2021 ST. MARTINS MARSH AND BIG BEND SEAGRASSES AQUATIC PRESERVES ANNUAL SEAGRASS MONITORING REPORT

Florida Department of Environmental Protection

Office of Resilience and Coastal Protection

Big Bend Seagrasses Aquatic Preserve

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St. Martins Marsh Aquatic Preserve (SMMAP) and Big Bend Seagrasses Aquatic Preserve (BBSAP) Annual Seagrass Monitoring Report

Latest Update:

Principal Investigator and Other Contact Persons:

Principal Investigator:
Katherine S. Suchanec
Environmental Specialist I
3266 North Sailboat Avenue
Crystal River, Florida 34428
(352) 228-6032
Katherine.Suchanec@FloridaDEP.gov

Other Contact Persons:
Timothy Jones, Aquatic Preserve Manager
Email: Timothy.W.Jones@FloridaDEP.gov Phone: (352) 228-6031

Trisha Green, Environmental Specialist II
Email: Trisha.Green@FloridaDEP.gov Phone: (352) 228-6033

Background Information:

Seagrass beds are a tremendous natural resource that play a vital role in water quality, substrate stabilization, provide critical habitat, and serve as the primary food sources for many marine species. Florida waters contain over 2 million acres of seagrass habitat and support many commercially and recreationally significant species (FDEP, 2017). Based on the recent mapping data available, most of these seagrass beds are in southern Florida (1,300,000 acres), the Big Bend and Springs Coast region (618,000 acres), and the western Panhandle (39,200 acres) (Carlson and Yarbro, 2011). These extensive seagrass habitats support multimillion-dollar recreational and commercial fisheries, as nearly all estuarian and marine species spends at least part of its life cycle within the seagrass beds (Dawes, 2004).

Seagrasses are grass-like flowering plants that are typically found in shallow coastal marine and estuarine waters. Seagrasses are typically found as small, patchy beds; however, if water quality and sediment conditions remain favorable, and human disturbance is kept to a minimum, these small patches can join to form large, continuous beds known as seagrass meadows (FWC, 2014). There are over 50 species of seagrass worldwide; however, only seven species of seagrass are found in Florida's coastal waters: *Thalassia testudinum*, *Syringodium filiforme*, *Halodule wrightii*, *Ruppia maritima*, *Halophila engelmannii*, *Halophila decipens*, and *Halophila johnsonii* (FDEP, 2017).

Survival requirements vary from species to species, but the overall health of the seagrass beds can be correlated to a system's light attenuation, salinity, sediment type, and nutrient availability. The amount of light available to seagrass is one of the primary factors associated with the maximum depth at which these plants can grow. All seagrass species have different requirements for levels of both light and salinity tolerance. *R. maritima* thrives in lower salinity regimes when compared to *S. filiforme*, and *H. wrightii* does better than *T. testudinum* in lower light conditions. Each species in Florida has some unique criteria for optimal growth and survival. Where water quality and clarity are poor, seagrasses may only be found in the shallowest waters (FWC, 2014).

Seagrasses are vulnerable to many direct and indirect human impacts, especially eutrophication and other processes that reduce water clarity. Dredge-and-fill projects and pollution run-off can lead to declines in water quality and pose significant threats to seagrass. In addition, propeller scarring is a major contributor to seagrass loss in Florida's coastal areas (FWC, 2014). Although intensive efforts to improve water quality throughout Florida have resulted in an increase in some seagrass coverage, total seagrass coverage in Florida's coastal waters is less than it was in the 1950's, with some regions still experiencing declines (Carlson and Yarbro, 2011).

Macroalgae (seaweeds) are multicellular algae that are typically found in shallow marine waters. It is often categorized into three groups: red, brown, and green. Although some macroalgae resemble seagrass, they have significant differences. Macroalgae require sunlight, like seagrass, but do not have traditional root systems. Instead, most macroalgae require a hard surface to adhere to using a holdfast and absorb nutrients through their blades. Macroalgae photosynthesize and provide food and shelter for many marine animals (FDEP, 2017). When noted together, seagrass and macroalgae are more commonly referred to as submerged aquatic vegetation (SAV).

Research Methods:

Sampling Methods

Researchers locate each fixed monitoring location using predetermined GPS coordinates. Once at the correct monitoring location, the quadrat is randomly distributed four times, and the Braun-Blanquet visual cover assessment is conducted. Assessment of seagrass and macroalgae is completed using the Braun-Blanquet method. The original Braun-Blanquet scale is an 8-point scale (0, r, +, 1, 2, 3, 4, 5); however, BBSAP utilizes a modified scale. Staff adjusted to only use scale values 0-5 to assign a more tangible value representing percent cover. If no submerged aquatic vegetation is observed in a quadrat, staff record "No Grass in Quadrat" (NGIQ) on the data sheet. The Braun-Blanquet method is used to measure the community composition, percentage cover, and density of the benthic community (NOAA, 2014). This method involves placing a one-meter square quadrat on the substrate and visually inspecting the content inside the boundary. The presence of each species of seagrass and macroalgae are identified and assigned a cover-abundance scale value (Table 1).

Table 1. Modified Braun-Blanquet Density Values

1	Numerous, but Less than 5% Cover
2	5-25% Cover
3	25-50% Cover
4	50-75% Cover
5	75-100% Cover

Data recorded includes values for each seagrass and macroalgae species observed within the quadrat, in addition to values for total SAV cover, total seagrass cover, and total macroalgae cover. Staff utilize abbreviations for each SAV species while monitoring within SMMAP and BBSAP (Tables 2 & 3). In 2018, *Penicillus capitatus* and *Penicillus dumetosa* were combined into one code, *Penicillus spp.,* to streamline sampling. Drift algae is observed annually at most sites; however, since it is not attached to the sea floor, it is not included in the total SAV or total coverage BB scores. Additional observations that are documented include: epiphyte density, sediment type, presence of urchins (*Lytechinus variegatus*) or bay scallops (*Argopecten irradians*), and presence of propeller scars or "blowouts". Blowouts are barren areas created from an outboard engine attempting to get up on a plane without an adequate amount of water depth. Abiotic water quality parameters (temperature, salinity, pH, and dissolved oxygen) are recorded at each sample site using a YSI EXO1 datalogger. The datalogger is calibrated prior to sampling each day per instructions set forth in the YSI EXO User Manual. Cores were historically taken at randomly selected sites to measure above and below ground biomass; however, AP staff discontinued biomass sampling in 2009. From these monitoring surveys, staff can detect seasonal and annual trends, as well as short and long-term changes, within seagrass communities using statistical analyses.

Table 2: Seagrass Species Encountered During Seagrass Monitoring

Common Name	Scientific Name	Monitoring Code
Star Grass	*Halophila engelmannii*	HENG
Shoal Grass	*Halodule wrightii*	HWRI
Widgeon Grass	*Ruppia maritima*	RMAR
Manatee Grass	*Syringodium filiforme*	SFIL
Turtle Grass	*Thalassia testudinum*	TTES

Table 3: Macroalgae Species Encountered During Seagrass Monitoring

Species Name	Monitoring Code
Acetabularia crenulata	ACRE
Avrainvillea levis	ALEV
Anadyomene stellata	ASTE
Bataphora oerstedi	BOER
Caulerpa ashmeadii	CASH
Caulerpa cupressoides	CCUP
Caulerpa langinosa	CLAN
Caulerpa mexicana	CMEX
Caulerpa paspaloides	CPAS
Caulerpa prolifera	CPRO
Caulerpa racemosa	CRAC
Codium isthmocladum	CIST
Digenia simplex	DSIM
Halimeda incrassata	HINC
Penicillus capitatus	PCAP
Penicillus dumetosus	PDUM
Penicillus spp.	PXXX

Padina vickersiae	PVIC
Rhipocephalus phoenix	RPHO
Sargassum spp.	SXXX
Udotea flabellum	UFLA
Ulva spp.	ULVA
Drift Algae	Drift

Data Analysis Methods

The Braun-Blanquet cover abundance scale is a scale which allows researchers to visually estimate the community composition by assigning a value from 0-5 to each individual species, total grass, and total algae within each quadrat. Each value represents a range of percent cover (see Table 1). These values, as ordinal numbers, are highly debated on how they can be used in statistical analysis. Braun-Blanquet method is used in the field due to its practical ability to be used quickly and efficiently to quantify large plots of environments without disturbing the area (Furman, 2018). While the Braun-Blanquet score is extremely useful in the field, it does present issues for statistical data analysis as the numbers are categorical. Many researchers have attempted to determine the best way to work with the values including by converting the values into ordinal values that can be analyzed; however, these transformations are still debated and are meant for use on a 9-point Braun-Blanquet scale. The Braun-Blanquet scale used by BBSAP is a modified scale that ranges only from 0-5. Some seagrass researchers still support the use of Braun-Blanquet values for statistical analysis if it is not being used to forecast the seagrass growth or decline in years to come. BBSAP uses these Braun-Blanquet values only to analyze the current and past data to observe the trends over time. Braun-Blanquet scores allow for reliable and consistent measurements of submerged aquatic vegetation, and the resulting data can function effectively in statistical analysis (Furman, 2018).

Using the Braun-Blanquet observations from each site, three statistical approaches were computed for each species: density, frequency, and abundance (Fourqurean et al., 2001). In addition to individual species analysis, the overall density and abundance of all seagrass species combined was calculated. Density (D) was calculated as:

$$D_i = \frac{\sum_{j=1}^{n} S_{ij}}{n}$$

where D_i= density of species i, $j =$ quadrat number from 1 to n, the total number of quadrats sampled at a site, and S_{ij}= the Braun-Blanquet score for species i in quadrat j. For any species, D can range between 0 and 5 (Fourqurean et al., 2001). Abundance (A) was calculated as:

$$A_i = \frac{\sum_{j=1}^{n} Sij}{N_i}$$

where N_i= the number of quadrats at a site in which species i was present, excluding any quadrats without species i present. Abundance can range between 0 and 5. Frequency (F) was calculated as:

$$F_i = \frac{N_i}{n}$$

Frequency can range from 0-1 and shows the number of times species i was present in a site (Fourqurean et al., 2001). Data analysis was run in order to test for significant data and trends over time. All data analysis was completed using Microsoft Excel

Site Location and Character

Seagrass monitoring in St. Martins Marsh Aquatic Preserve began in 1997 with 25 seagrass sites initially being monitored twice per growing season, May and September. As the seagrass monitoring program expanded, monitoring was reduced to once per growing season. In Big Bend Seagrasses Aquatic Preserve, seagrass monitoring began in 2000 with the establishment of 25 seagrass sites in Steinhatchee (STCH). In 2006, staff expanded the program in BBSAP by establishing 25 sites in both Cedar Key (CK) and St. Marks (SMAR), thus totaling 75 stations throughout the Big Bend region. In 2013, an additional 25 monitoring stations were added in the Dekle Beach/Keaton Beach (DBKB). It is important to note, in 2017, these sites were reselected to increase distribution of sampling throughout the region. To date, 125 fixed locations are currently monitored annually to determine species composition, abundance, and distribution of seagrasses in the SMMAP and BBSAP.

Big Bend Seagrasses Aquatic Preserve

Big Bend Seagrasses Aquatic Preserve is comprised of mostly rural and undeveloped coastal habitats. The coast of the Big Bend has shallow depths and low winds which makes it a low energy coastline. Contributions of groundwater draining from the region's rivers, in combination with the Big Bend's shallow depths and low wave energy allow for an environment that is highly conducive to the growth and survival of seagrasses (Mattson, 2000). These pristine and relatively undisturbed waters make ideal habitat for seagrasses. BBSAP is home to the second-largest near-shore seagrass bed in Florida (Dawes, 2004). Six different species of seagrasses are found in BBSAP boundary: *Halodule wrightii*, *Halophila decipens*, *Halophila engelmannii*, *Ruppia maritima*, *Syringodium filiforme,* and *Thalassia testudinum*. *Halophila decipens* is found in deeper waters of the AP, outside the BBSAP seagrass monitoring program zone. Distribution of these grasses is largely dependent upon water clarity, water depth, and salinity.

The Big Bend region of Florida is especially important for commercial and recreational fisheries. The seagrass beds provide vital habitat to many sport fish such as redfish, speckled sea trout, and grouper. Commercially targeted species include stone crab, blue crab, oysters, shrimp, and mullet. The Big Bend is home to the largest recreational scallop fishery in the state and accounts for 25-33% of the total commercial blue crab landings in Florida (Mattson et al., 2007). Approximately 2.2 million acres of seagrass have been mapped in estuarine and nearshore Florida waters. Every year these waters provide ecological services worth over $20 billion in revenue (Carlson and Yarbro, 2011).

As BBSAP's shallow, estuarine waters are impacted by climate change, it is important to collect and establish baseline conditions within the BBSAP for post-impact comparisons and to identify any habitat restoration or watershed management opportunities. Collection of this data allows researchers to track changes in habitat conditions as well as to observe any trends over time. BBSAP's seagrass and water quality data provides helpful information which can be used to address future management issues of the resource.

St. Martins Marsh Aquatic Preserve

The St. Martins Marsh Aquatic Preserve includes approximately 28,000 acres of submerged lands from the Crystal River to the Homosassa River in coastal Citrus County, Florida. It is composed of open water, mangrove islands, several inlet bays, tidal rivers and creeks, saltmarsh, and adjoins upland hammock islands. Nutrient exchange between the marshes and the Gulf of Mexico makes the saltmarsh a significant area of primary production and a nursery ground for commercial and recreational fish species. Five different species of seagrasses are found in SMMAP: *Halodule wrightii*, *Halophila engelmannii*, *Ruppia maritima*, *Syringodium filiforme*, and *Thalassia testudinum*. Distribution of these grasses is largely dependent upon water clarity, water depth, and salinity.

The SMMAP is especially important for commercial and recreational fisheries. The seagrass beds in this region provide vital habitat to many recreational fish species such as redfish, spotted sea trout, and grouper. The seagrass beds also provide vital habitat to Florida's bay scallops; in conjunction with the Steinhatchee area in the Big Bend, these coastal waters are considered the state's leading scallop harvesting grounds.

It is important to collect and establish baseline conditions within the St. Martins Marsh Aquatic Preserve for post-impact comparisons and to identify any habitat restoration or watershed management opportunities. SMMAP's seagrass and water quality data provides helpful information which can be used to help address management issues of the resource.

Station Locations

St. Martins Marsh (SID) monitoring stations are located within the St. Martins Marsh Aquatic Preserve, between the Crystal and Homosassa Rivers in Citrus County, Florida. Cedar Key, Steinhatchee, Dekle Beach/Keaton Beach, and St. Marks monitoring stations are located within the Big Bend Seagrasses Aquatic Preserve. Geographically Cedar Key (CK) monitoring stations are in the coastal waters of Cedar Key in Levy County. Steinhatchee (STCH) monitoring stations are located west and south of the town of Steinhatchee in both Dixie and Taylor Counties. Dekle Beach/Keaton Beach (DBKB) monitoring stations are in the coastal waters of Taylor County extending from the communities of Keaton Beach to the north and Hagen's Cove to the south. St. Marks (SMAR) monitoring stations are in Apalachee Bay, south of the town of St. Marks in Wakulla and Jefferson Counties.

Table 4: St. Martins Marsh (SID) Monitoring Stations

Site Name	Latitude	Longitude
SID01	28.8309559	-82.7787302
SID02	28.8309556	-82.7597306
SID03	28.8309553	-82.7407309
SID04	28.830955	-82.7217313
SID05	28.8309548	-82.7027316
SID06	28.8142891	-82.7787306
SID07	28.8142888	-82.7597309
SID08	28.8142885	-82.7407312
SID09	28.8142883	-82.7217315
SID10	28.814288	-82.7027319
SID11	28.7976223	-82.7787308
SID12	28.7976221	-82.7597312
SID13	28.7976218	-82.7407315
SID14	28.7976215	-82.7217319
SID15	28.7976212	-82.7027322

SID16	28.7809556	-82.7787312
SID17	28.7809553	-82.7597315
SID18	28.780955	-82.7407318
SID19	28.7809547	-82.7217322
SID20	28.7809545	-82.7027325
SID21	28.7642888	-82.7787315
SID22	28.7642885	-82.7597318
SID23	28.7642883	-82.7407321
SID24	28.764288	-82.7217325
SID25	28.7642877	-82.7027329

Table 5: Cedar Key (CK) Monitoring Stations

Site Name	Latitude	Longitude
CK01	29.10353	-83.07146
CK02	29.10169	-83.0667
CK03	29.09684	-83.06095
CK04	29.0958	-83.06958
CK05	29.1006	-83.07297
CK06	29.09957	-83.08224
CK07	29.10458	-83.08136
CK08	29.11029	-83.08109
CK09	29.11466	-83.07697
CK10	29.09577	-83.02865
CK11	29.09841	-83.03444
CK12	29.0984	-83.02859
CK13	29.10166	-83.03252
CK14	29.08084	-83.05309
CK15	29.08583	-83.06857
CK16	29.10689	-83.09766
CK17	29.12688	-83.10284
CK18	29.13523	-83.10408
CK19	29.13709	-83.09472
CK20	29.13389	-83.08359
CK21	29.11887	-83.0801
CK22	29.11855	-83.02962
CK23	29.12137	-83.03386
CK24	29.1241	-83.034768
CK25	29.12799	-83.03003

Table 6: Steinhatchee (STCH) Monitoring Stations

Site Name	Latitude	Longitude
STCH01	29.675	-83.44167
STCH02	29.675	-83.475
STCH03	29.6675	-83.4669
STCH04	29.65833	-83.425
STCH05	29.64167	-83.40833
STCH06	29.6414	-83.4146
STCH07	29.6444	-83.4257
STCH08	29.64167	-83.44167
STCH09	29.63453	-83.42518
STCH10	29.625	-83.425
STCH11	29.6129	-83.4237
STCH12	29.60833	-83.40833
STCH13	29.60046	-83.41712
STCH14	29.59167	-83.425
STCH15	29.5916	-83.4386
STCH16	29.5824	-83.4252
STCH17	29.57611	-83.42495
STCH18	29.57499	-83.44167
STCH19	29.5652	-83.4207
STCH20	29.55833	-83.425
STCH21	29.5462	-83.4152
STCH22	29.5477	-83.4342
STCH23	29.54166	-83.44167
STCH24	29.5334	-83.4203
STCH25	29.524499	-83.425

Table 7: Dekle Beach/Keaton Beach (DBKB) Monitoring Stations*

Site Name	Latitude	Longitude
DBKB01	29.878389	-83.65393
DBKB02	29.875575	-83.64136
DBKB03	29.872392	-83.65296
DBKB04	29.869164	-83.63774
DBKB05	29.861339	-83.6398
DBKB06	29.852903	-83.66123

DBKB07	29.847611	-83.6322
DBKB08	29.841328	-83.62485
DBKB09	29.836858	-83.64365
DBKB10	29.832939	-83.62881
DBKB11	29.825997	-83.62142
DBKB12	29.818311	-83.62869
DBKB13	29.821886	-83.60457
DBKB14	29.806744	-83.63106
DBKB15	29.801469	-83.61715
DBKB16	29.808836	-83.60098
DBKB17	29.798536	-83.59284
DBKB18	29.792311	-83.58659
DBKB19	29.787878	-83.60005
DBKB20	29.778703	-83.60527
DBKB21	29.773236	-83.59347
DBKB22	29.764725	-83.59856
DBKB23	29.752664	-83.58935
DBKB24	29.751886	-83.57327
DBKB25	29.736514	-83.58194

*Dekle Beach/Keaton Beach site locations were updated in 2017 to maximize sampling efforts in this region. Historic site coordinates are available upon request.

Table 8: St. Marks (SMAR) Monitoring Stations

Site Name	Latitude	Longitude
SMAR01	30.06016	-84.17051
SMAR02	30.06131	-84.15289
SMAR03	30.06414	-84.13629
SMAR04	30.065	-84.11961
SMAR05	30.06376	-84.10274
SMAR06	30.06156	-84.08627
SMAR07	30.06176	-84.06987
SMAR08	30.06325	-84.05243
SMAR09	30.07262	-84.03893
SMAR10	30.07518	-84.02169
SMAR11	30.08974	-84.04982
SMAR12	30.07838	-84.06923
SMAR13	30.0747	-84.08907
SMAR14	30.07464	-84.10557
SMAR15	30.08141	-84.11957

SMAR16	30.05055	-84.15928
SMAR17	30.05278	-84.14236
SMAR18	30.05541	-84.12576
SMAR19	30.05745	-84.10857
SMAR20	30.05676	-84.09095
SMAR21	30.05761	-84.07223
SMAR22	30.05926	-84.05395
SMAR23	30.07869	-84.05362
SMAR24	30.07083	-84.05075
SMAR25	30.07035	-84.07165

Results

St. Martins Marsh

Submerged aquatic vegetation monitoring began in 1997; however, only species occurrence and coverage were reported for each site. Staff began recording total grass and total SAV Braun-Blanquet scores in 2002. The St. Martins Marsh monitoring region is a unique area in that five species of seagrasses and approximately 20 species of macroalgae (See Tables 2 & 3) have been documented by staff. Hardbottom habitat is also intermixed throughout the seagrass meadows where the karst limestone bedrock makes up the substrate. In St. Martins Marsh, *T. testudinum* is the most encountered species of seagrass followed by *S. filiforme* then *H. wrightii* (Figure 3). *H. engelmannii* has been observed every year but not to the extent of the other seagrass species. *R. maritima* has been documented intermittently at the eastern monitoring sites that experience more freshwater input.

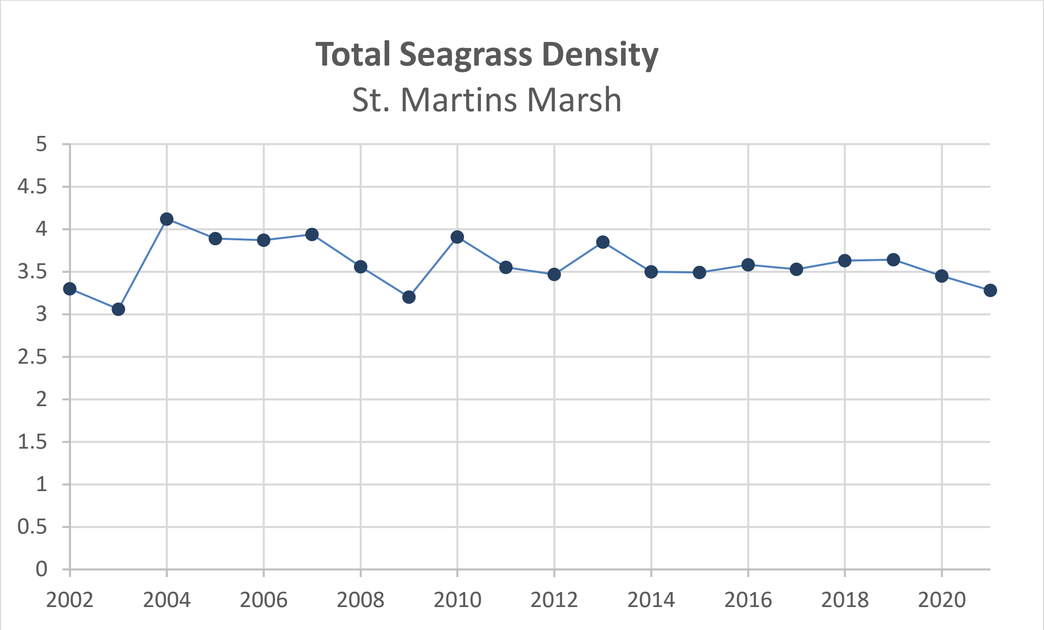

Figure 1. Overall seagrass density over the sampling years. There is no significant trend over time.

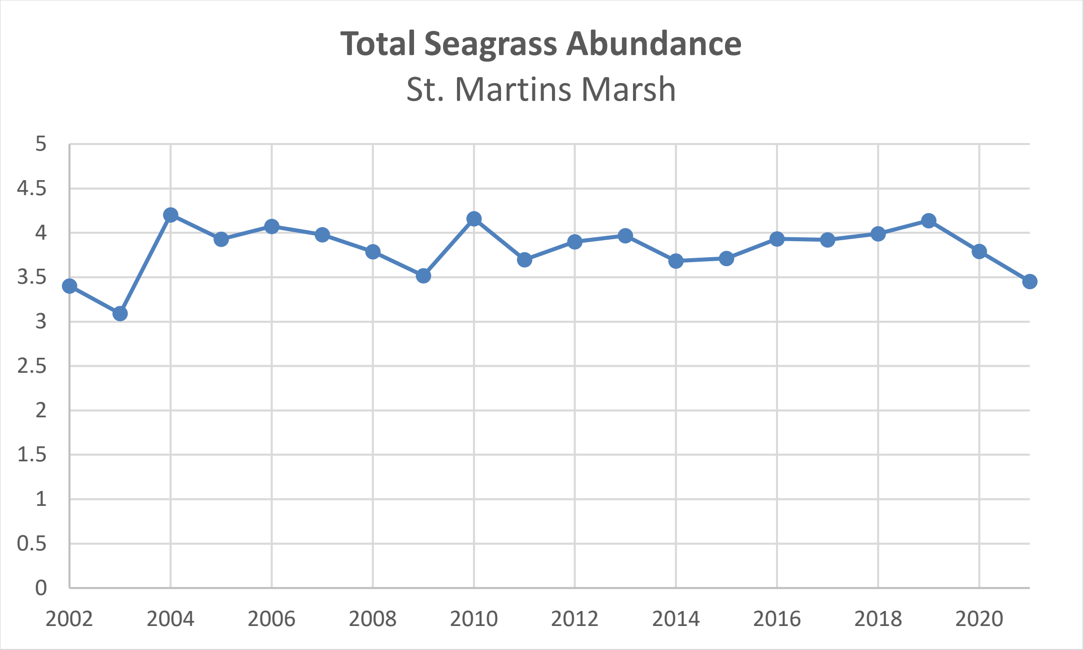

Figure 2. Overall seagrass abundance in St. Martins Marsh over the sampling years. No significant trends over time.

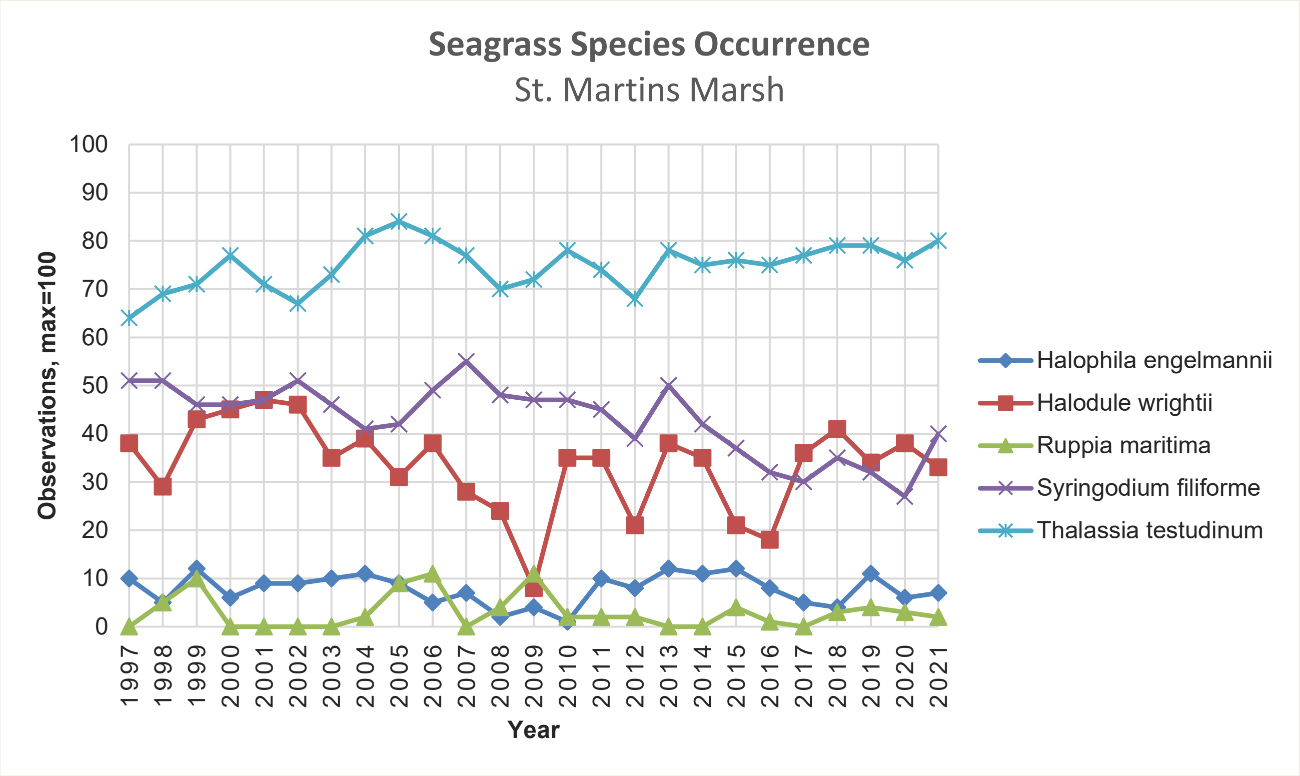

Figure 3. The number of times each species of seagrass occurred (max of 100) in St. Martins Marsh over time.

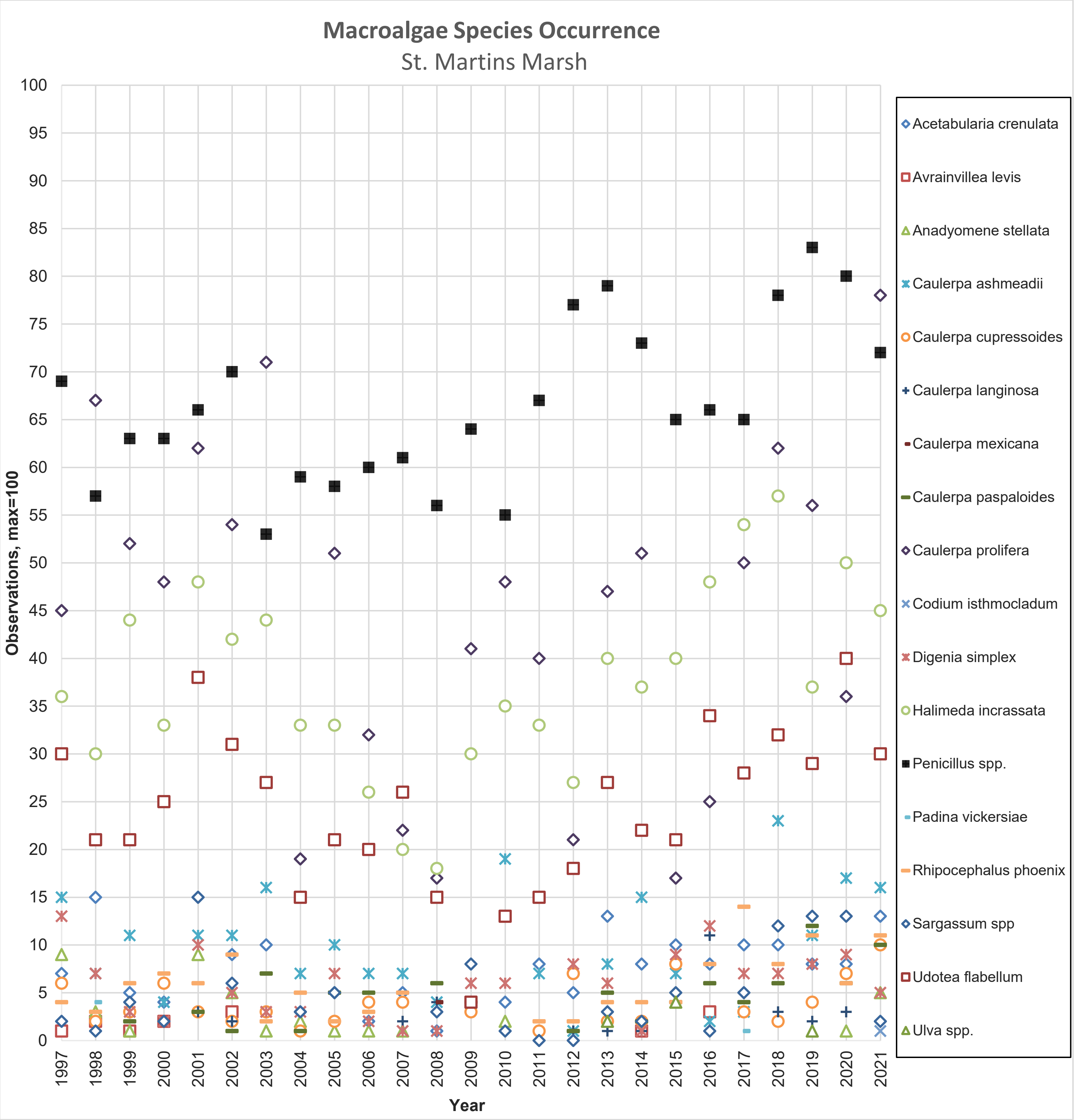

Figure 4. The number of times each species of macroalgae occurred (max of 100) in St. Martins Marsh

over time. Although over 20 species of macroalgae have been observed in the St. Martins region, *Caulerpa prolifera*, *Penicillus capitatus, Penicillus dumetosa*, *Udotea flabellum*, and *Halimeda incrassata* have been the most prominent species.

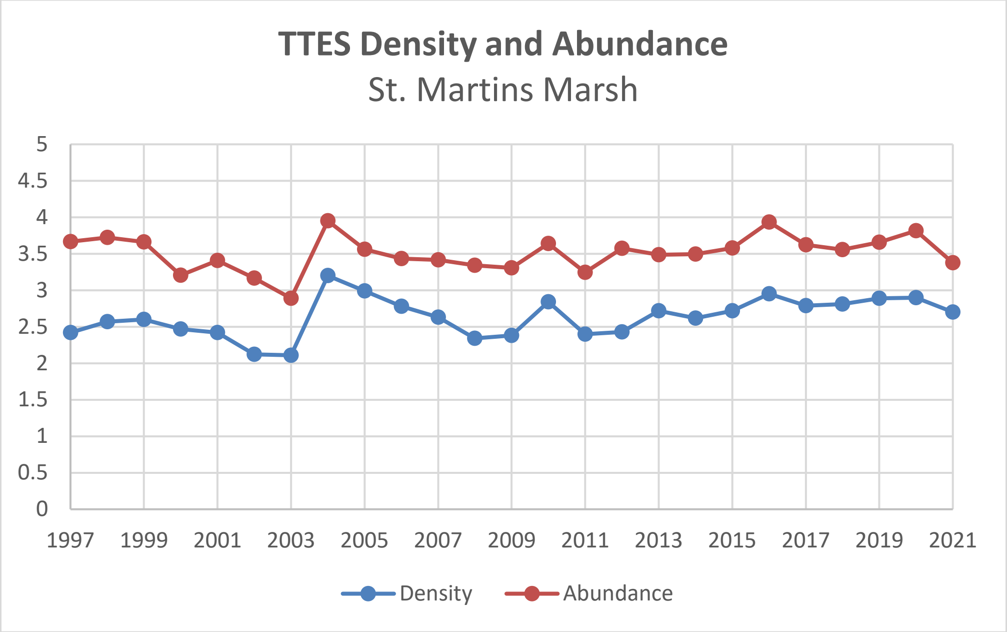

Figure 5. *Thalassia testudinum* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

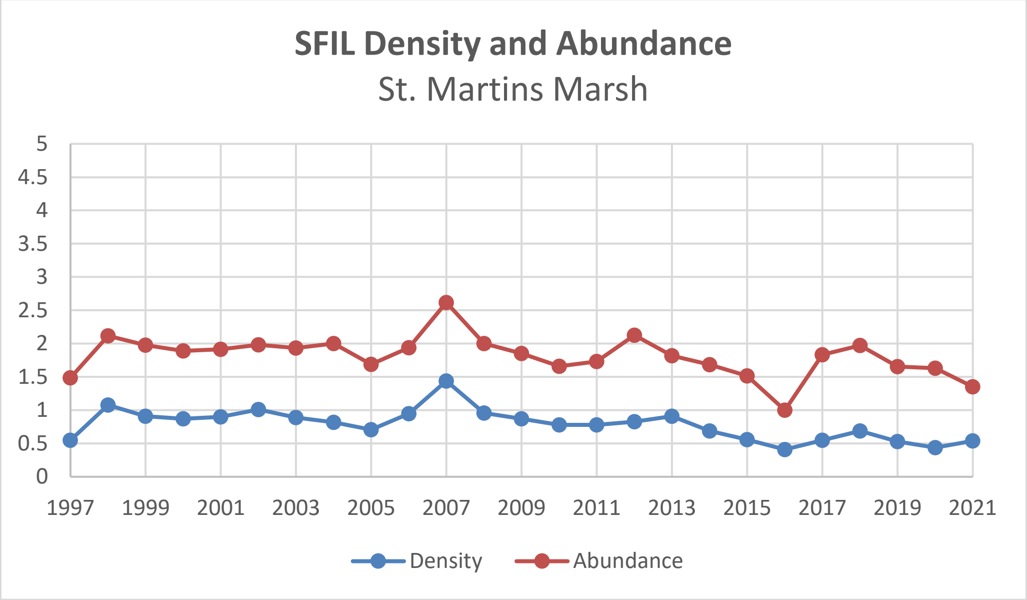

Figure 6. *Syringodium filiforme* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

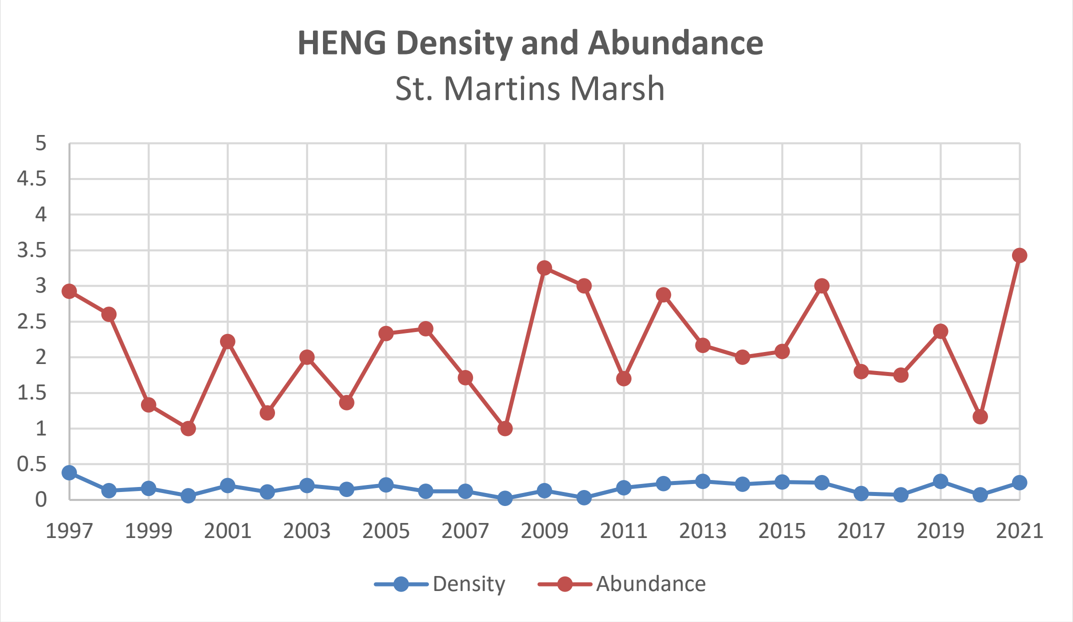

Figure 7. *Halophila engelmannii* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

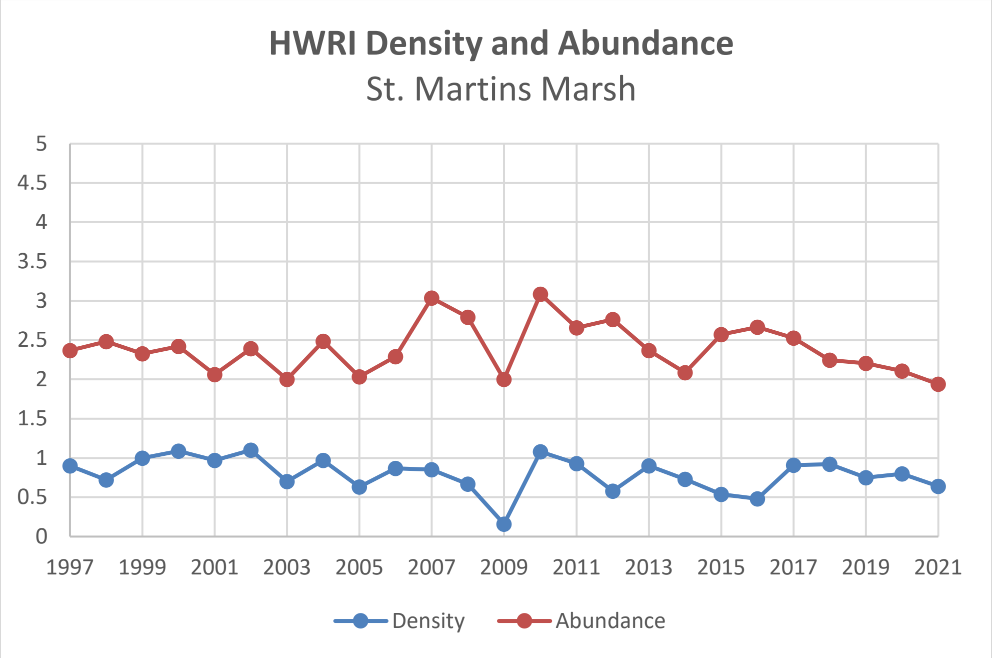

Figure 8. *Halodule wrightii* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

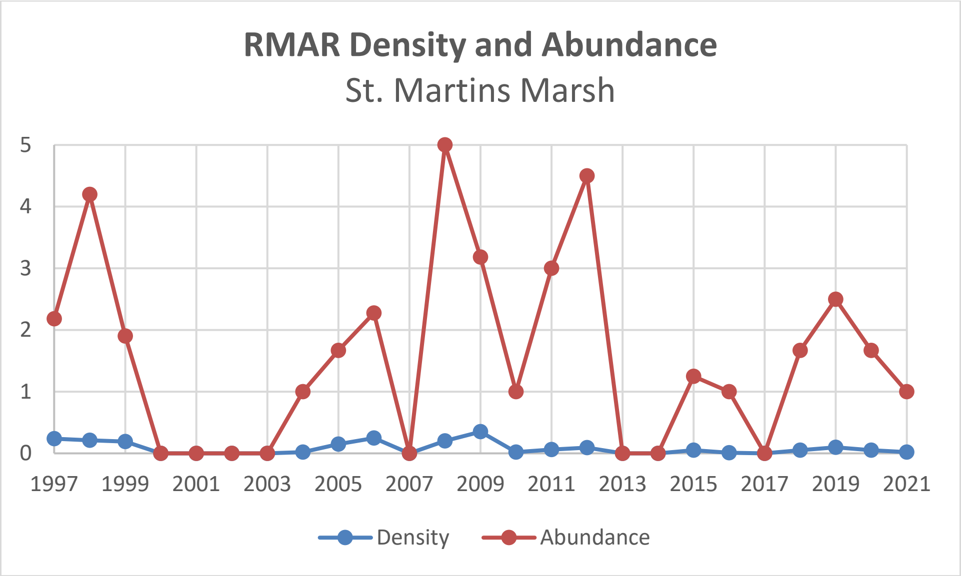

Figure 9. *Ruppia maritima* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

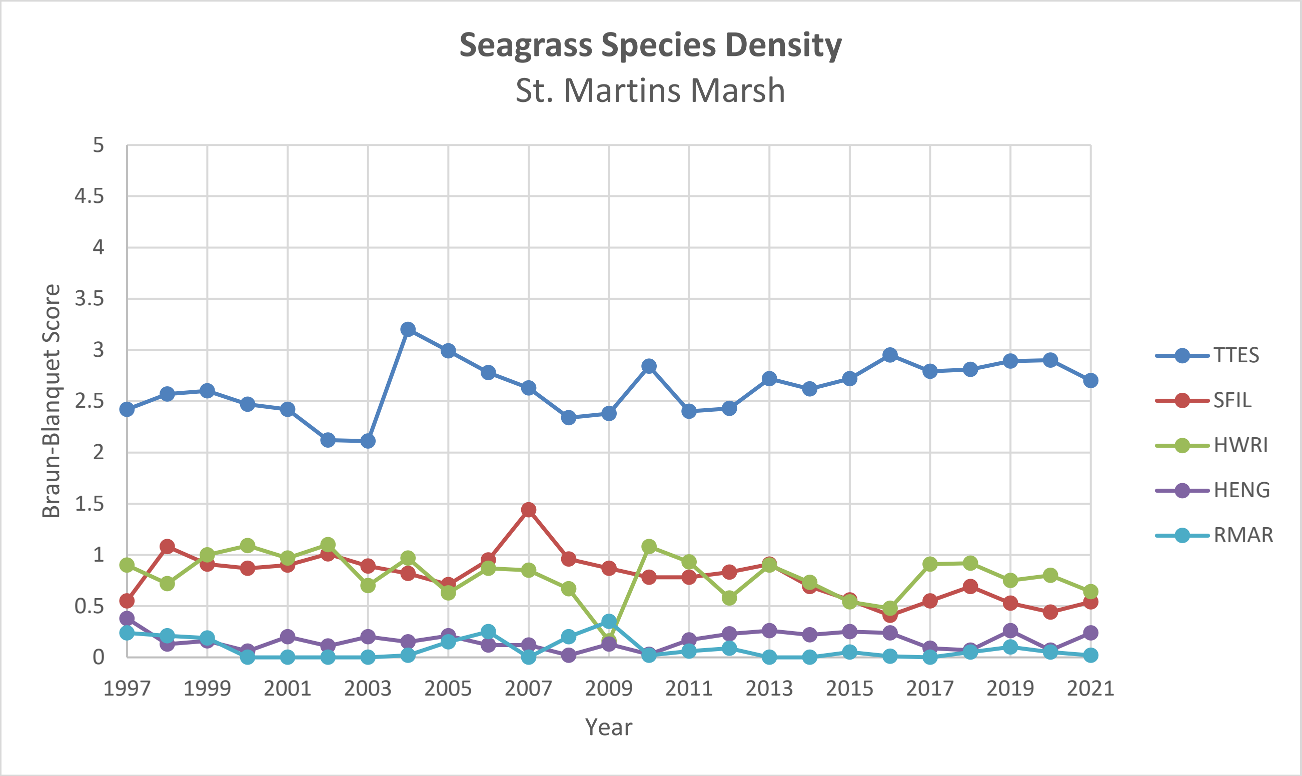

Figure 10. Individual seagrass species densities in St. Martins Marsh over time. Graph shows that *T. testudinum* is the densest seagrass species found in SID.

Cedar Key

Submerged aquatic vegetation monitoring began in Cedar Key in 2006. Staffing shortage and unfavorable weather patterns prevented monitoring in 2011. To date, four species of seagrass and six species of macroalgae have been recorded in Cedar Key. *T. testudinum*, *H. wrightii*, and *S. filiforme* are the most encountered species of seagrass. *T. testudinum* is the most common seagrass species in Cedar Key (See Figure 13). *R. maritima* has not been observed in Cedar Key. Historically, Cedar Key differed from the other monitoring regions in that it has significantly lower macroalgae species present. Only seven species of macroalgae have been observed in Cedar Key since 2015, and only *Caulerpa prolifera* had been observed between 2006 and 2014.

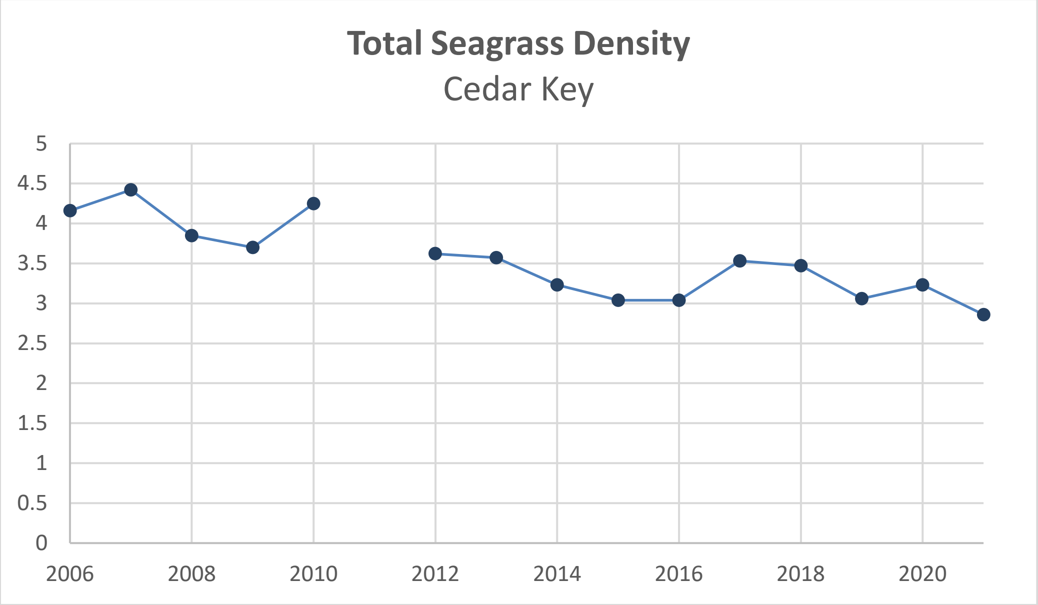

Figure 11. Overall density of all seagrass species combined over time in Cedar Key.

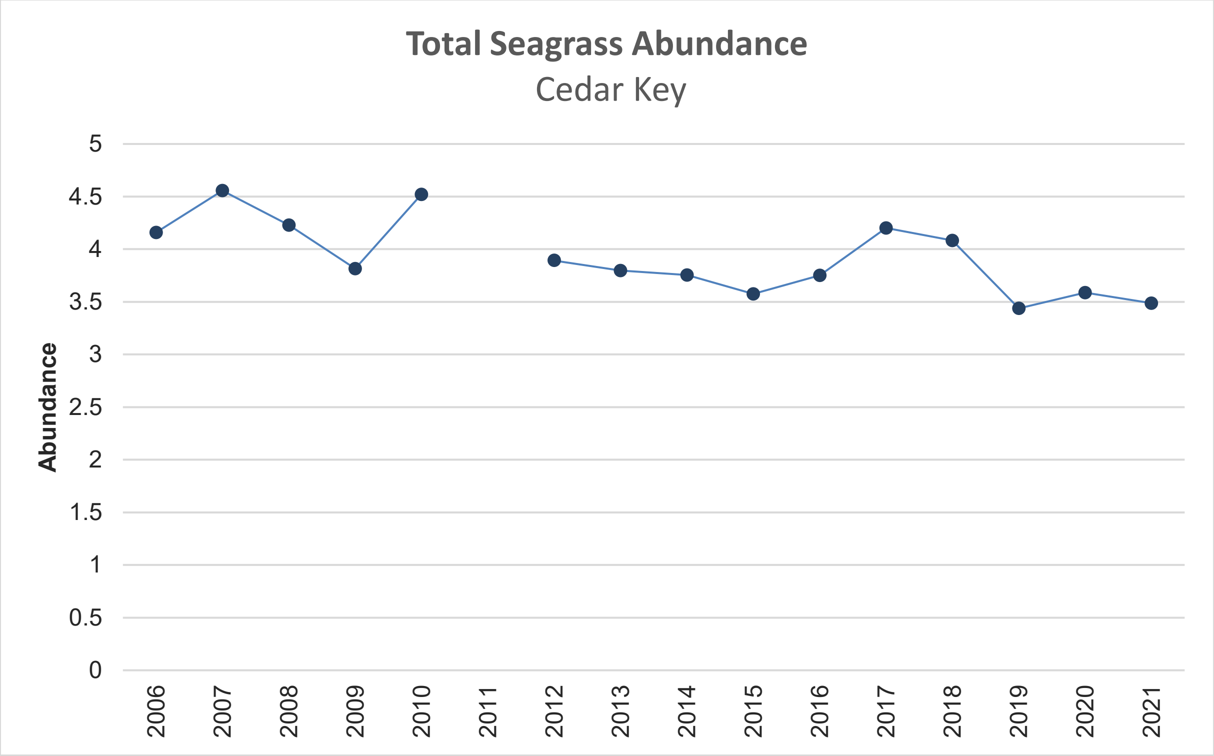

Figure 12. Overall abundance of all seagrass species combined over time in Cedar Key.

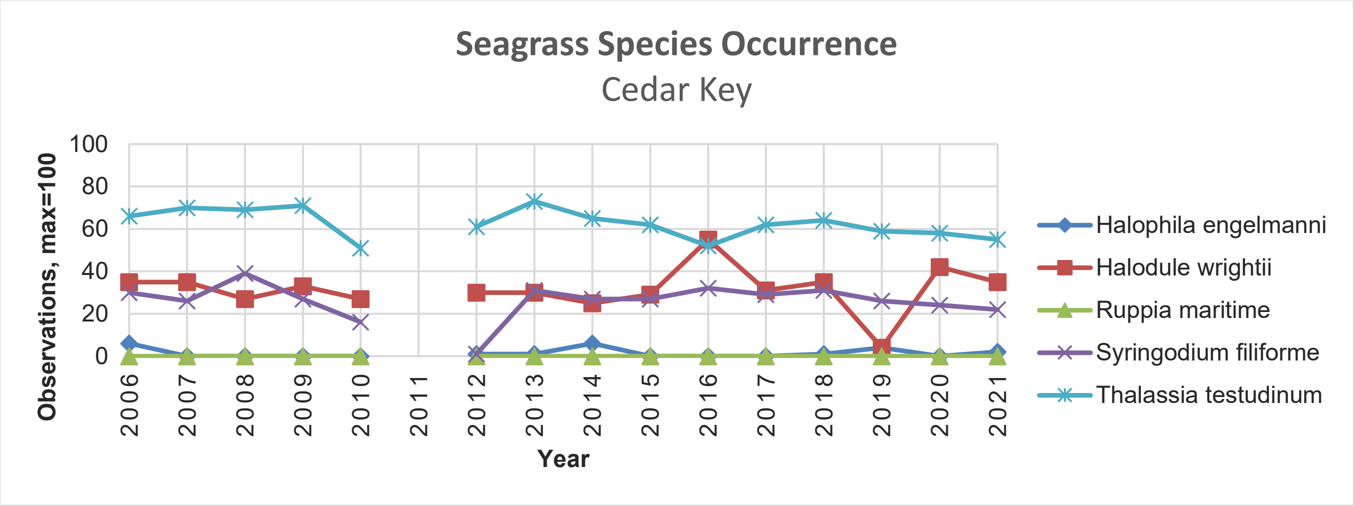

Figure 13. Number of times each seagrass species occurred in quadrats (max of 100) over time in Cedar Key.

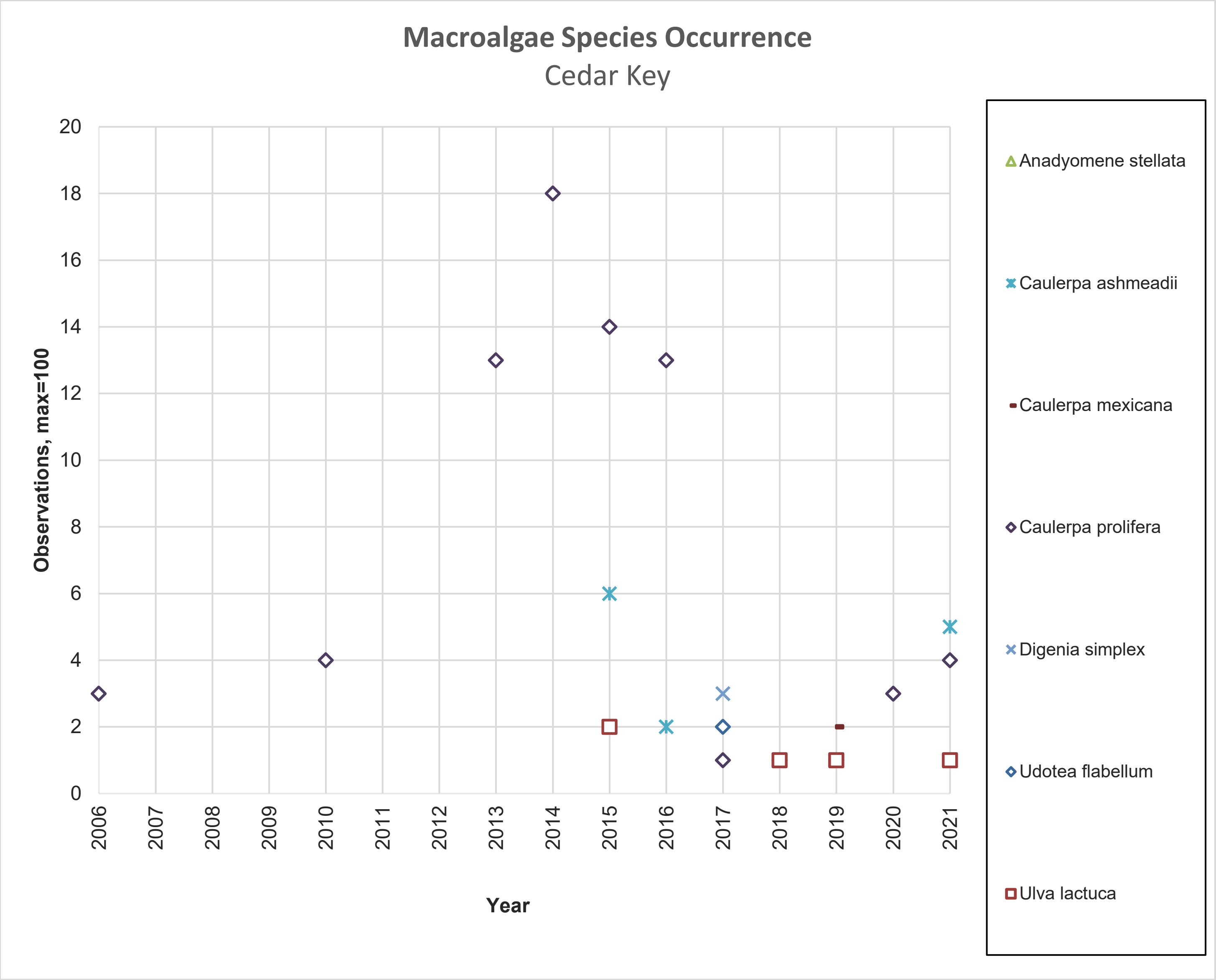

Figure 14. Number of times each macroalgae species was found in a quadrat (max = 100) over time in Cedar Key.

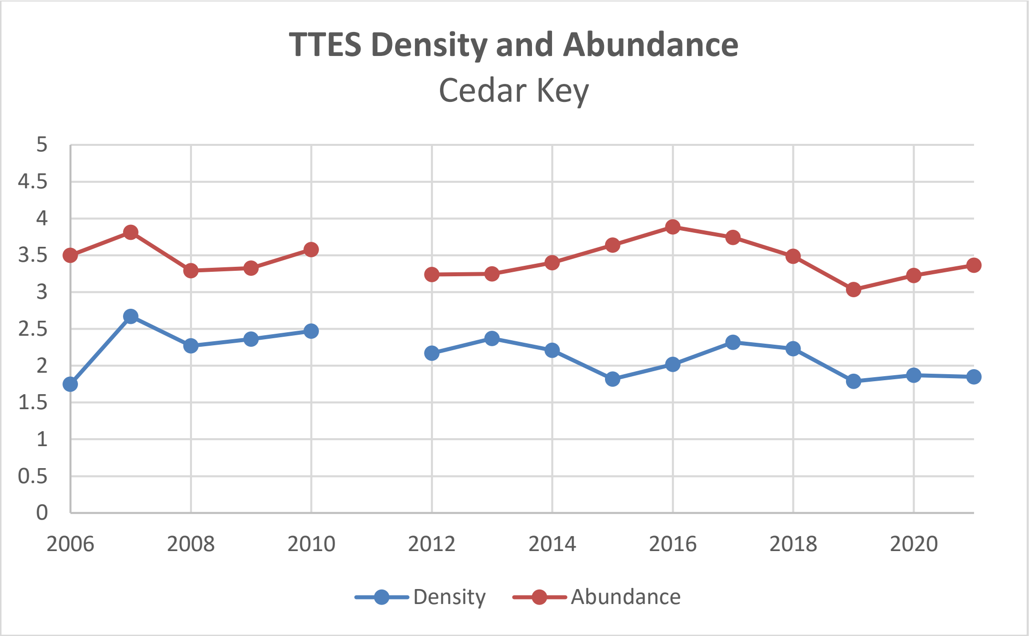

Figure 15. *Thalassia testudinum* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

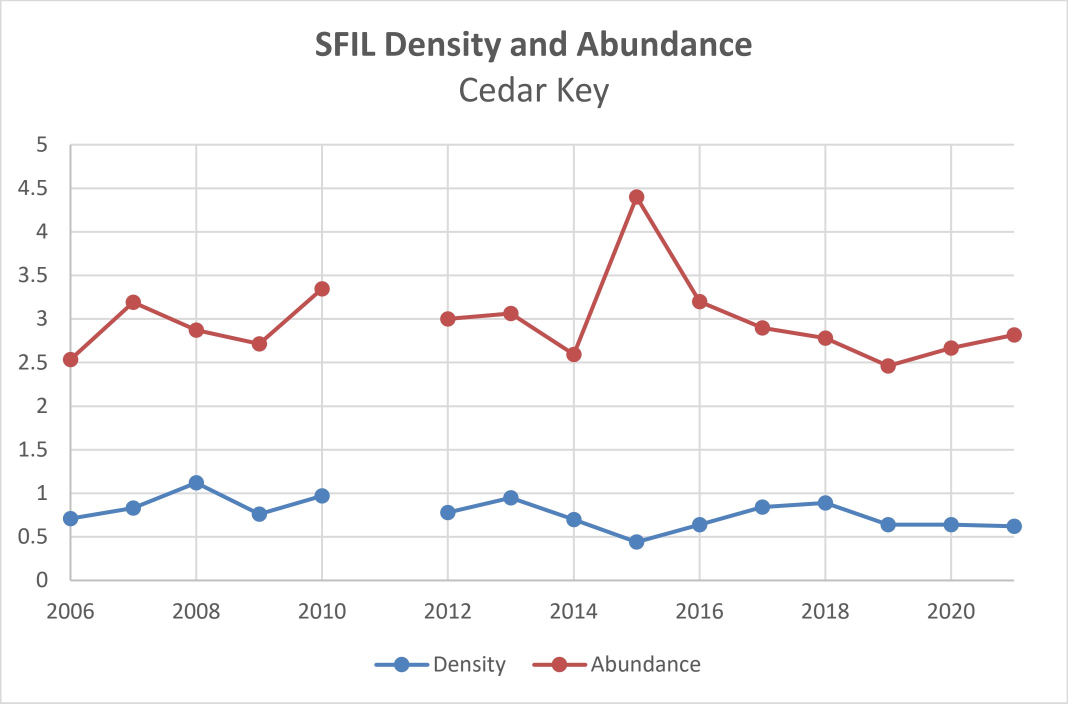

Figure 16. *Syringodium filiforme* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

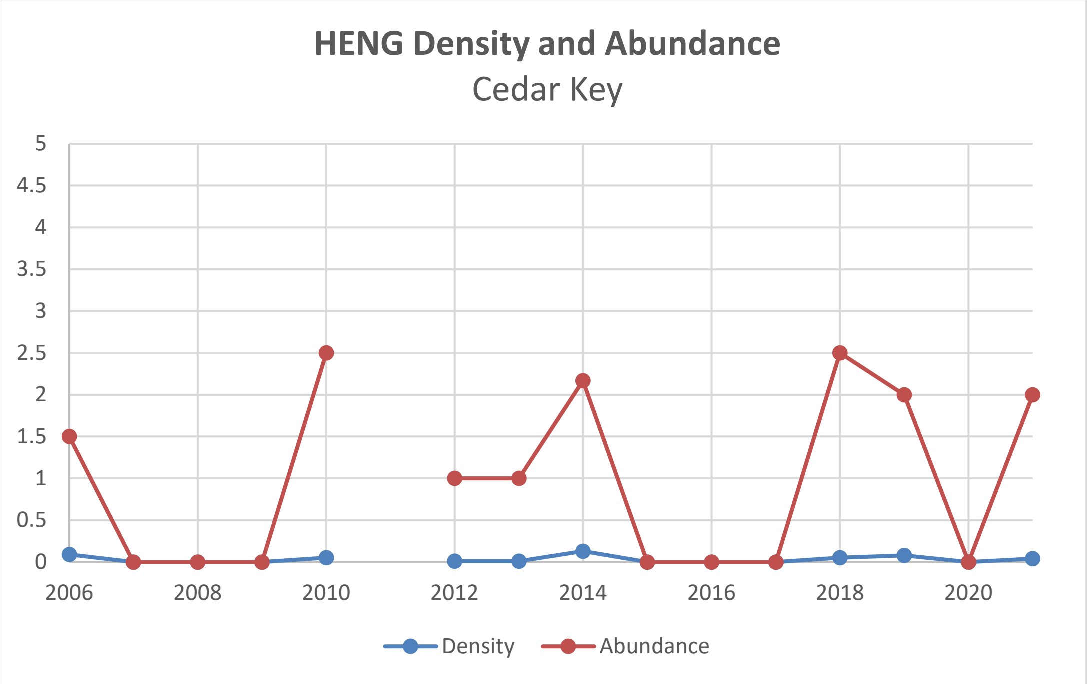

Figure 17. *Halophila engelmannii* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

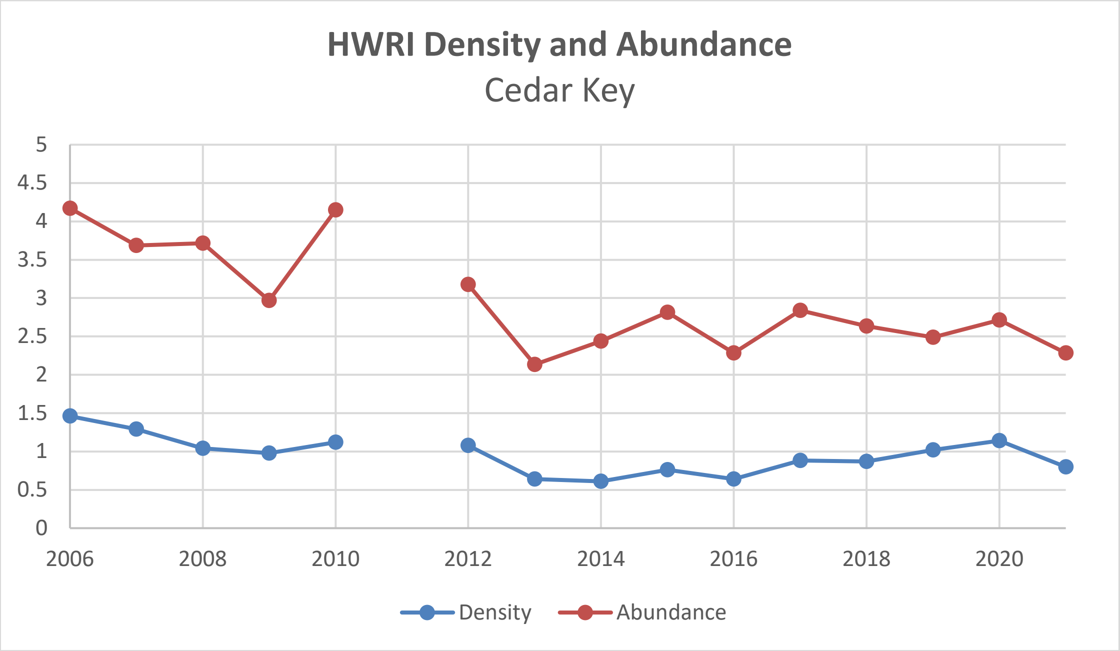

Figure 18. *Halodule wrightii* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

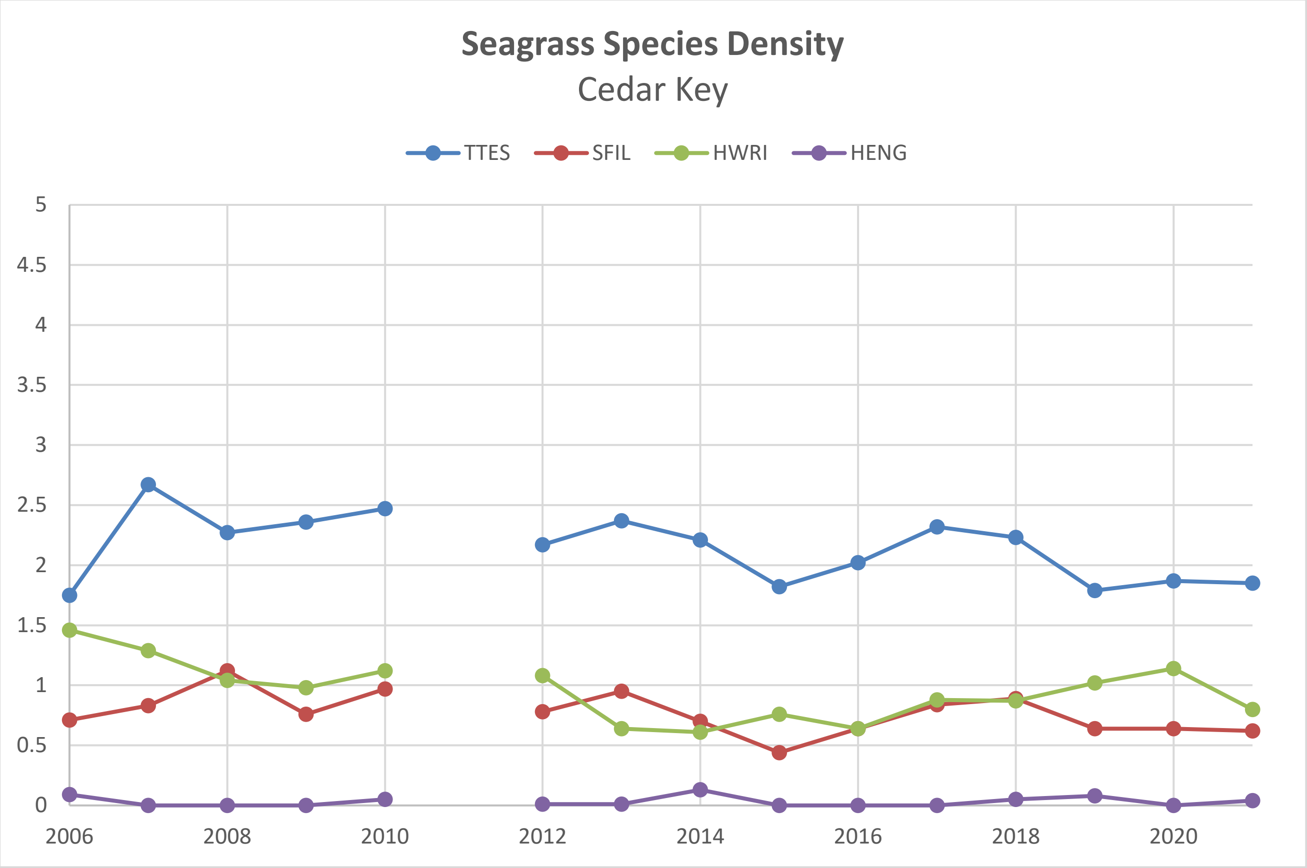

Figure 19. Individual seagrass species densities Cedar Key over time. Graph shows that *T. testudinum* is the densest seagrass species found in CK.

Steinhatchee

Submerged aquatic vegetation monitoring began in Steinhatchee in 2000. However, Braun-Blanquet scores were not recorded until 2003. No data was collected in 2005 due to lack of staff. Severe weather events prevented data collection in 2012 and 2015 due to significant tannic output from the Steinhatchee River, which resulted in a dark plume in the Gulf of Mexico.

Five species of seagrass and approximately 18 different species of macroalgae in Steinhatchee have been recorded. *T. testudinum* and *S. filiforme* are the most encountered species of seagrass; however, since 2010, *T. testudinum* has become the most dominant seagrass species (See Figure 29). *H. wrightii*, *H. engelmannii*, and *R. maritima* are observed occasionally, but not to the extent of the other seagrass species.

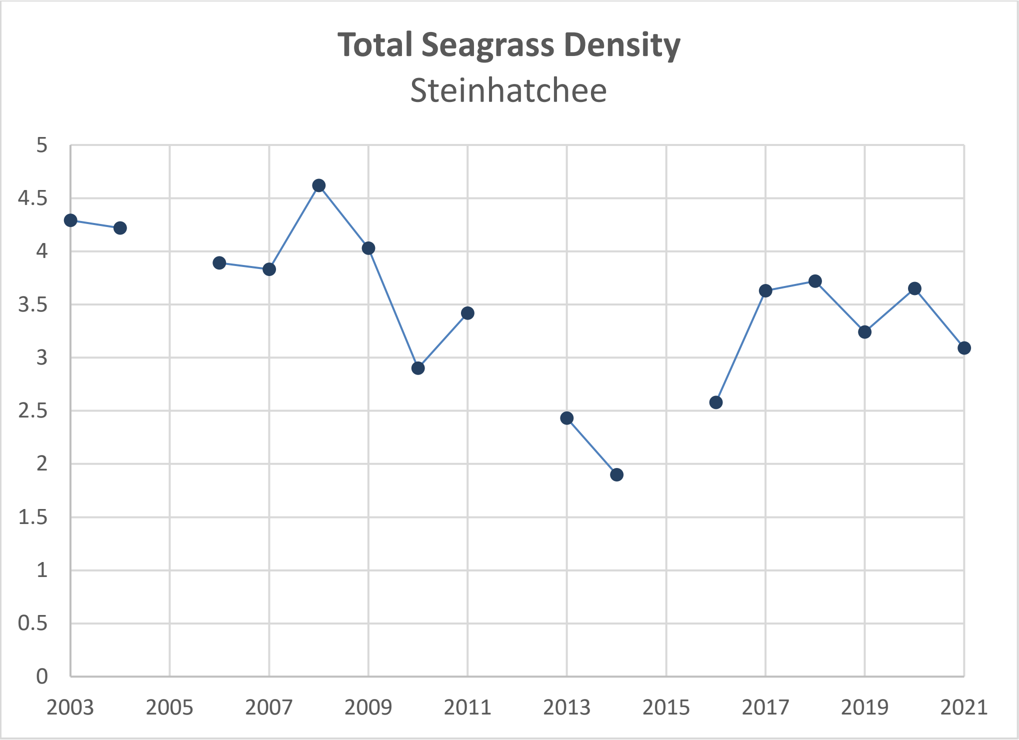

Figure 20. Overall seagrass density in Steinhatchee over the sampling years.

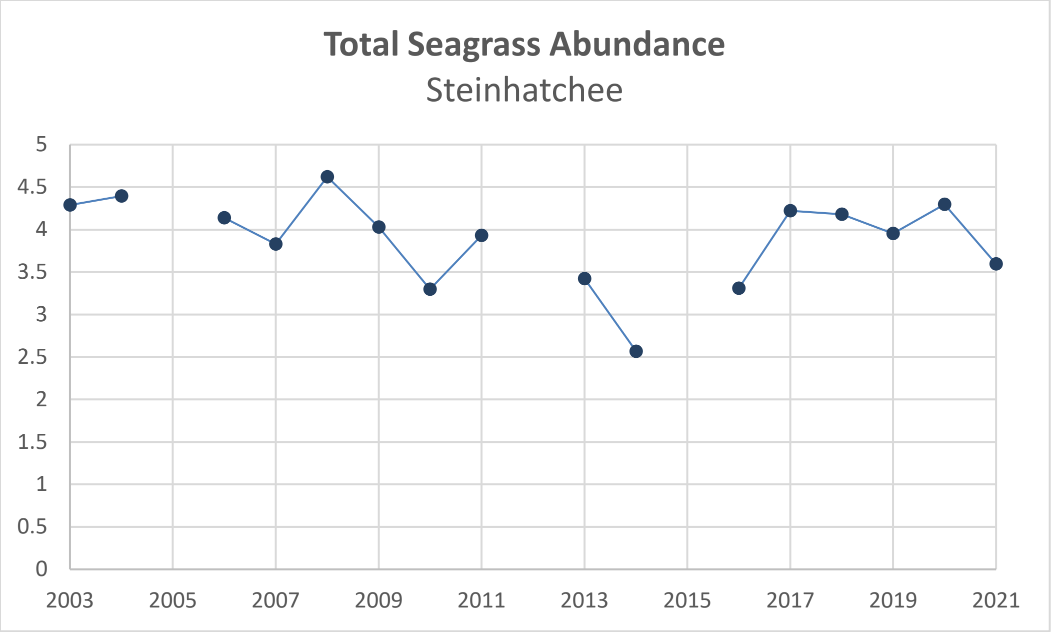

Figure 21. Overall seagrass abundance in Steinhatchee over the sampling years.

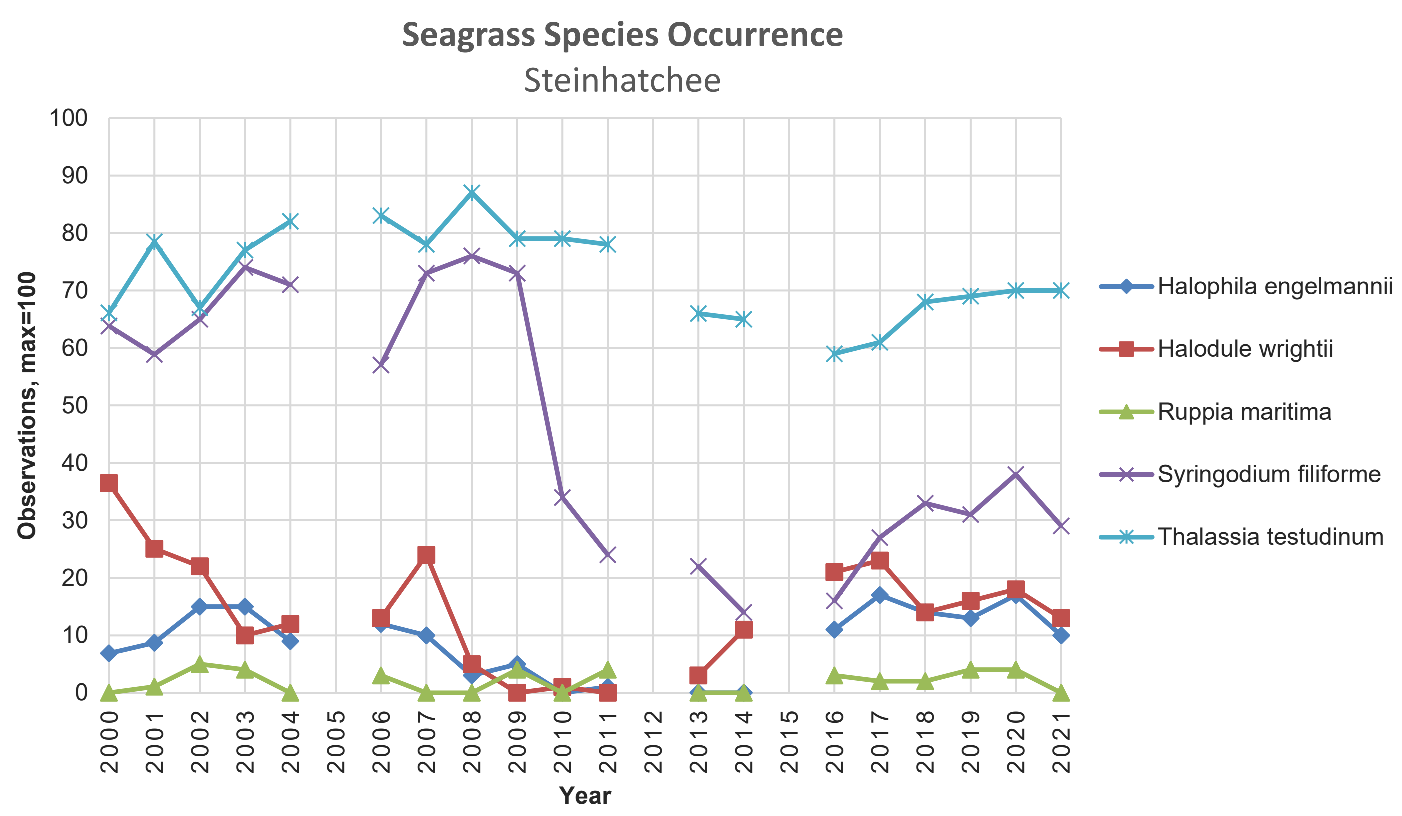

Figure 22. The number of times each species of seagrass occurred (max of 100) in Steinhatchee over time.

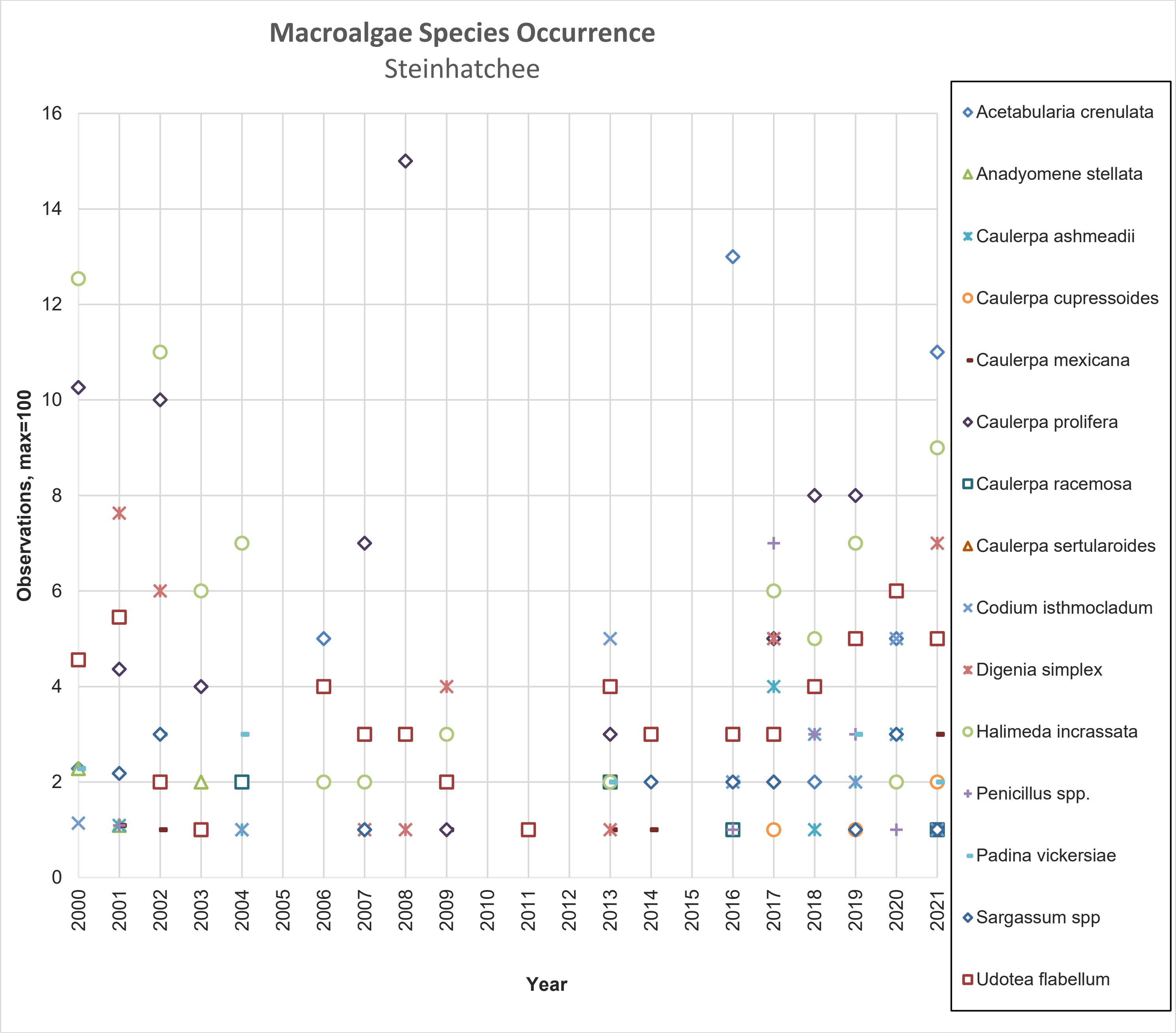

Figure 23. Number of times each macroalgae was observed at each site (max = 100) in Steinhatchee.

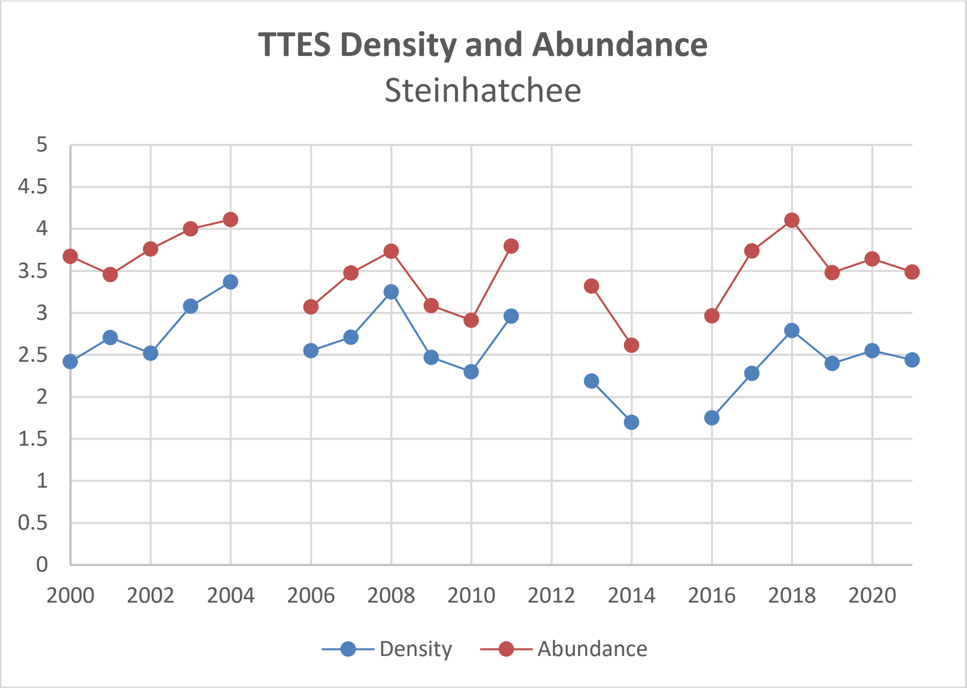

Figure 24. *Thalassia testudinum* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

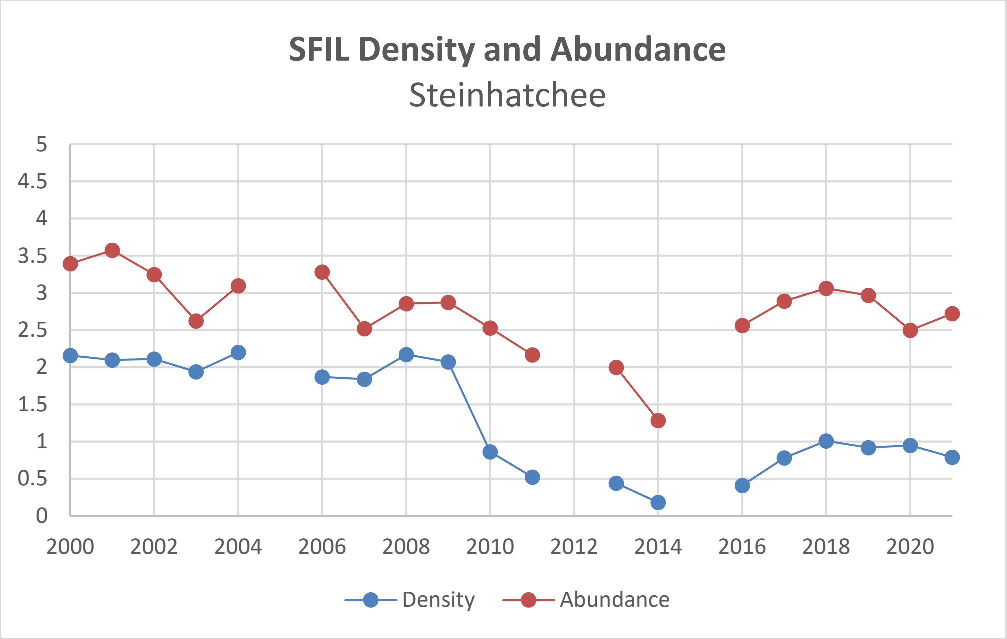

Figure 25. *Syringodium filiforme* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

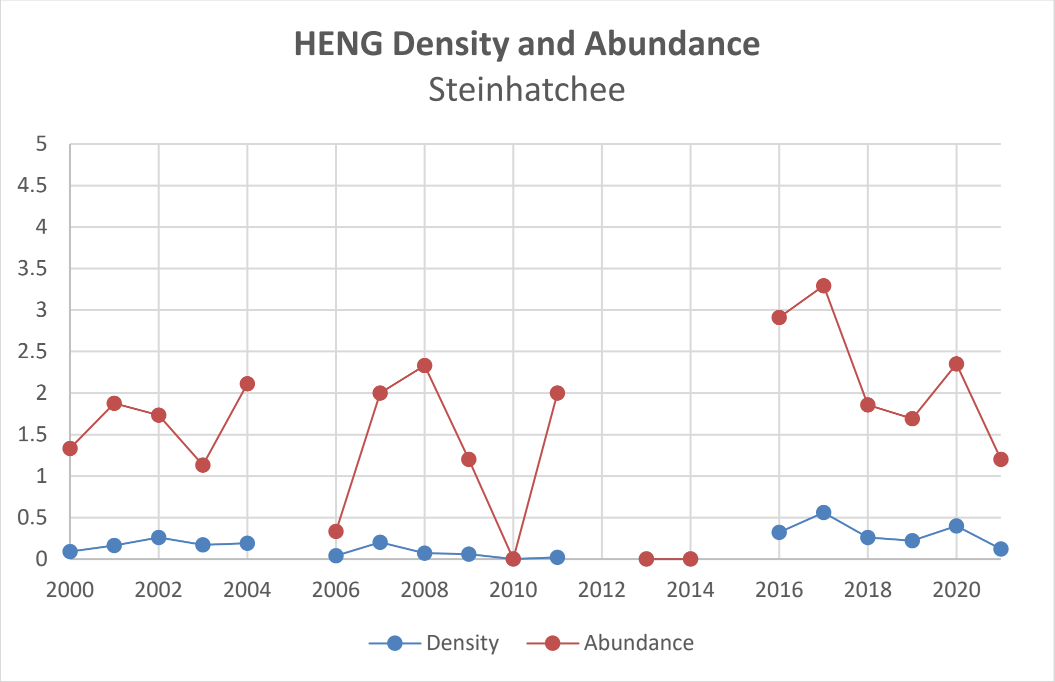

Figure 26. *Halophila engelmannii* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

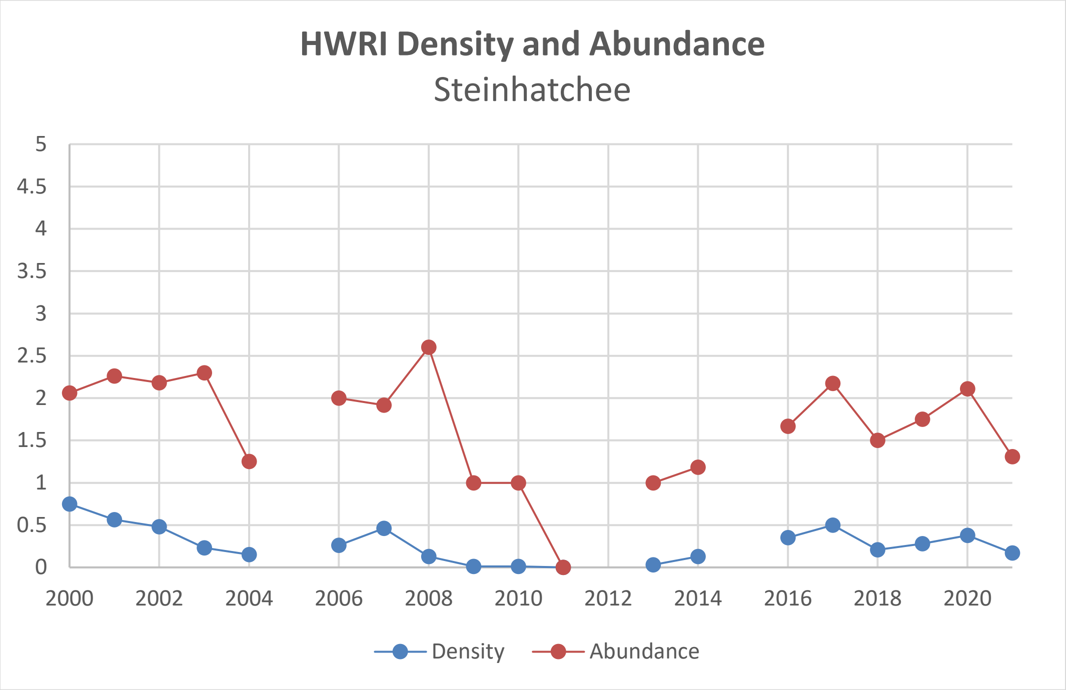

Figure 27. *Halodule wrightii* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

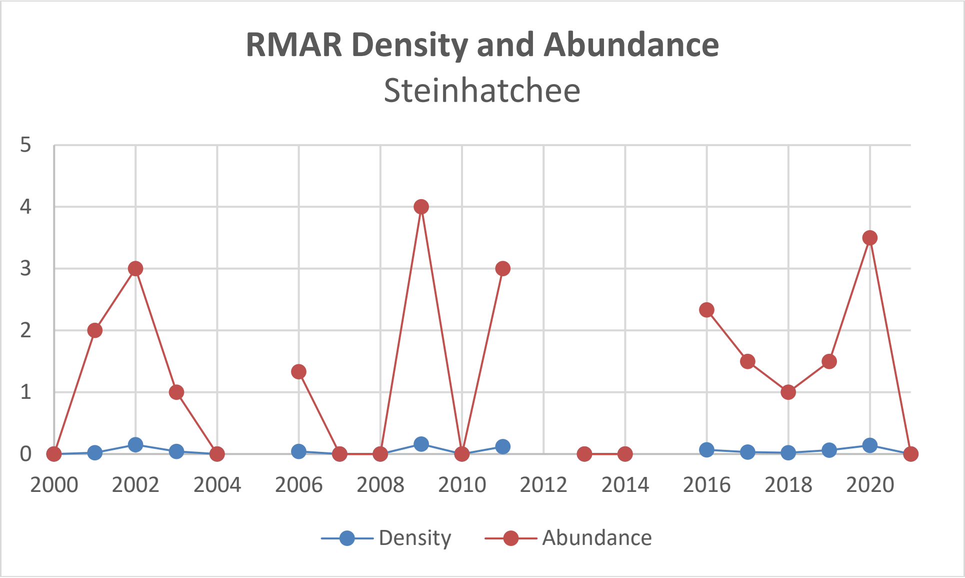

Figure 28. *Ruppia maritima* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

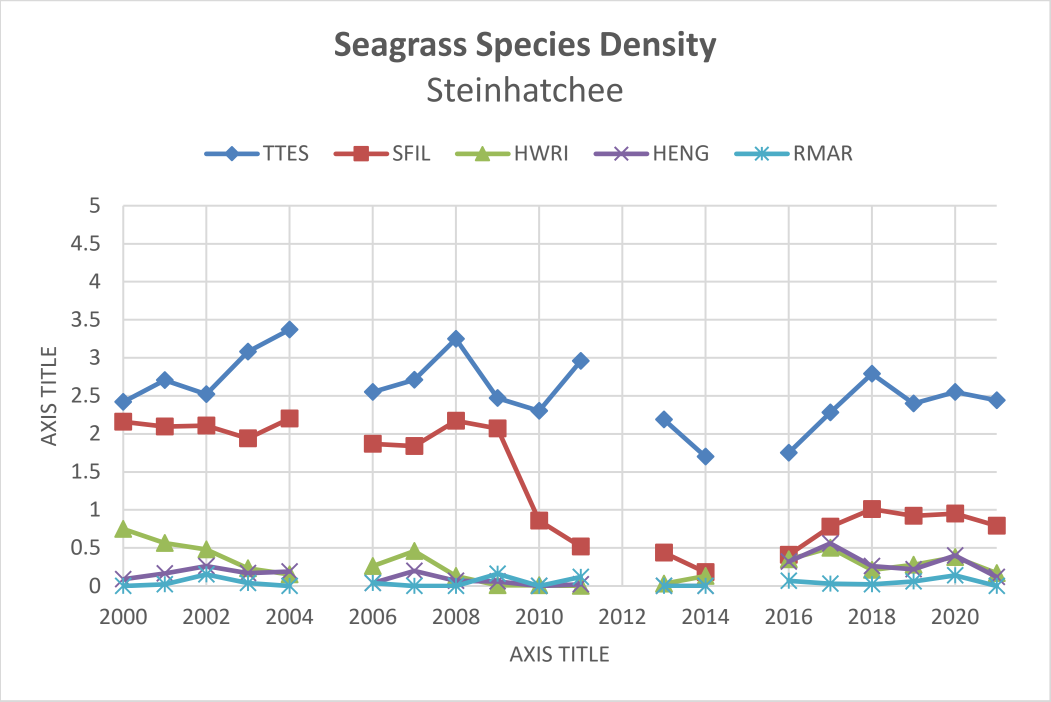

Figure 29. Individual seagrass species densities in Steinhatchee over time. Graph shows that *Thalassia testudinum* is the densest seagrass species found in STCH.

Dekle Beach/Keaton Beach

In order to develop a better understanding of seagrass occurrence and coverage within Big Bend Seagrasses Aquatic Preserve, an additional 25 monitoring sites were established in the Dekle Beach/Keaton Beach region in 2013. In 2017, these sites were redistributed to maximize sampling coverage of the area. Historical site coordinates for 2013-2016 are available upon request.

Due to insufficient staffing, monitoring did not occur in this region in 2016. *S. filiforme* and *T. testudinum* are the most common species of seagrass in DBKB; *H. engelmannii* and *H. wrightii* were sparsely observed (Figure 32). Interestingly, while *T. testudinum* has been the dominant species of seagrass at the other monitoring regions, *S. filiforme* was the dominant species of seagrass from 2013-2015 until it had a steep decline in 2016. In 2016, *T. testudinum* presented an increase, overtaking *S. filiforme* as the dominant seagrass species in DBKB. *Halimeda incrassata* was the most frequently encountered species of macroalgae. Other species of macroalgae that were recorded include *Acetabularia crenulata* and *Caulerpa paspaloides* (Figure 33). Drift algae was encountered and documented at most sites; however, since it is not attached to the sea floor, it is not included in the total SAV or total coverage BB scores.

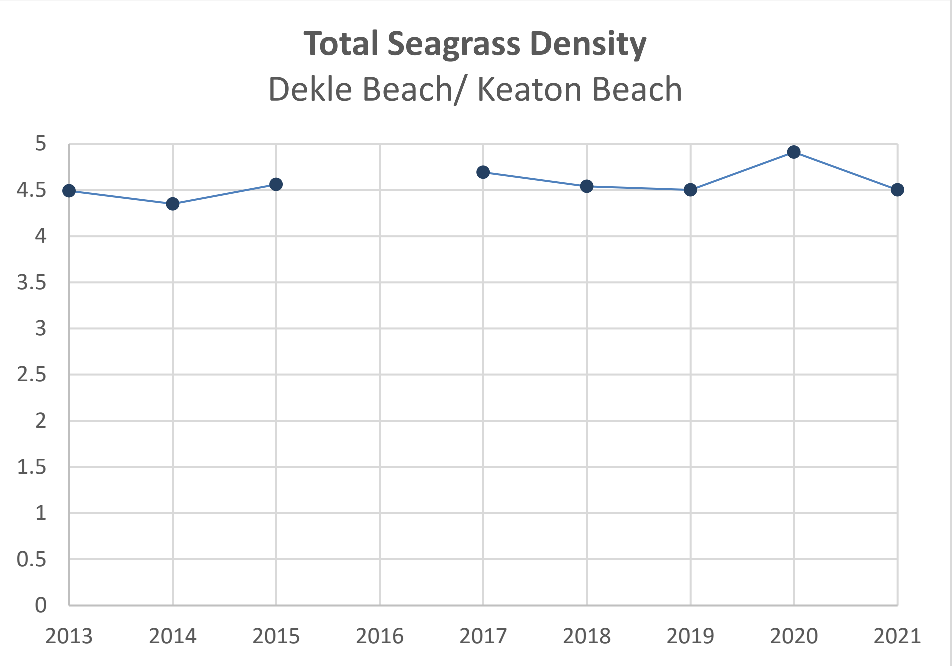

Figure 30. Graph of all seagrass species density combined over time in Dekle Beach/Keaton Beach.

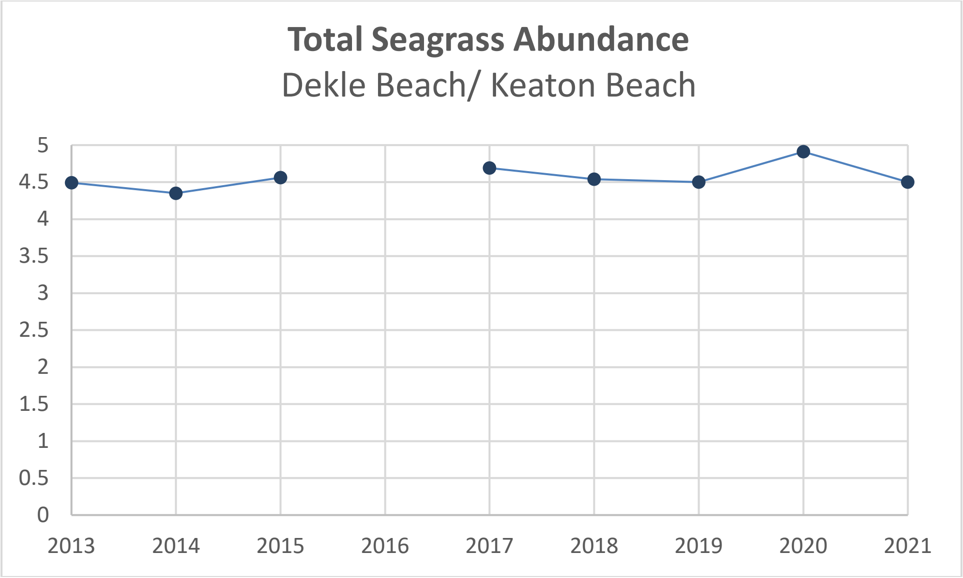

Figure 31. Graph of all seagrass species abundance combined over time in Dekle Beach/Keaton Beach.

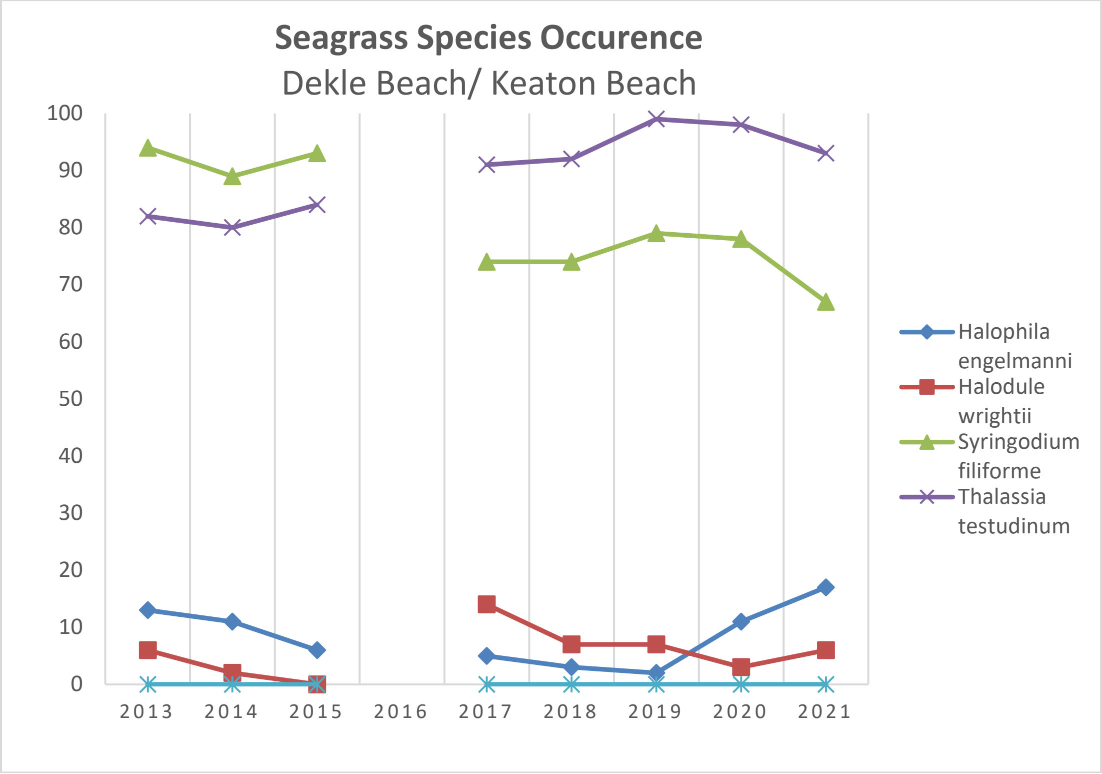

Figure 32. Graph of all seagrass species occurrence (max = 100) over time in Dekle Beach/Keaton Beach.

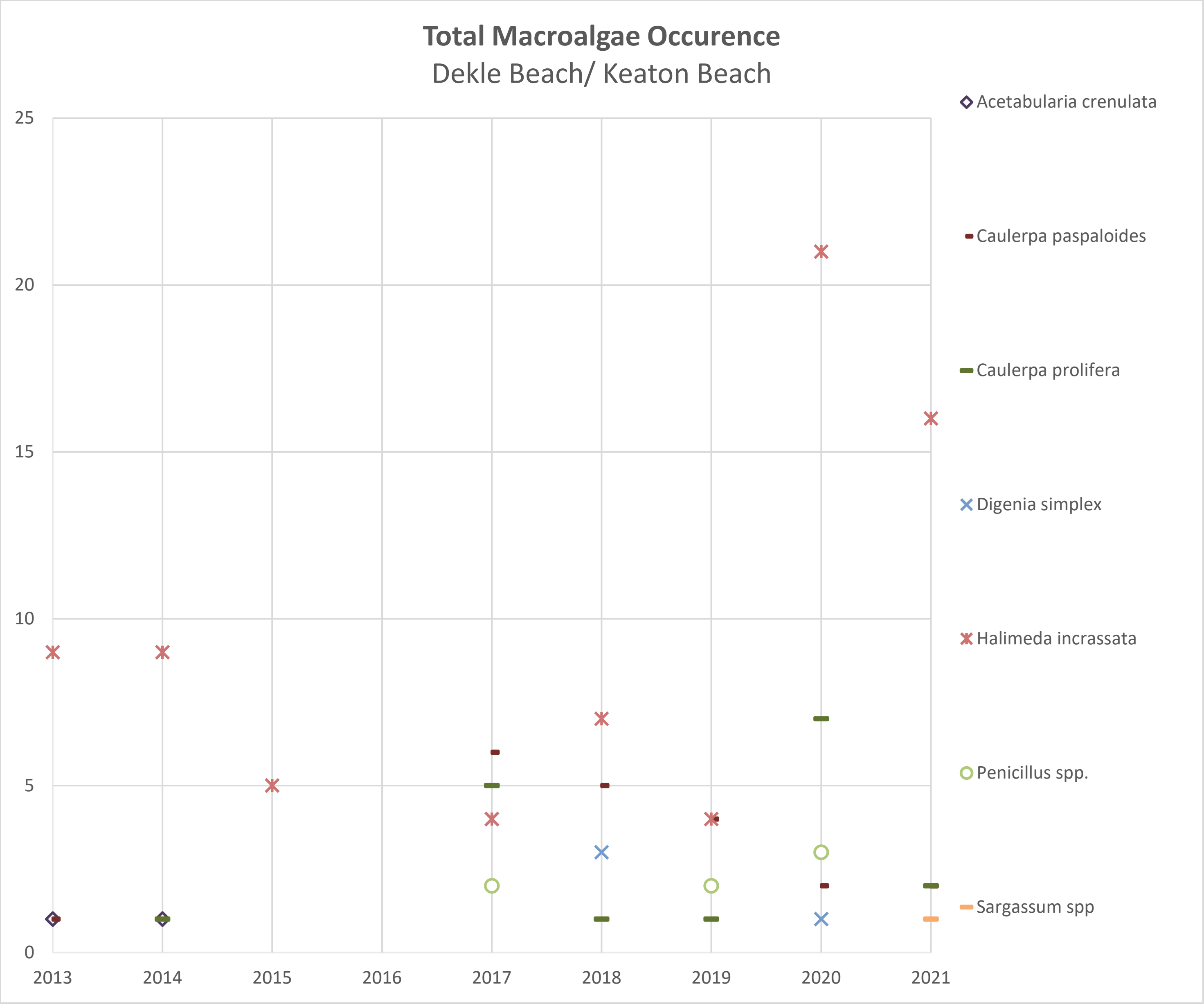

Figure 33. Graph of all macroalgae species occurrence (max = 100) over time in Dekle Beach/Keaton Beach.

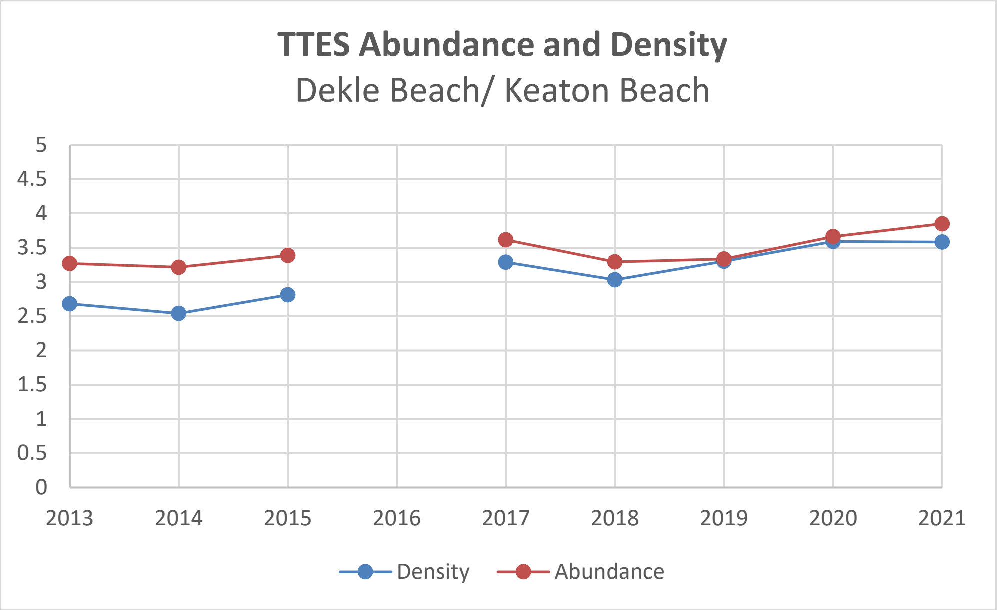

Figure 34. *Thalassia testudinum* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

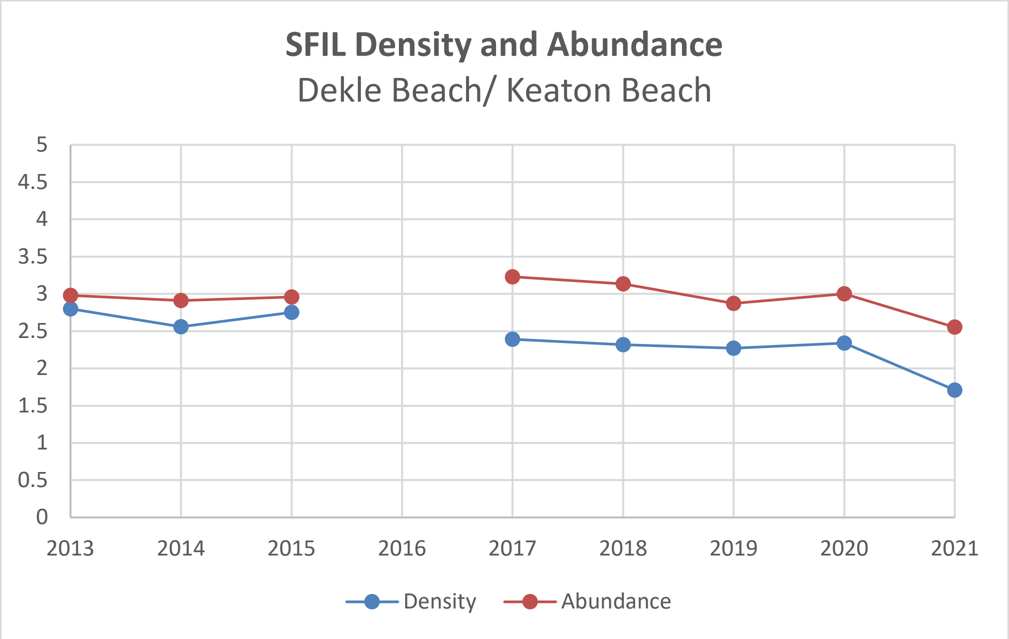

Figure 35. *Syringodium filiforme* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

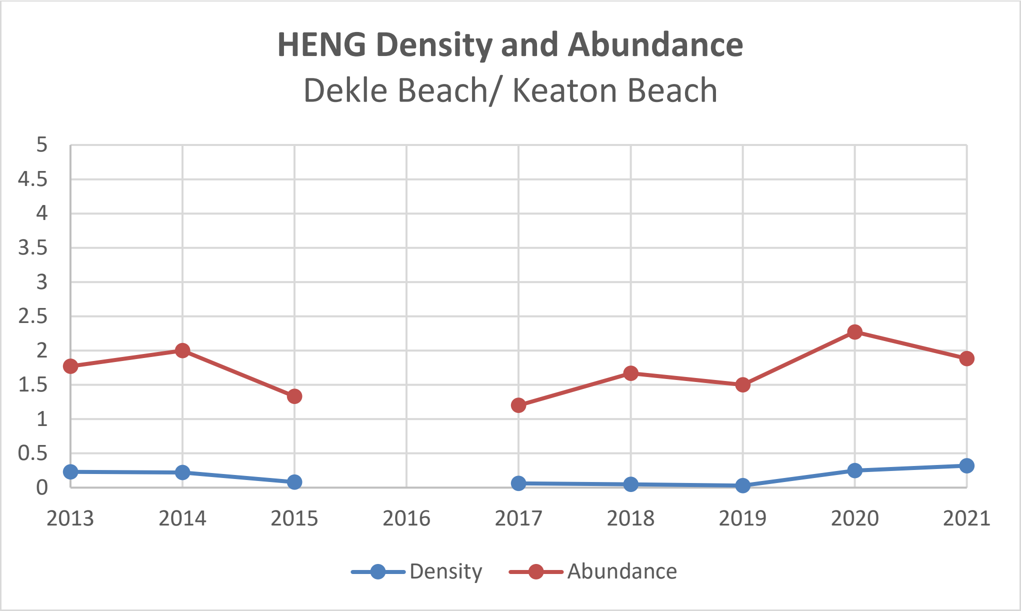

Figure 36. *Halophila engelmannii* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

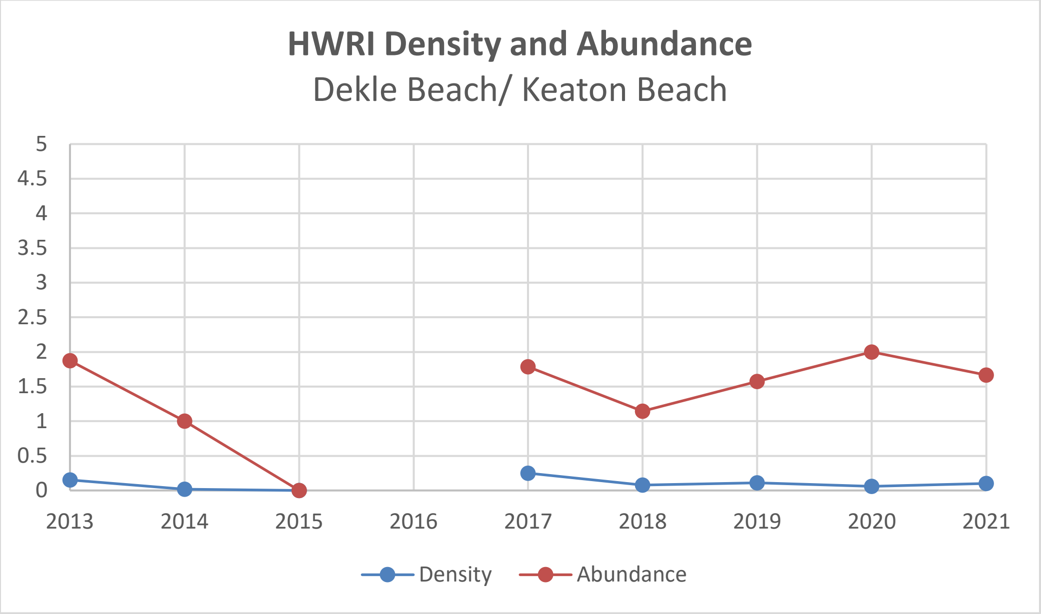

Figure 37. *Halodule wrightii* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

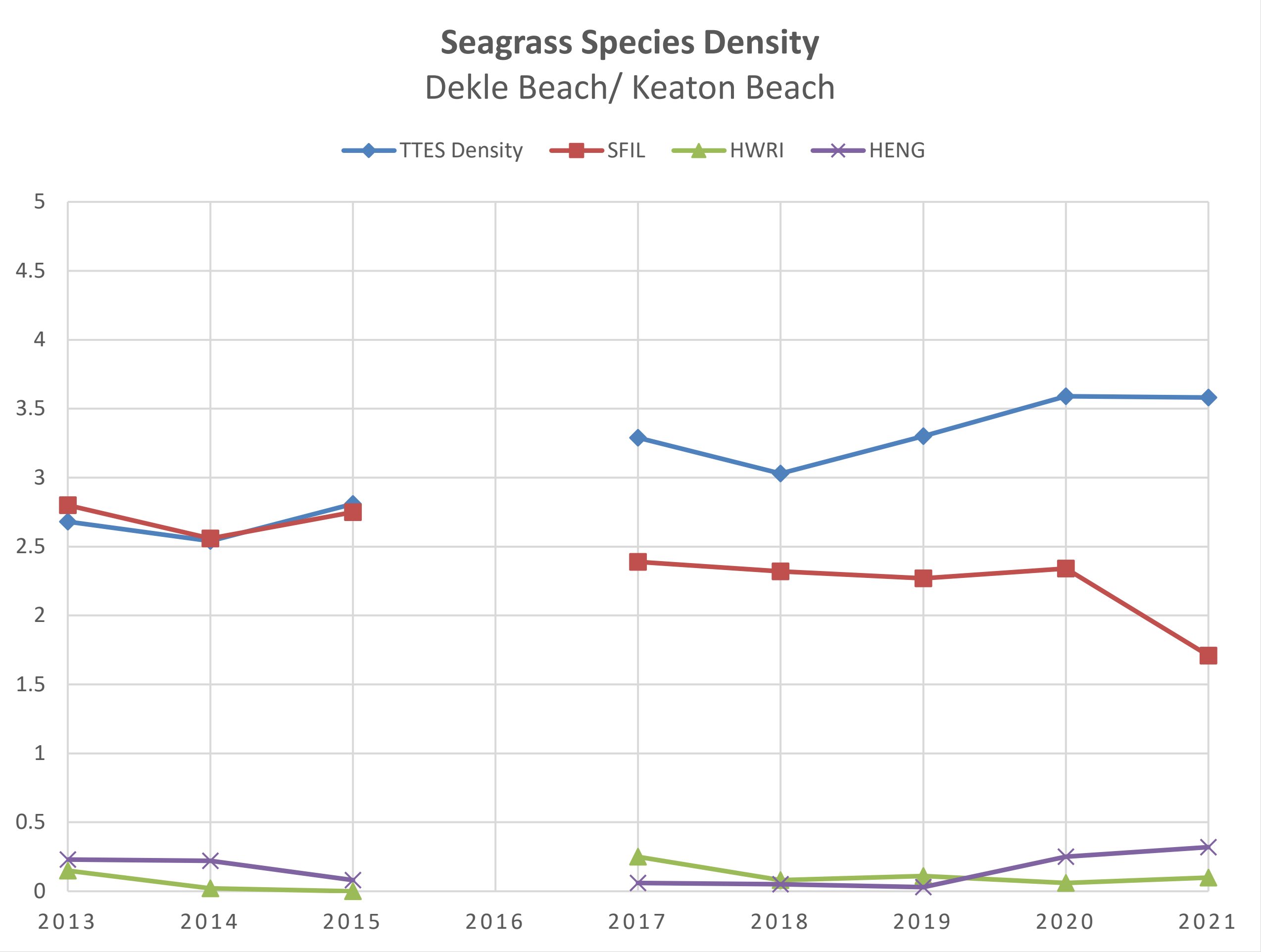

Figure 38. Individual seagrass species densities in Dekle Beach/Keaton Beach over time. Graph shows that *T. testudinum* is the densest seagrass species found in DBKB. *R. maritima* has not been observed in DBKB.

St. Marks

Submerged aquatic vegetation monitoring began in St. Marks in 2006. No data was collected in 2012 and 2013 due to the presence of heavy rains and intense tropical weather; output from the St. Marks, Wakulla, Wacissa, and Ecofina Rivers created a dark plume in the Gulf of Mexico, and the dark water prevented staff from completing sampling. Staff have documented four species of seagrass and twelve species of macroalgae in St. Marks.

T. testudinum and *S. filiforme* are the most encountered species of seagrass in St. Marks with *T. testudinum* as the dominant species (See Figure 48). *H. wrightii* and *H. engelmannii* have been observed every year, but not to the extent of the other two grasses. Additionally, the observed trend for *H. engelmannii* was in decline from 2006 to 2011. This trend reversed in 2015, and *H. engelmannii* was observed more than *H. wrightii* as of 2018 monitoring. *R. maritima* was documented for the first time in 2018 at a site located near shore.

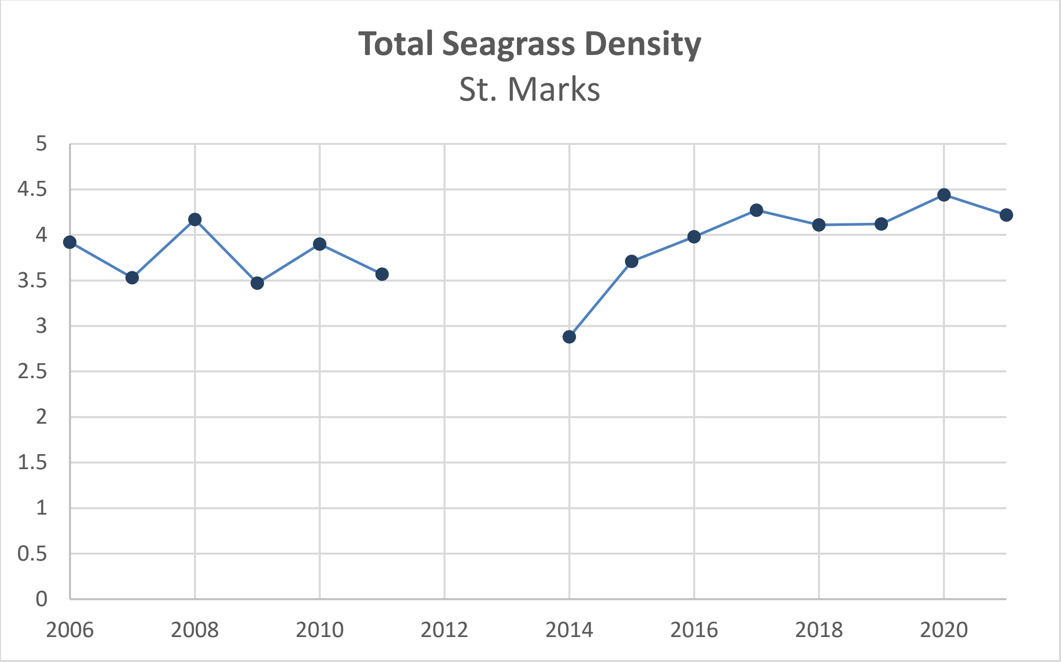

Figure 39. All seagrass species density combined for all sites in St. Marks over time.

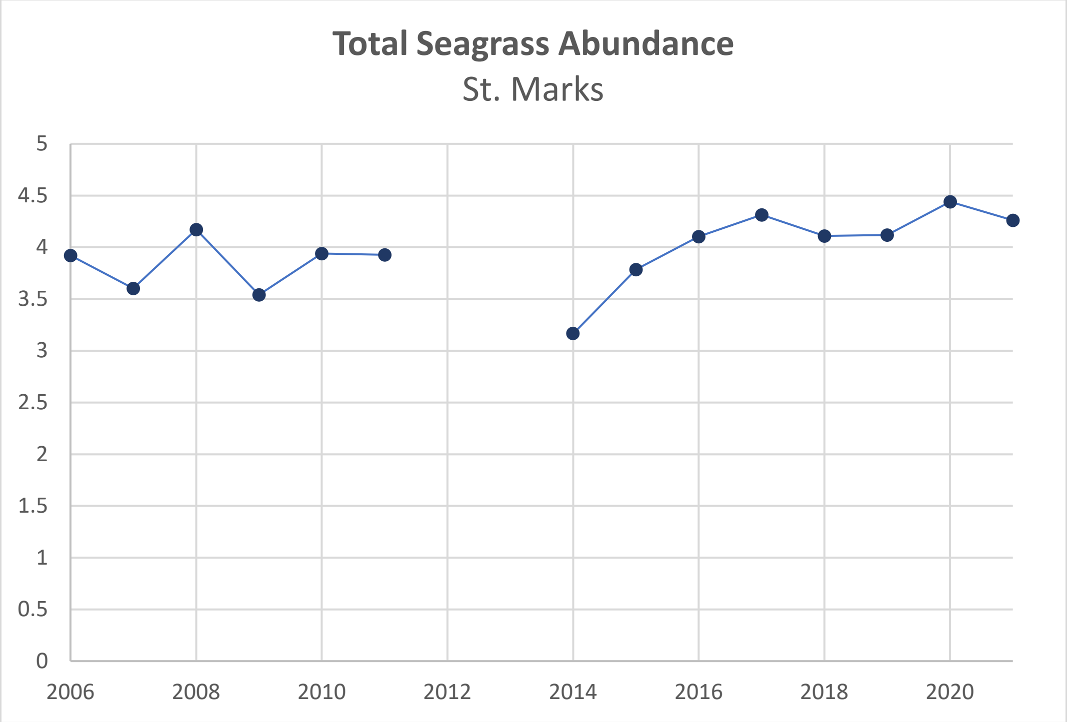

Figure 40. All seagrass species abundance combined for all sites in St. Marks over time.

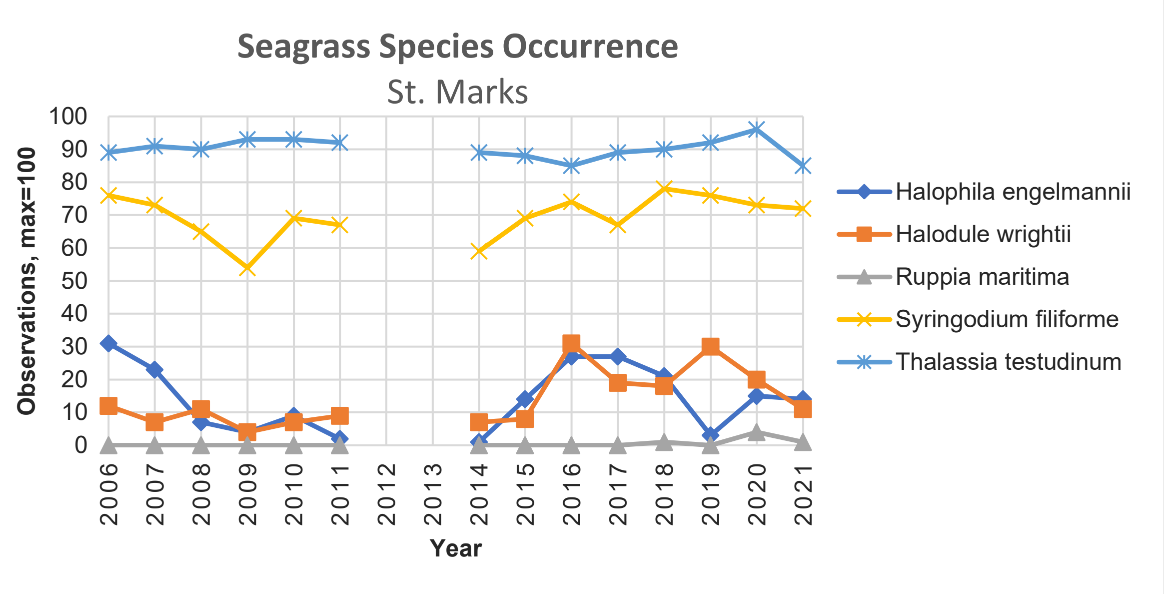

Figure 41. Graph of all seagrass species occurrence (max = 100) over time in St. Marks.

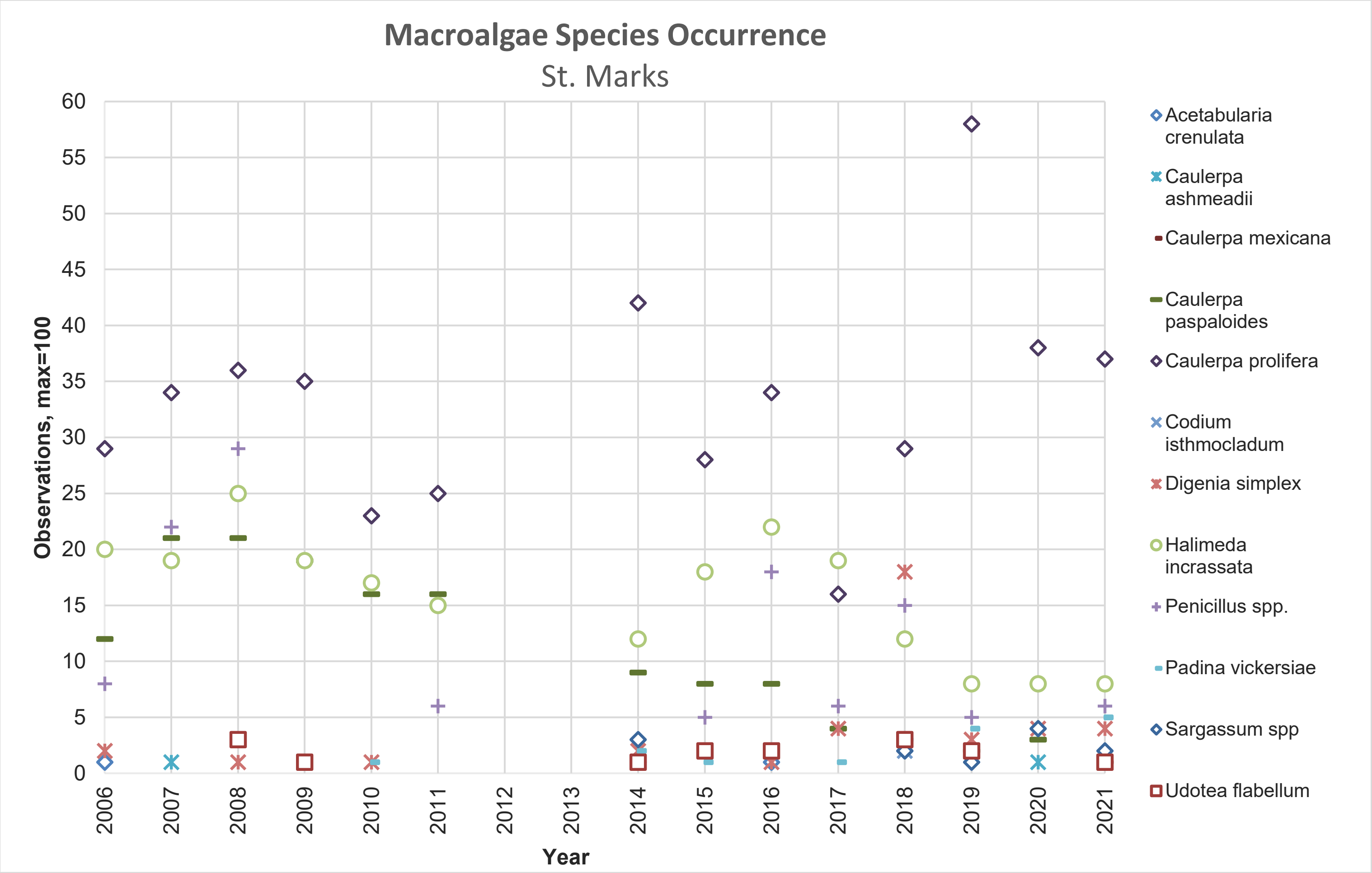

Figure 42. Graph of all macroalgae species occurrence (max = 100) over time in St. Marks.

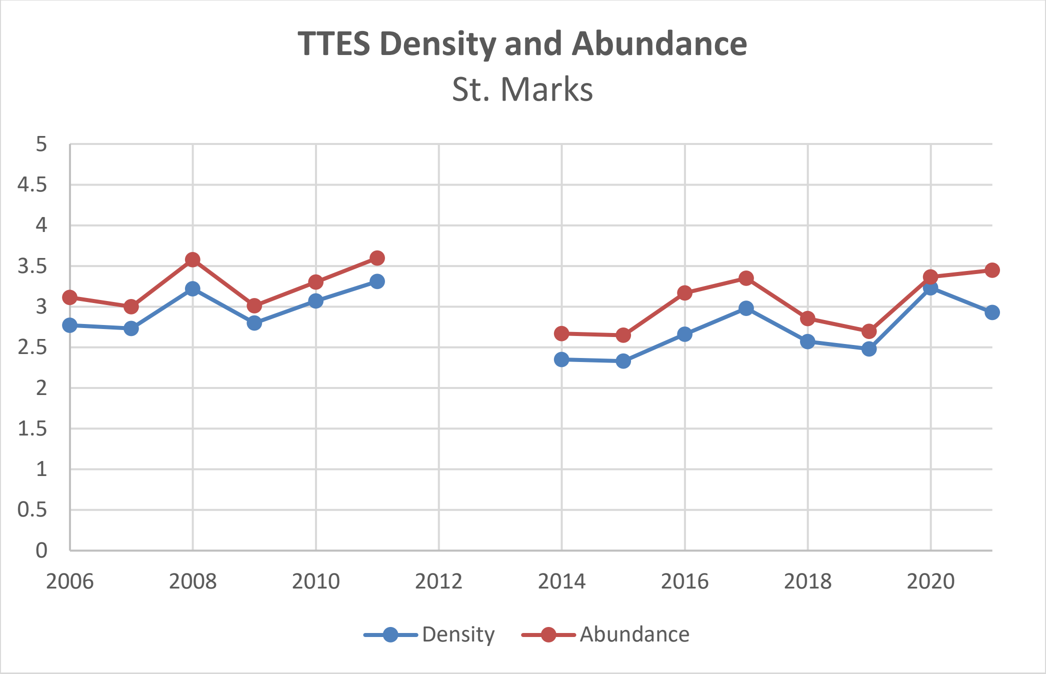

Figure 43. *Thalassia testudinum* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

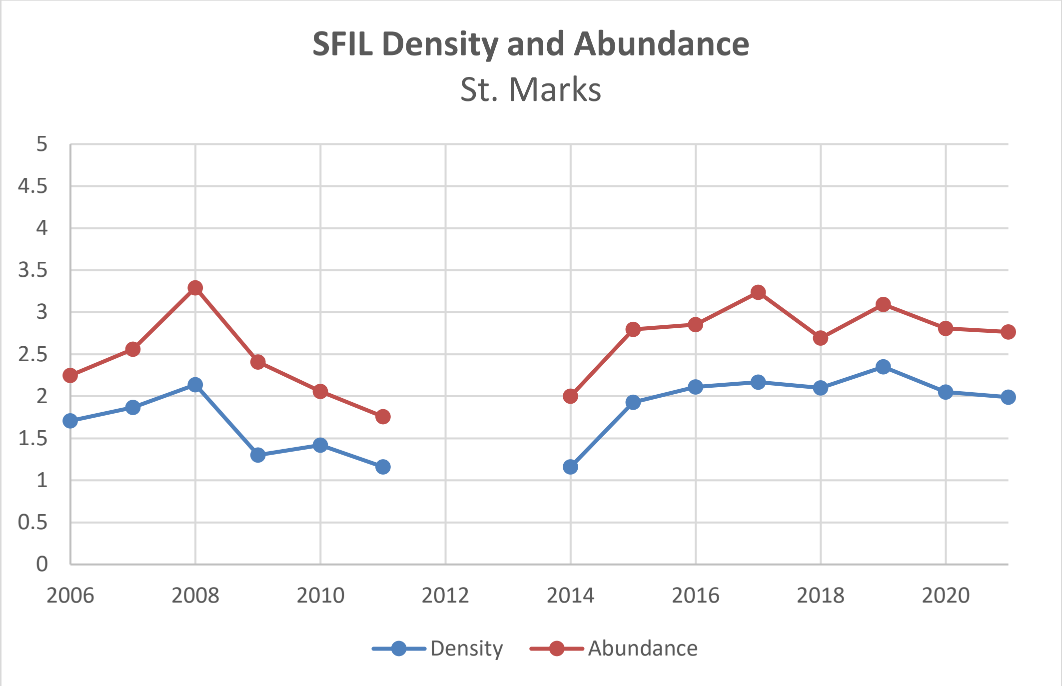

Figure 44. *Syringodium filiforme* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

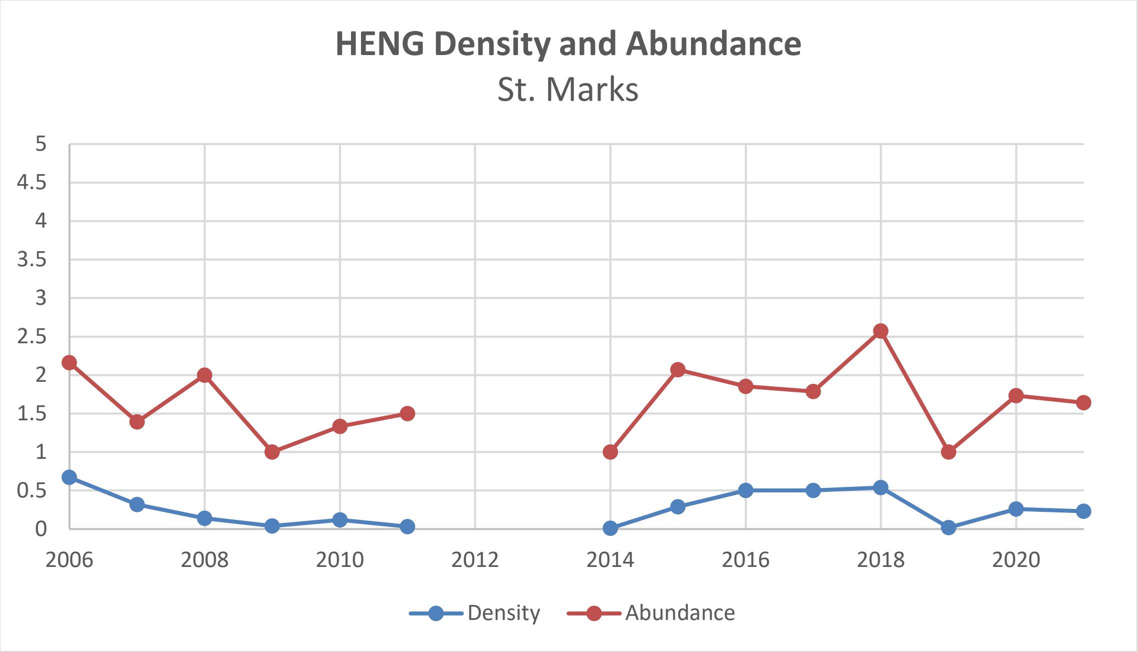

Figure 45. *Halophila engelmannii* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

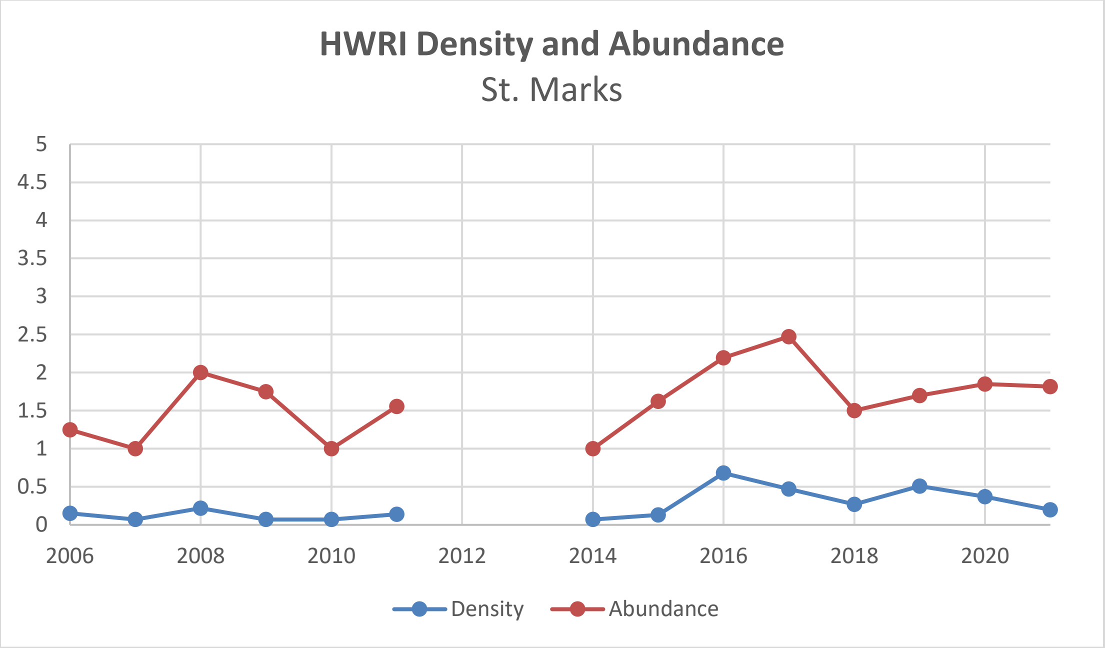

Figure 46. *Halodule wrightii* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

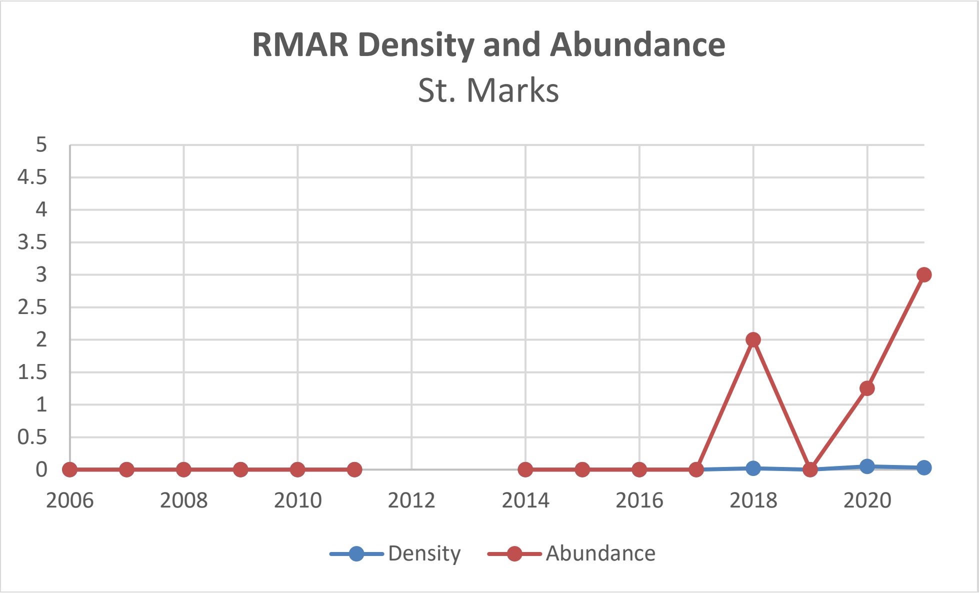

Figure 34. *Ruppia maritima* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

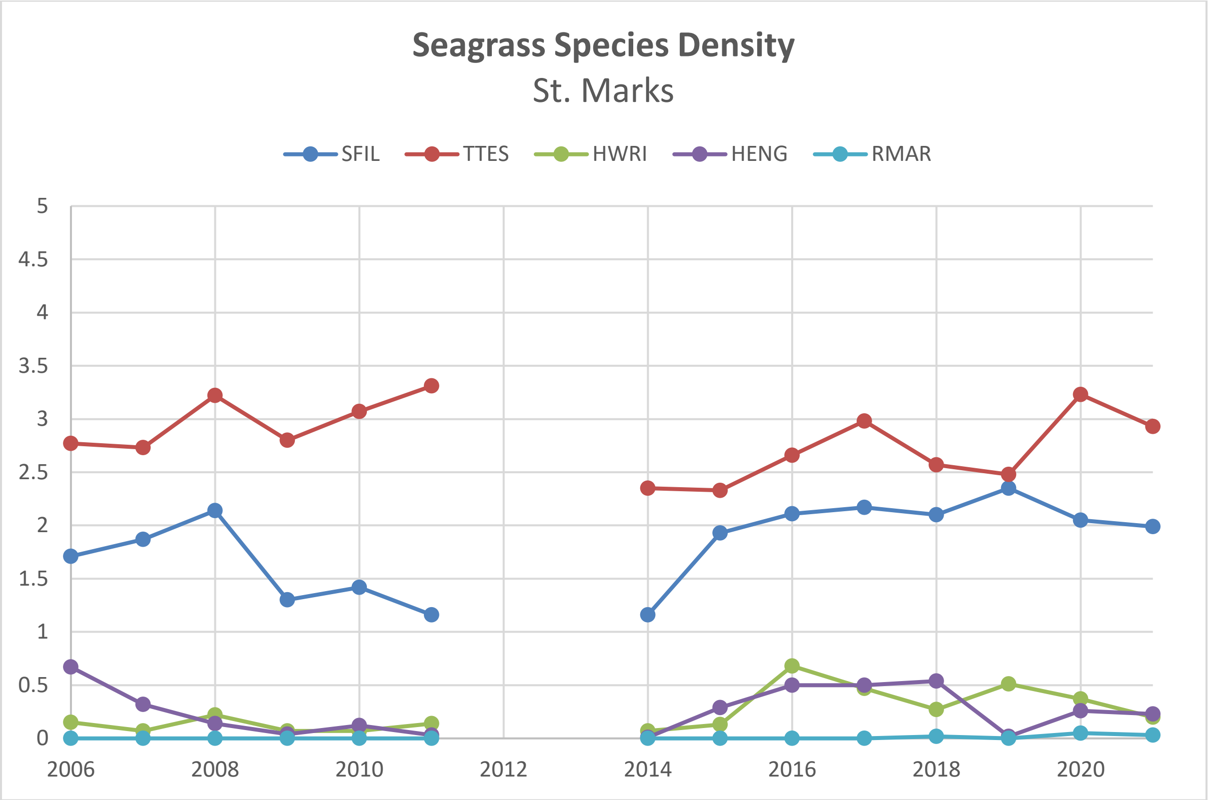

Figure 38. Individual seagrass species densities in SMAR over time. Graph shows that *T. testudinum* is the densest seagrass species found in St. Marks.

Discussion

St. Martins Marsh

There are no notable trends in St. Martins Marsh for the overall seagrass density and abundance from 1997 through 2021. Although, when looking at the data for seagrass density and abundance from the last five years, 2017 through 2021, there is a decline in overall density, but it is not statistically significant (R value= -0.724, p value= 0.16). Seagrass abundance also exhibits a decline over the last five years; however, it is not statistically significant (R = -0.670, p-value= 0.19). The overall seagrass data has a high p-value and cannot be considered statistically significant however, this should be closely monitored over the next few years to observe if seagrass density and abundance continue to decline in St. Martins Marsh. If needed, management actions should be adjusted to reduce these impacts. There is a significant decline of *S. filiforme* over the last ten years in SID (Figure 39).

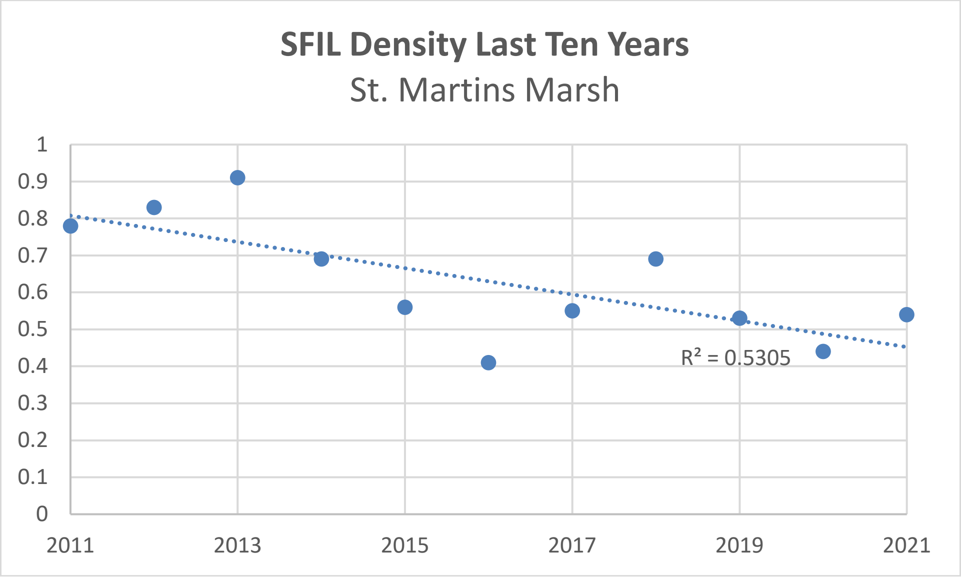

Figure 39. Over the last ten years SFIL in SID has been experiencing a strong negative association (R= -0.72, R^2= 0.531, p-value= 0.025). This data supports a significant decline in SFIL at St. Martins Marsh in the last ten years.

Cedar Key

Hurricanes are a major driver of change in coastal water systems, both from physical disturbance and changes in water quality. Cedar Key is often impacted by hurricanes and tropical storms during the Atlantic hurricane season (Table 9), leaving the seagrass beds susceptible to direct and indirect impacts of storms such as erosion, strong wave energy, and changes in water quality from increased rainfall and turbid run-off (Wilson, 2020). Each storm has unique effects on the area and the species, as each storm has different windspeeds, rainfall, and tracks. Not all areas within the same region may experience similar changes from the same storm, as some sites may experience more loss than others. However, hurricanes and other storms may be a main driver of overall seagrass density loss over time as seen in Cedar Key (Figure 40) and should be closely monitored. With Cedar Key's primarily sandy substrate, several wash-over events have been observed during post-hurricane assessments. Seagrass can be buried under several inches of washed-over sand making photosynthesis and blade growth difficult.

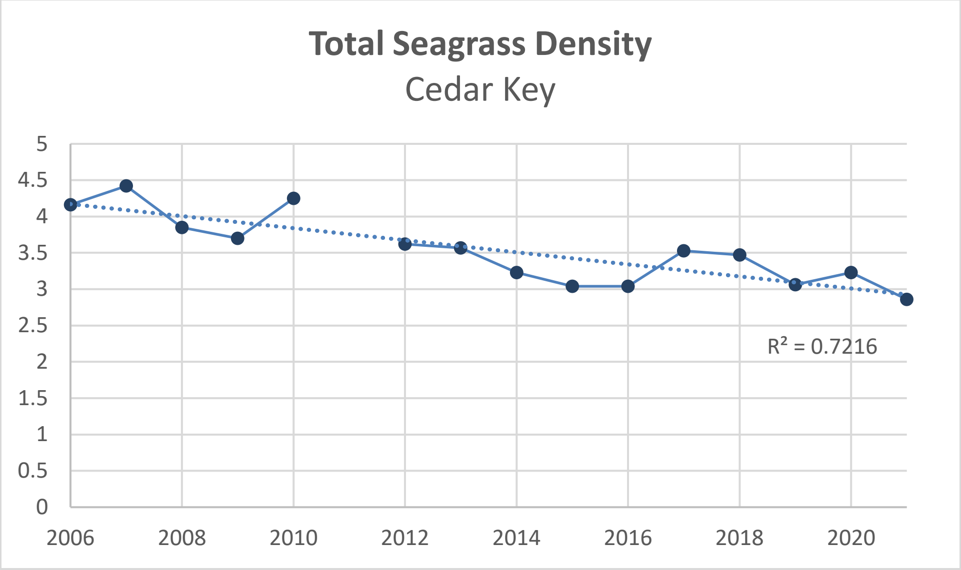

Figure 40. Cedar Key total seagrass density has a very strong negative association over time (R = -0.849, R^2= 0.722, p-value= 0.000287). This data supports a very significant decline of seagrass density in Cedar Key from 2006-2021.

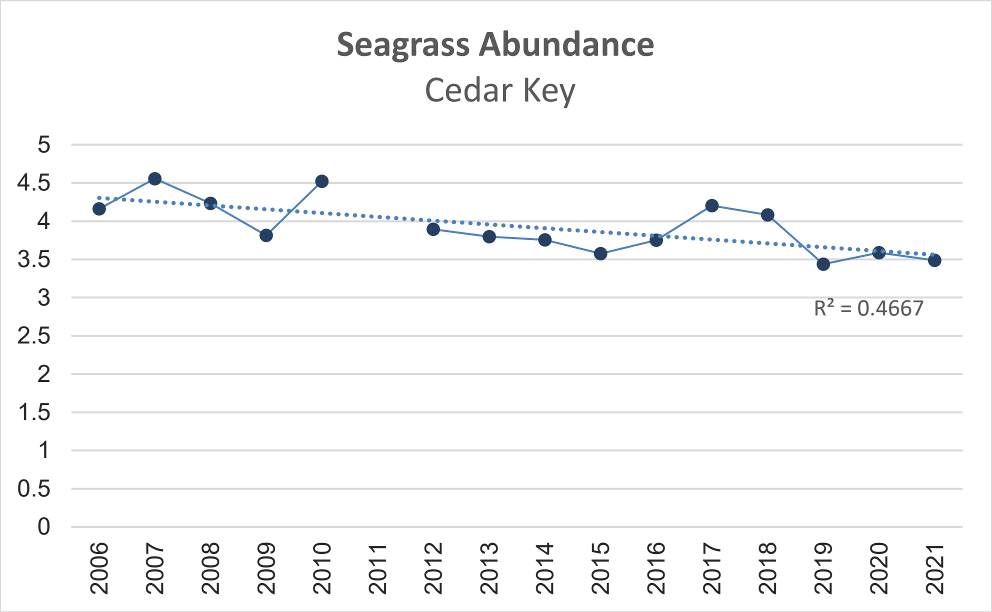

Figure 41. Cedar Key total seagrass abundance has a strong negative association over time (R = -0.683, R^2= 0.467, p-value= 0.007). This data supports a significant decline of seagrass density in Cedar Key from 2006-2021.

Steinhatchee

There are no notable long-term trends in Steinhatchee. This could, in part, be due to many gaps in the data. These data gaps, from unfavorable conditions to monitor, break up the data making it harder to detect trends over time. While there are no notable overall seagrass data trends, there is a notable trend in *S. filiforme* density (Figure 42).

Since 2010, major storm events have brought heavy rains resulting in seasonal increases of tannins coming out of the Steinhatchee River, a blackwater river. The darker water output from wet summers is suspected to be negatively impacting seagrass growth. Sediments entering the bay from upriver can affect water column turbidity and light penetration, potentially diminishing seagrass productivity. The amount of light available to seagrasses is one of the primary determinants of the maximum depth at which these plants can grow; some species of seagrass require greater levels of light than others. Where water quality and clarity are poor, seagrasses may only be found in the shallowest waters (FWC, 2014). In October 2019, a continuous water quality monitoring station was installed in Deadman Bay of Steinhatchee. Once a long-term dataset is collected, the seagrass data and water quality data can be compared and analyzed to negate or support this hypothesis of reduced water clarity impacting seagrass growth in Steinhatchee.

In addition to reduced light penetration, lower salinities may be impacting seagrass growth, and potentially causing SAV dieback. Seagrasses can grow in salinity ranges from 5-45 parts per thousand (ppt); however, species experience different growth rates at different salinity levels. *T. testudinum* experiences maximum growth rates when the salinity is between 30-40 ppt whereas *S. filiforme* has a maximum growth rate around 25 ppt (Lirman and Cropper, 2003). *S. filiforme* is one of the seagrass species with a lower tolerance for fluctuating salinities (Buzzelli, 2012). The spring-summer seagrass growing season coincides with Florida's wet season, and local salinities often drop below this optimum during this period. Seagrasses can survive exposure to lower salinities, but growth is impacted. If low salinity conditions persist for an extended period, seagrass habitats can thin and decline, and dieback is likely (Buzzelli, 2012). A further analysis of water quality, depth, and light requirements of seagrass may be needed; more sophisticated optical models are needed to identify specific water quality constituents affecting the light environment of seagrasses (Kenworthy and Fonseca 1996).

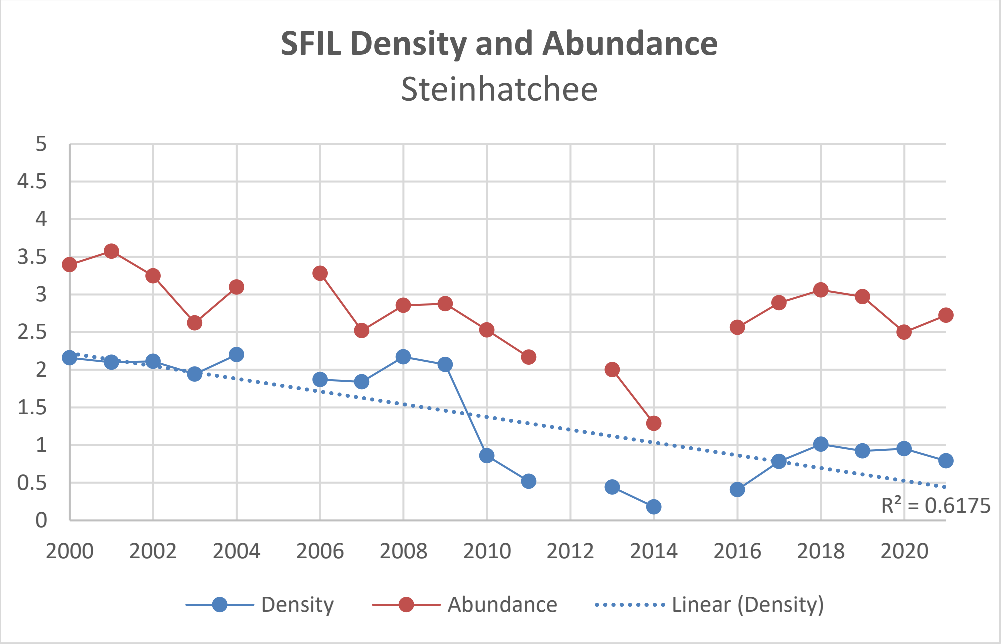

Figure 42. *Syringodium filiforme* density (blue) and abundance (red) in Steinhatchee over time. The SFIL density has a strong negative association over time (R = -0.786, R^2= 0.616, p-value= 0.0001). The abundance does not have a significant decline, which means that in areas we do find SFIL, it is still relatively abundant; however, we are finding less SFIL over time.

Dekle Beach/ Keaton Beach

There are no overall trends in seagrass density and abundance in Dekle Beach/Keaton Beach. There are, however, trends in both *T. testudinum* and *S. filiforme* (Figures 43 and 44). DBKB shows an inverse trend between *S. filiforme* and *T. testudinum* density. As *S. filiforme* density has been decreasing over time, *T. testudinum* has been increasing. The abundance of either species shows no statistically significant trend.

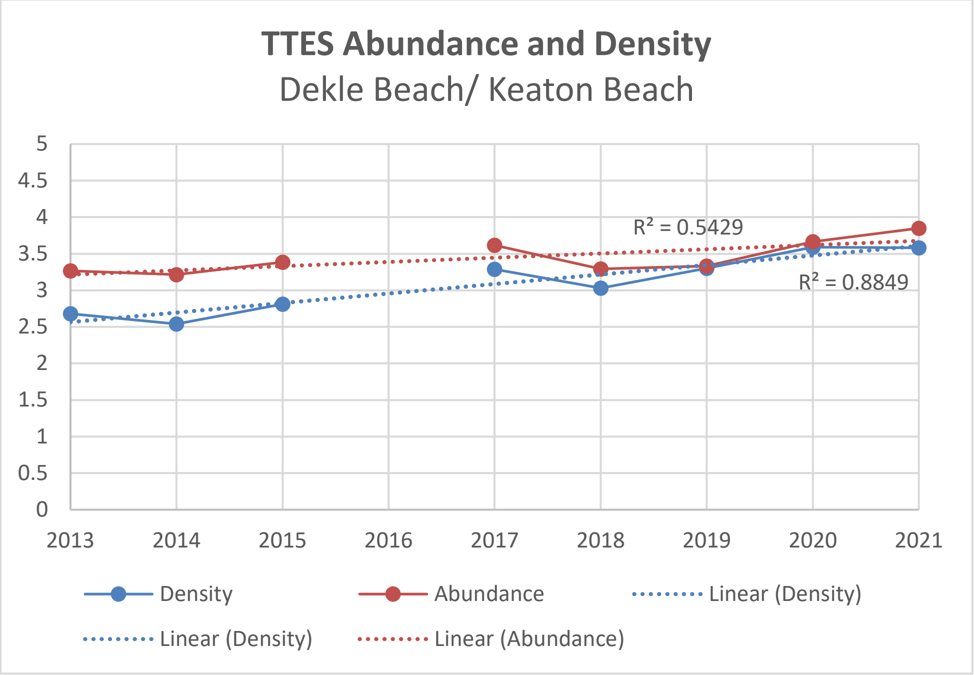

Figure 43. *Thalassia testudinum* density (blue) and abundance (red) in Dekle Beach/ Keaton Beach over time. The TTES density has a very strong positive association over time (R = 0.941, R^2= 0.885, p-value= 0.0004) and the TTES abundance has a strong positive association over time (R-value = 0.737, R^2= 0.543, p-value= 0.03). This data supports an increase in TTES density and abundance over time in Dekle Beach/ Keaton Beach.

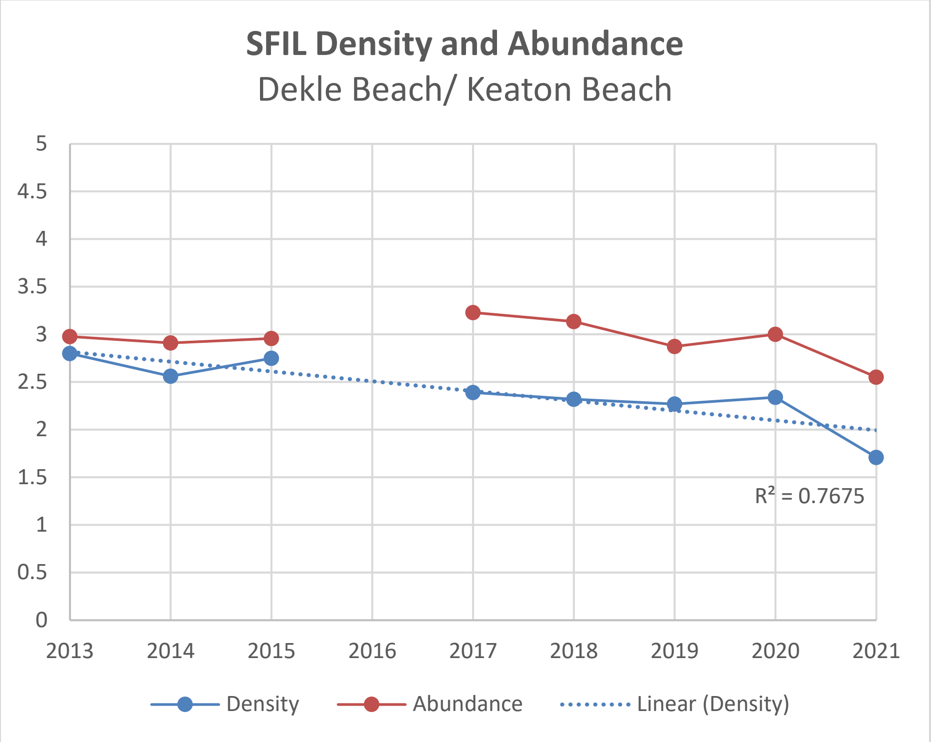

Figure 44. *Syringodium filiforme* density (blue) and abundance (red) in Dekle Beach/ Keaton Beach over time. The SFIL density very strong negative association over time (R = -0.876, R^2= 0.768, p-value= 0.004). This data shows that over time there has been a significant decline in SFIL over time; however, there has not been a significant decline in abundance over time.

St. Marks

Sampling did not occur in 2012 or 2013 due to heavy rainfall resulting in a significant increase in output from the St. Marks, Wakulla, Wacissa, and Ecofina Rivers. This increase created a dark plume of turbid, tannic water in the Gulf of Mexico, reducing visibility to almost zero. The increased turbidity subsequently decreased light availability, which may have resulted in the slight seagrass decline recorded in 2014, once sampling resumed.

There were no statistically significant trends for any species or overall totals. Further monitoring will be useful to track trends in shifts of species. Switching methods to percent cover rather than BB scores in the future might show more notable changes in seagrass species composition.

Major Storm Events

Major tropical events have the potential to disrupt the productivity of seagrasses. Tropical weather events can directly and indirectly affect seagrass communities; heavy rains can alter salinity regimes and increase turbidity in coastal waters. All major storms (tropical depression, tropical storms, and hurricanes) that may have impacted the St. Martins Marsh and Big Bend Seagrasses Aquatic Preserves are listed in Table 9.

Table 9: Major Storm Events in the Big Bend Region of Florida since 2002

Storm Name	Date(s) of Impact	Storm Classification	Max Winds (mph)	Systems Impacted*
Edouard	September 1-6, 2002	Tropical Depression	55 mph	SID, CK
Henri	September 3-8, 2003	Tropical Storm	50 mph	SID, CK
Bonnie	April 11-13, 2004	Tropical Storm	55 mph	SMAR, DBKB, STCH
Frances	September 5-7, 2004	Hurricane	125 mph	SID, CK, STCH, DBKB, SMAR
Ivan	September 15-16, 2004	Hurricane	145 mph	SMAR
Jeanne	September 26-27, 2004	Hurricane	105 mph	SID, CK, STCH, DBKB, SMAR
Alberto	June 12-13, 2006	Tropical Storm	60 mph	SID, CK, STCH, DBKB, SMAR
Barry	June 2, 2007	Tropical Storm	50 mph	SID, CK
Fay	August 22-23, 2008	Tropical Storm	60 mph	SMAR, DBKB, STCH
Claudette	August 16-17, 2009	Tropical Storm	50 mph	SMAR
Beryl	May 28-29, 2012	Tropical Storm	60 mph	SMAR, DBKB, STCH
Debby	June 24-27, 2012	Tropical Storm	55 mph	SID, CK, STCH, DBKB, SMAR
Andrea	June 5-6, 2013	Tropical Storm	65 mph	SID, CK, STCH, DBKB, SMAR
Colin	June 5-7, 2016	Tropical Storm	50 mph	SID, CK, STCH, DBKB, SMAR
Hermine	September 1-3, 2016	Hurricane	70 mph	SID, CK, STCH, DBKB, SMAR
Irma	September 9-12, 2017	Hurricane	155 mph	SID, CK, STCH, DBKB, SMAR
Michael	October 9-10, 2018	Hurricane	160 mph	SID, CK, STCH, DBKB, SMAR
Eta	November 11-13, 2020	Hurricane	130 mph	CK
Elsa	July 7-8, 2021	Hurricane	85 mph	SID, CK, STCH, DBKB, SMAR
Fred	August 15-16, 2021	Tropical Storm	65 mph	SMAR

*Underlined if storm made landfall directly on the system

Other Remarks/Notes

a) Electronic copies of data can be obtained through the Principal Investigator or the Statewide Ecosystem Assessment of Coastal and Aquatic Resources (SEACAR).

b) Accreditation must be given to Florida Department of Environmental Protection's Office of Resilience and Coastal Protection staff of the Big Bend Seagrasses Aquatic Preserves for all data used.

References

Buzzelli, C., Robbins, R., Doering, P., Chen, Z., Sun, D., Wan, Y., & Schwarzschild, A. (2012). Monitoring and Modeling of Syringodium filiforme (Manatee Grass) in Southern Indian River Lagoon. *Estuaries and Coasts*, *35*, 1401-1415.

Carlson, Paul and Yarbro, Laura. (2011). Seagrass Integrated Mapping and Monitoring for the State of Florida Mapping and Monitoring Report No. 1. Florida Fish and Wildlife Commission, Fish and Wildlife Research Institute. St. Petersburg, FL.

Dawes, C. J., Phillips, R. C., Morrison, G., & Dawes, C. J. (2004). *Seagrass communities of the Gulf Coast of Florida: status and ecology*. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute.

Florida Department of Environmental Protection. (2017). "Florida Seagrasses." Retrieved from: http://floridadep.gov/fco/fco/content/florida-seagrasses

Florida Fish and Wildlife Commission. (2014). Seagrass Information. Retrieved from: http://www.myfwc.com/research/habitat/seagrasses/information/

Fourqurean, J. W., Willsie, A., Rose, C. D., & Rutten, L. M. (2001). Spatial and temporal pattern in seagrass community composition and productivity in south Florida. *Marine Biology*, *138*(2), 341 354.

Furman, B. T., Leone, E. H., Bell, S. S., Durako, M. J., & Hall, M. O. (2018). Braun-Blanquet data in ANOVA designs: comparisons with percent cover and transformations using simulated data. *Marine Ecology Progress Series*, *597*, 13-22.

Kenworthy WJ and MS Fonseca. (1996). Light requirements of seagrasses, *Halodule wrightii* and *Syringodium filiforme* derived from the relationship between diffuse light attenuation and maximum depth distribution. Estuaries, Volume 19, Issue 3: 740-750. Retrieved from http://link.springer.com/article/10.2307/1352533

Mattson, R.A. (2000). Seagrass ecosystem characteristics and research and management needs in the Florida Big Bend, *in* Bortone, S.A., ed., Seagrasses. monitoring, ecology, physiology, and management: Boca Raton, Fla., CRC Press, 259–277.

Mattson, R. A., T. K. Frazer, J. Hale, S. Blitch, and L. Ahijevych. (2007). Florida Big Bend. Pp. 171-188 IN: L. Handley, D. Altsman, and R. DeMay (eds.), Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002. U. S. Geological Survey Scientific Investigations Report 2006-5287.

National Oceanic and Atmospheric Administration: Damage Assessment, Remediation, and Restoration Program. (2014). “Injury Assessment: Mini-312 Seagrass Restoration Program. Retrieved from http://www.darrp.noaa.gov/partner/mini312/protocol.html.

Poore, M. E. D. (1955). The use of phytosociological methods in ecological investigations. I. The Braun-Blanquet system. Journal of Ecology 43: 226–244.

Wilson, S. S., Furman, B. T., Hall, M. O., & Fourqurean, J. W. (2020). Assessment of Hurricane Irma impacts on South Florida seagrass communities using long-term monitoring programs. *Estuaries and Coasts*, *43*(5), 1119-1132.