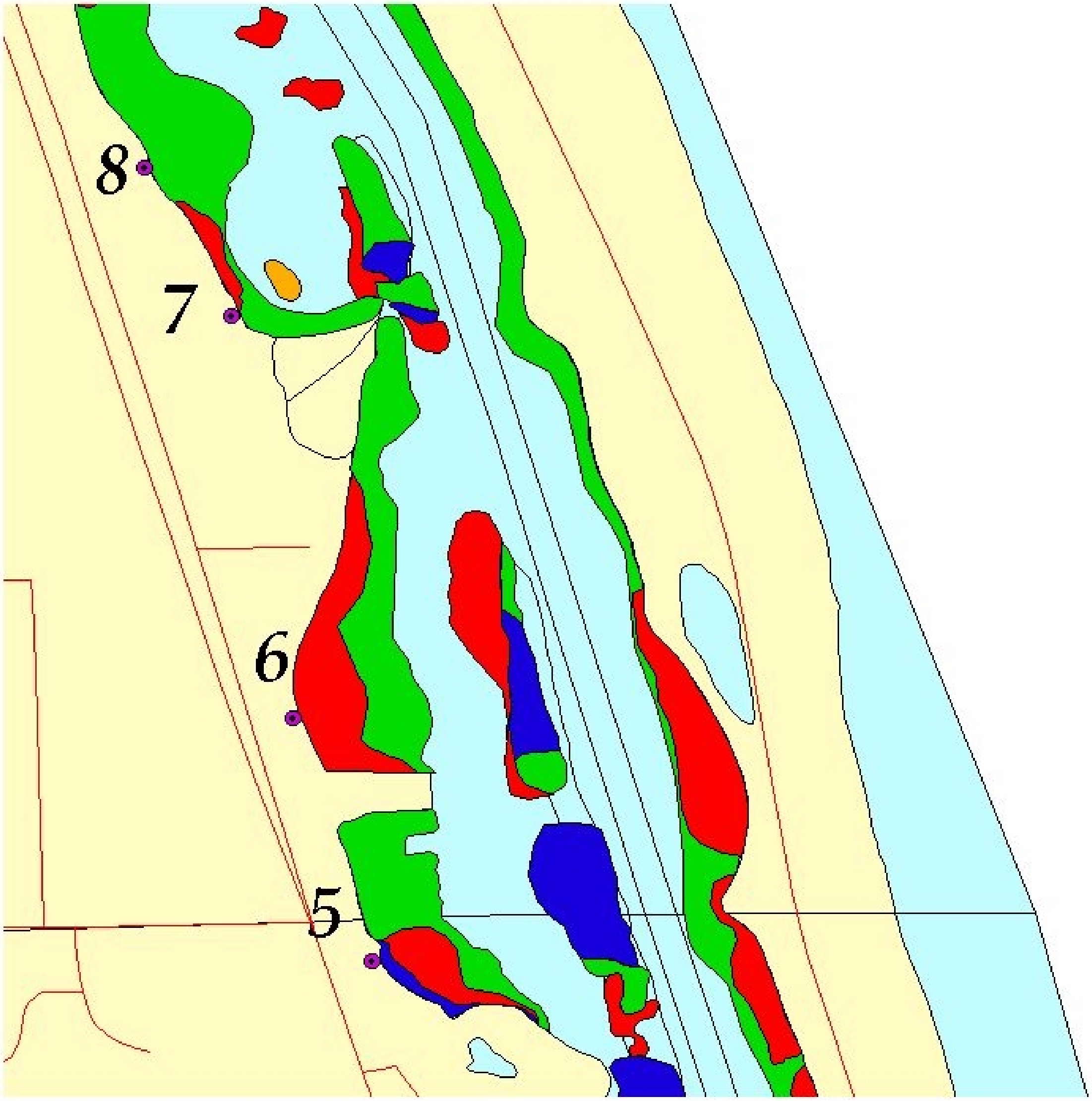
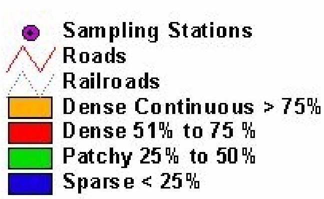


Figure 8. Jupiter Sound South: 5, 6, 7, 8
Spatial Distribution and Relative Density of SAV



Loxahatchee River
Environmental Control District

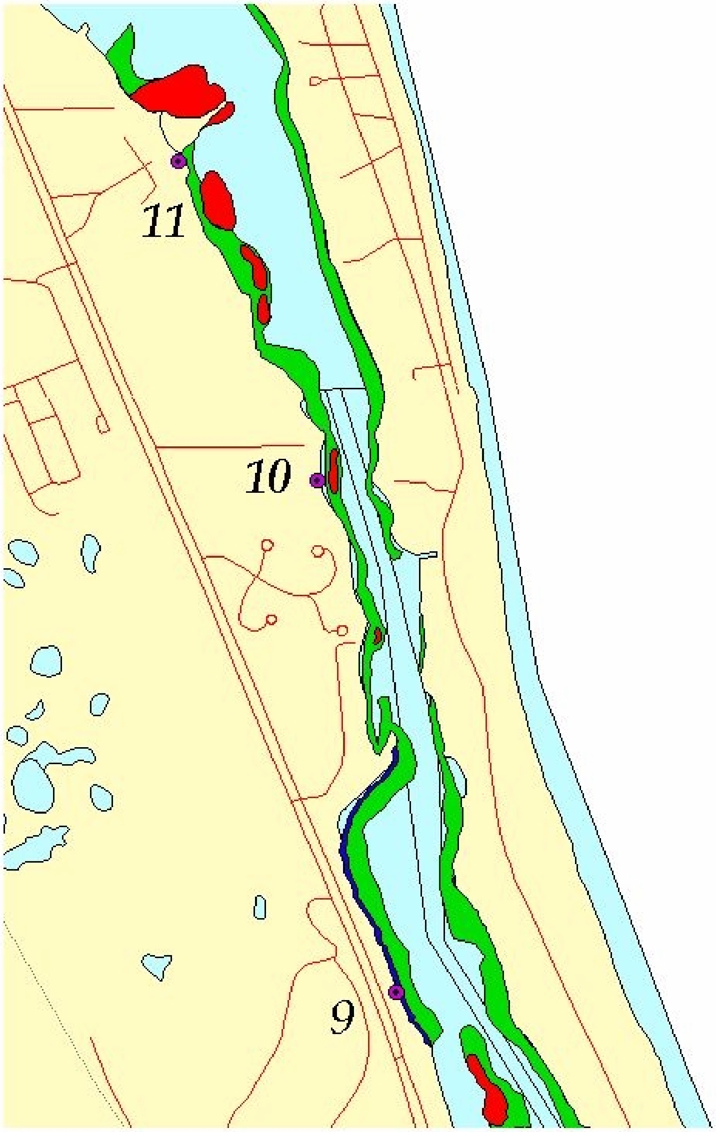
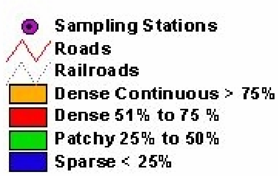
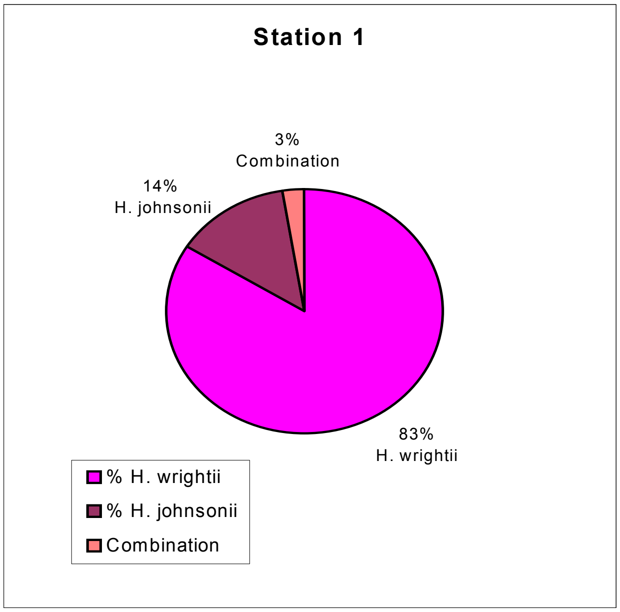


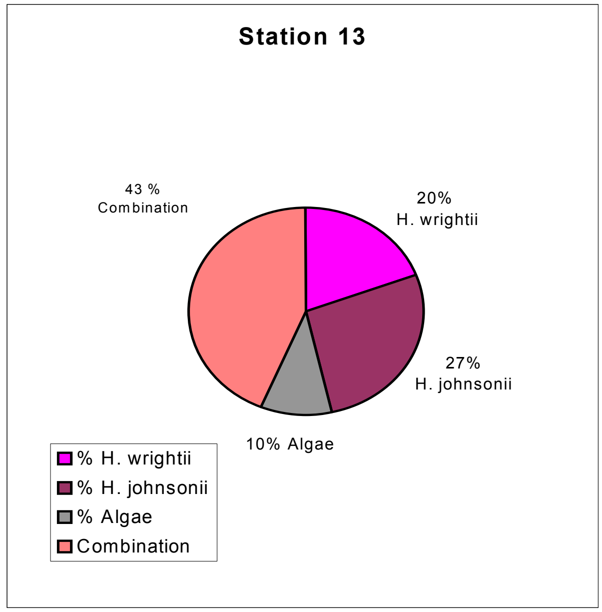
Figure 9: Jupiter Sound North: 9, 10, 11
Spatial Distribution and Relative Density of SAV



Loxahatchee River
Environmental Control District

Figure #11: Submerged Aquatic Vegetation Composition at Jupiter Inlet and Loxahatchee River Stations (1, 13, and 14)





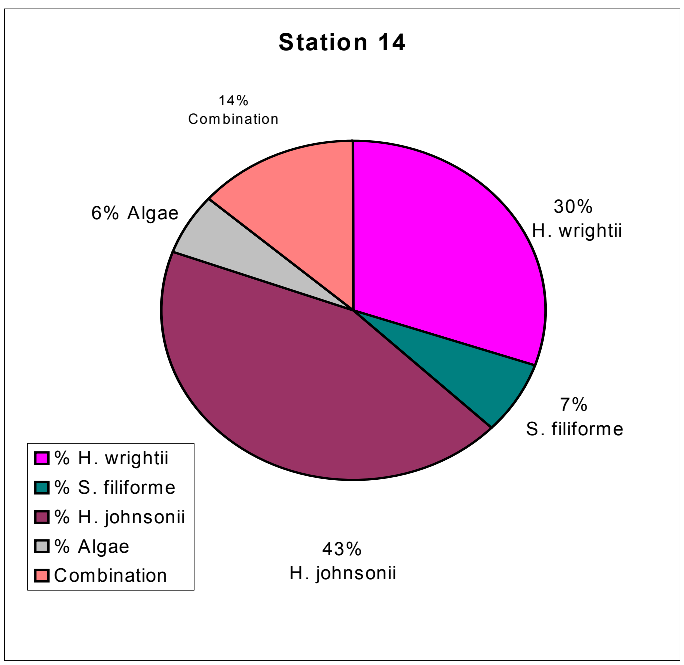


Figure #12: Submerged Aquatic Vegetation Composition at Jupiter Narrows Stations (2, 3, 3E, 4)

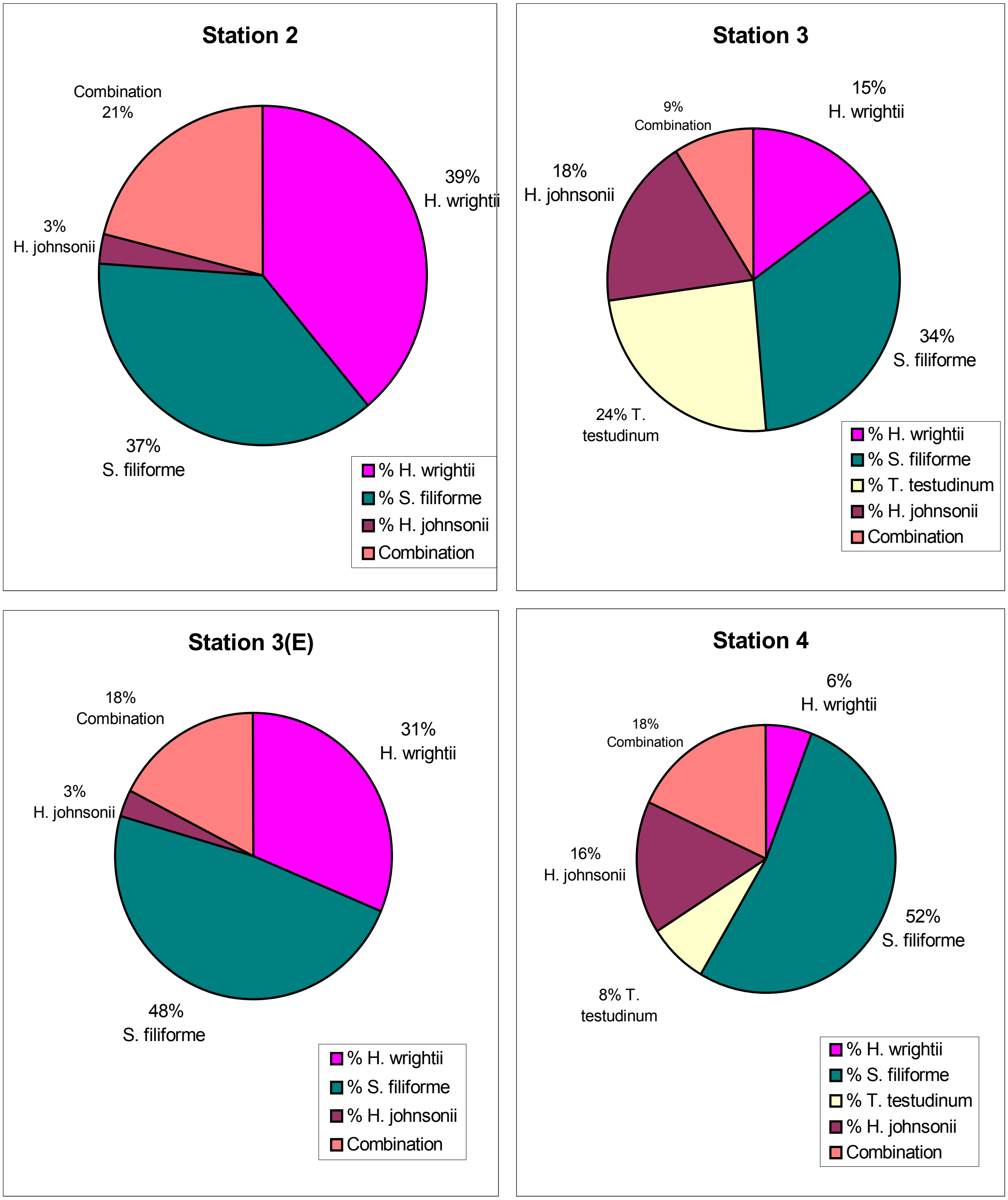


Figure #13: Submerged Aquatic Vegetation Composition at Jupiter Sound South Stations (5, 6, 7, 8)

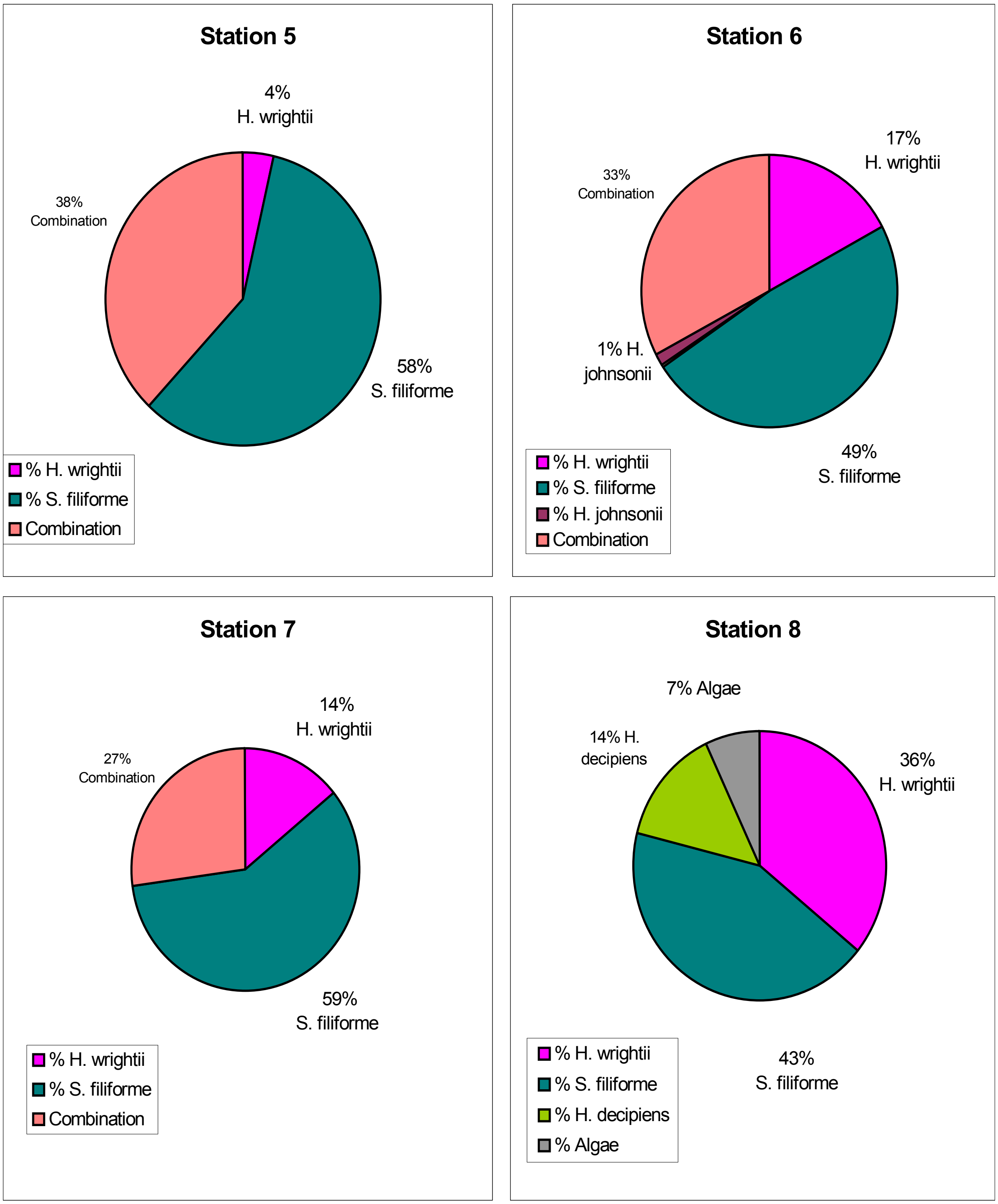
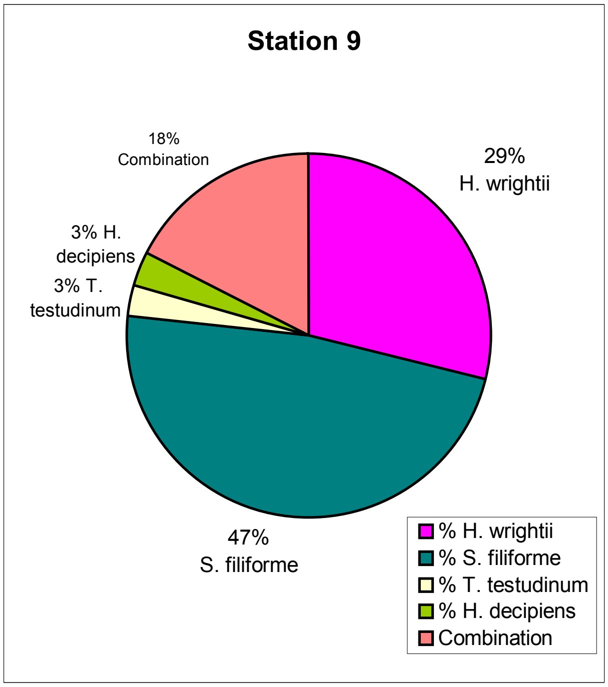
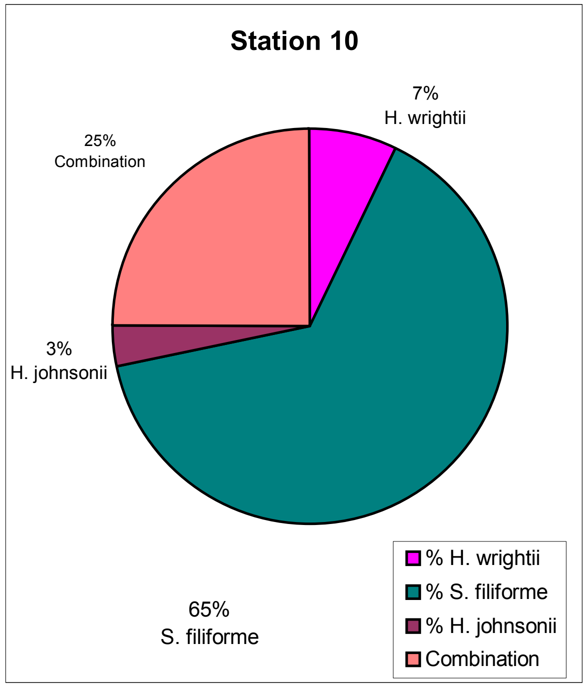
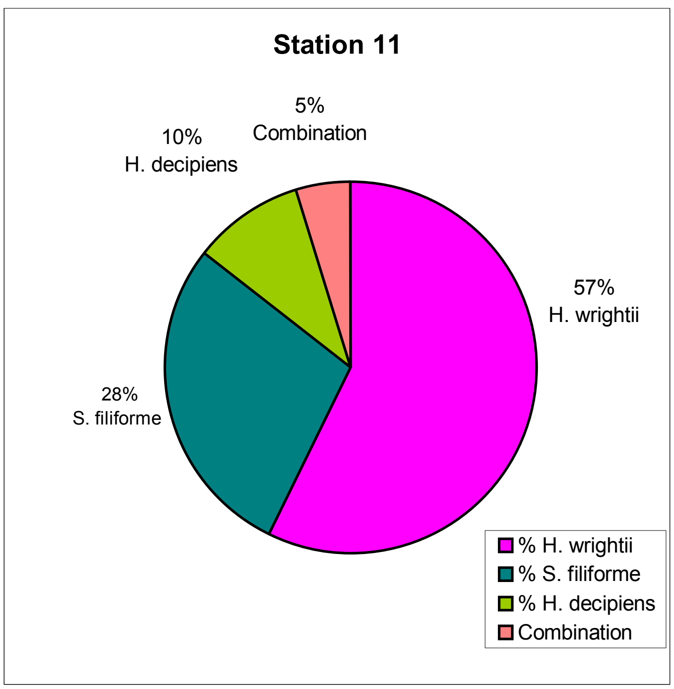


Figure #14: Submerged Aquatic Vegetation Composition at Jupiter Sound North Stations (9, 10, 11)







Appendix A

Station 1	Transect 1	Transect 2	Transect 3		Average
% Sand	69.6	52.3	48.9		56.93
% Halodule wrightii	22.5	48.8	39.8		37.03
% Halophila johnsonii	7.9	0	10.2		6.03
Combination:					
% Halodule wrightii + Halophila johnsonii	1.1	0	2.3		1.13

Station 2	Transect 1	Transect 2	Transect 3	Transect 4	Average
% Sand	39.7	63.4	59.8	56	54.73
% Halodule wrightii	13.4	3.7	30.7	21.3	17.28
% Syringodium filiforme	28.5	20.9	7.9	9.3	16.65
% Thallasia testudinum	1.1	2.2	0	0	0.83
% Halophila decipiens	0	0	0	2.7	0.68
% Halophila johnsonii	4.5	0	0	0	1.13
% Algae	0.56	0	0	0	0.14
Combinations:					
% Thallasia testudinum + Halodule wrightii	0	0.75	0	0	0.19
% Thallasia testudinum + Syringodium filiforme	11.2	0	0	0	2.80
% Algae + Syringodium filiforme	1.1	0	0	0	0.28
% Halophila johnsonii + Halodule wrightii	0.56	0	0	0	0.14
% Halodule wrightii + Syringodium filiforme	0	9.7	2.4	12	6.03

Station 3	Transect 1	Transect 2	Average
% Sand	39	44.5	41.75
% Halodule wrightii	5	12.5	8.75
% Syringodium filiforme	8	31.5	19.75
% Thallasia testudinum	16	12	14
% Halophila johnsonii	21.5	0	10.75
Combinations:			
% Thallasia testudinum + Syringodium filiforme	7	0	3.5
% Thallasia testudinum + Syringodium filiforme + Halodule wrightii	3.5	0	1.75

Station 3(E)	Transect 1	Transect 2	Average
% Sand	30.5	23.3	26.9
% Halodule wrightii	26.4	19.3	22.85
% Syringodium filiforme	38.2	31.4	34.8
% Thallasia testudinum	1.4	0	0.7
% Halophila johnsonii	2.1	2.4	2.25
Combinations:			
% Syringodium filiforme + Halodule wrightii	0.69	7.2	3.945
% Thallasia testudinum + Syringodium filiforme	0.69	0	0.345
% Sand + Halodule wrightii	0	11.3	5.65
% Syringodium filiforme + Sand	0	5.6	2.8

Appendix A

Station 4	Transect 1	Transect 2	Average
% Sand	42.3	25.8	34.05
% Halodule wrightii	1	6.5	3.75
% Syringodium filiforme	34.1	35	34.55
% Thallasia testudinum	6.2	3.8	5
% Halophila johnsonii	15.9	5.4	10.65
% Algae	0	1.1	0.55
Combinations:			
% Thallasia testudinum + Syringodium filiforme	0.48	4.8	2.64
% Thallasia testudinum + Syringodium filiforme + Halodule wrightii	0	3.2	1.6
% Halodule wrightii + Syringodium filiforme	0	15.1	7.55

Station 5	Transect 1	Transect 2	Average
% Sand	39.2	52.8	46
% Halodule wrightii	2.5	1.5	2
% Syringodium filiforme	29.1	33.1	31.1
% Halophila johnsonii	1.5	0	0.75
Combinations:			
% Syringodium filiforme + Halodule wrightii	27.6	0	13.8
% Syringodium filiforme + Thallasia testudinum	0	13.1	6.55

Station 6	Transect 1	Transect 2	Average
% Sand	35	55.6	45.3
% Halodule wrightii	18.1	1	9.55
% Syringodium filiforme	11.5	41.8	26.65
% Thallasia testudinum	0	0.5	0.25
% Halophila johnsonii	0	1.5	0.75
Combination			
% Halodule wrightii + Syringodium filiforme	36.2	0	18.1

Station 7	Transect 1	Transect 2	Average
% Sand	19.9	22.9	21.4
% Halodule wrightii	6.9	15.5	11.2
% Syringodium filiforme	31.4	60.4	45.9
% Algae	0	0.6	0.3
Combination:			
% Halodule wrightii + Syringodium filiforme	42.1	1	21.5

Station 8	Transect 1
% Sand	81.4
% Halodule wrightii	6.6
% Syringodium filiforme	7.9
% Halophila decipiens	2.6
% Algae	1.3

Appendix A

Station 9	Transect 1	Transect 2	Transect 3	Average
% Sand	64	36.5	71.9	57.47
% Halodule wrightii	4	14.3	19.1	12.47
% Syringodium filiforme	25	33.3	3.4	20.57
% Thallasia testudinum	0	0	3.4	1.13
% Halophila decipiens	4	0	0	1.33
% Algae	0.5	0	0	0.17
Combinations:				
% Sand + Syringodium filiforme	0	1.6	0	0.53
% Thallasia testudinum + Syringodium filiforme	1.5	14.3	0	5.27
% Thallasia testudinum + Halodule wrightii	0	0	2.2	0.73
% Halodule wrightii + Syringodium filiforme	1.5	0	0	0.5
% Syringodium filiforme + Decipiens	0	1.6	0	0.53

Station 10	Transect 1	Transect 2	Average
% Sand	38.3	27.9	33.1
% Halodule wrightii	6.2	3.6	4.9
% Syringodium filiforme	25.9	63	44.45
% Halophila johnsonii	0	4.5	2.25
% Algae	1.2	0	0.6
Combinations:			
% Sand + Halodule wrightii	1.2	0	0.6
% Halophila johnsonii + Halodule wrightii	0	2.7	1.35
% Sand + Syringodium filiforme	16	0.9	8.45
% Sand + Algae	11.1	0	5.55
% Sand + Algae + Syringodium filiforme	1.2	0	0.6

Station 11	Transect 1	Transect 2	Average
%Sand	49.5	57.9	53.7
% Halodule wrightii	10.81	42.1	26.46
% Syringodium filiforme	26.1	0	13.05
% Halophila decipiens	9	0	4.5
% Algae	0.8	0	0.4
Combination:			
% Halodule wrightii + Syringodium filiforme	4.3	0	2.15

Station 13	Transect 1	Transect 2	Transect 3	Average
% Sand	63.6	43.9	76.3	61.27
% Halodule wrightii	20	3.6	0	7.87
% Halophila johnsonii	10.9	1.2	19.7	10.6
% Algae	7.3	0	3.9	3.73
Combinations:				
% Sand + Algae	0	34.1	0	11.37
% Sand + Halophila johnsonii	0	18.3	1.3	6.53

Appendix A

Station 14	Transect 1	Transect 2	Transect 3	Average
% Sand	70	63.1	72.4	68.5
% Halodule wrightii	11.7	5.9	9.8	9.13
% Syringodium filiforme	2.5	3.8	0	2.1
% Thallasia testudinum	0	0.5	1.1	0.53
% Halophila johnsonii	11	16.6	11.8	13.13
% Algae	0.5	0.5	4.3	1.77
Combinations:				
% Sand + Algae	0	7.4	0	2.47
% Thallasia testudinum + Halophila johnsonii	0	0.2	0	0.07
% Sand + Algae + Halodule wrightii	0	0.2	0	0.07
% Halodule wrightii + Halophila johnsonii	0.7	0	0.2	0.3
% Halophila johnsonii + Syringodium filiforme	0.5	0	0	0.17
% Halodule wrightii + Syringodium filiforme	2	0	0	0.67
% Halophila johnsonii + Algae	0	0	0.2	0.07
% Sand + Halophila johnsonii	0	0.9	0	0.3