2022 ST. MARTINS MARSH AND BIG BEND SEAGRASSES AQUATIC PRESERVES ANNUAL SEAGRASS MONITORING REPORT

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Office of Resilience and Coastal Protection

Big Bend Seagrasses Aquatic Preserves

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

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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:

Updated Sampling Methods

As of 2022, the BBSAP and SMMAP staff switched from Braun-Blanquet cover assessment to percent cover. Braun-Blanquet method is explained in the historical sampling method section. The switch from Braun-Blanquet to percent coverage monitoring was made due to the accuracy of the percent cover method. Both cover assessments are quickly replicated; however, the percent cover gives more accurate insight to the composition of each quadrat.

Percent cover method is completed by first locating each fixed monitoring location using predetermined GPS coordinates (Tables 4, 5, 6, 7, 8). Once at the correct monitoring location, a one-meter square quadrat is randomly distributed four times and evaluated for total percent cover, between 0-100% coverage. If there is no submerged aquatic vegetation (SAV) observed within a quadrat, it is recorded as "No Growth in Quadrat" (NGIQ) on the data sheet. The total coverage and each individual species present are assigned the percent value they represent within the quadrat. All individual species' percentages add up to the total coverage percent within the quadrat. This method is repeated at each of the 25 sites for a total of 100 per system. Using these visual assessments researchers can measure the community composition, percentage cover, and density of the benthic community (NOAA, 2014).

Staff utilize abbreviations for each SAV species while monitoring within SMMAP and BBSAP (Tables 1 & 2). In 2018, *Penicillus capitatus* and *Penicillus dumetosa* were combined into one code, *Penicillus spp.,* to streamline sampling. In 2022, *Caulerpa sertularioides* was identified in the preserves, and staff began recording this species. Staff also determined in 2022 that *Padina vickersiae* was no longer considered an accepted species. Staff has since determined there may be more than one species of *Padina* within the preserve and will move forward calling this as *Padina spp.* (PADI) until further analysis can confirm the correct species.

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 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.

Table 1: 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 2: Macroalgae Species Encountered During Seagrass Monitoring

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

Penicillus spp.	PXXX
Padina spp.	PADI
Rhipocephalus phoenix	RPHO
Sargassum spp.	SXXX
Udotea flabellum	UFLA
Ulva spp.	ULVA
Drift Algae	Drift

Data Analysis Methods

After all collection is complete, the raw data is entered into an Excel file. The entry is then checked for quality control by a second staff member to ensure the data was correctly entered. The percent cover values collected starting in 2022 were recorded as percent cover values and later converted to a Braun-Blanquet score for trend analysis. Percent cover scores are easily converted to Braun-Blanquet values as the values represent a range of percentages (Table 3). 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 of grass and algae, total grass, total algae, and total cover within each quadrat. 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 if the score values can be converted into real numbers that can be analyzed; however, the transformations are debated and utilized for an 8-point Braun-Blanquet scale. The Braun-Blanquet scale used by BBSAP is a modified scale that ranges only from 0-5. Some seagrass researchers support the use of Braun-Blanquet values for statistical analysis as long as 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). Data collected in 2022 as percent cover was converted to Braun-Blanquet scores for this analysis as there are not enough percent values to analyze any time series data.

Using the Braun-Blanquet scores and converted percent cover 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. These statistical approaches were done separately for each year that data was collected. 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). Abundance, frequency, and density data analysis was completed using Microsoft Excel.

A Mann-Kendall (M-K) test for time series trend was run to determine any significant monotonic trends in the SAV data. The M-K test is a non-parametric test allowing for data without a normal distribution. It can also be used on a time series with missing data. The M-K test was preformed using the Microsoft Excel add-in Real Statistics Resource Pack software's Mann-Kendall and Sen's Slope data analysis tool (Zaiontz, 2020). In a two-tailed test, the M-K will determine if a trend is present or absent in the data. A one-sided test was completed if a trend was present to determine if the trend was positive or negative. For time series $x_1, \dots, x_n$ the M-K was calculated as:

$$S = \sum_{i=1}^{n-1} \sum_{j=k+1}^{n} sign(x_j - x_i)$$

Where n is the number of data points, $x_j - x_i$ are the values in the series i, and j $(j > i)$. $sign(x_j - x_i)$ is the sign of the function where:

$$sign(x_j - x_i) \begin{cases} +1, if\ x_j - x_i > 0 \\ 0, if\ x_j - x_i = 0 \\ -1, if\ x_j - x_i < 0 \end{cases}$$

The M-K test is frequently used to quantify the significance of trends in biological time series data (Gocic & Trajkovic, 2013). All tests were completed with a 95% confidence level, $\alpha = 0.05$. The Real Statistics Resource Pack Mann-Kendall data analysis tool produces the MK stat, z-stat, standard error, and p-value (Zaiontz, 2020). The function also produces the Sen's Slope where:

$$slope = Q_{med} = \left\{ \frac{x_j - x_i}{j - i} : i < j \right.$$

The sign of Q_{med} represents the direction of the slope, positive or negative, and the value represents the steepness of the trend (Gocic & Trajkovic, 2013).

In the coming years staff will continue to analyze all seagrass data using the Braun-Blanquet numbers with converted Braun-Blanquet values. Once staff have collected percent cover data for a minimum of three years, the percent cover data can be analyzed separately, in addition to the Braun-Blanquet series.

Historical Sampling Methods

Researchers located each fixed monitoring location using predetermined GPS coordinates. Once at the correct monitoring location, the one-meter square quadrat was randomly distributed four times, and the Braun-Blanquet visual cover assessment was conducted. Assessment of seagrass and macroalgae inside the quadrat was 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 was observed in a quadrat, staff recorded "No Growth in Quadrat" (NGIQ) on the data sheet. The presence of each species of seagrass and macroalgae were identified and assigned a cover-abundance scale value (Table 3).

Table 3. Modified Braun-Blanquet Density Values

NGIQ	No Growth in Quadrat
1	0.1-5% 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.

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.

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*. However, *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.

SMMAP is important for local 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 critical habitat for Florida's bay scallops; in conjunction with the Steinhatchee area in the Big Bend region, 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 located 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 located 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. Percent cover assessment replaced the Braun-Blanquet method in 2022. The St. Martins Marsh monitoring region is a unique area with five species of seagrasses and approximately 20 species of macroalgae (See Tables 1 & 2) currently 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 commonly occurring 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.

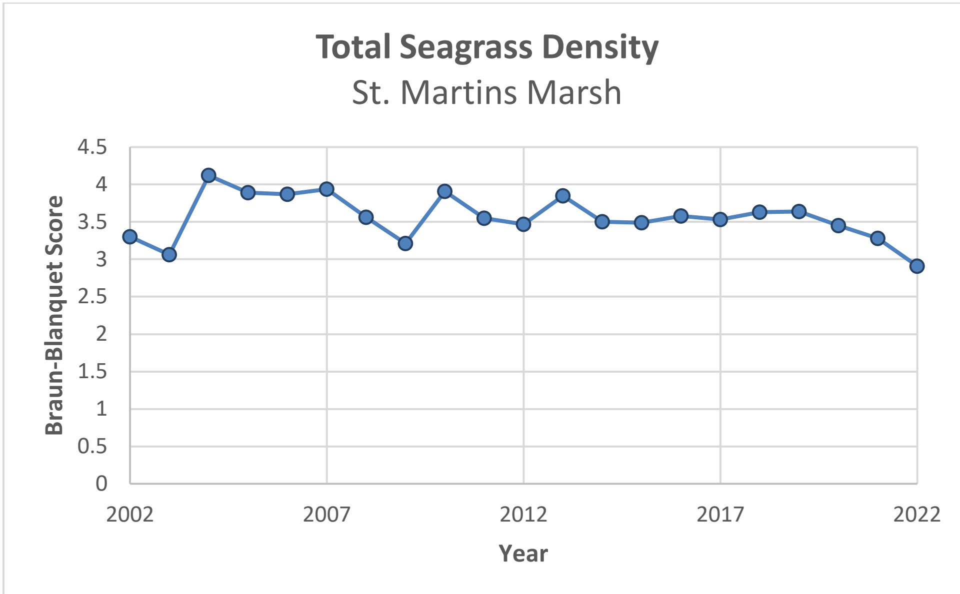

Figure 1. Overall seagrass density over the sampling years.

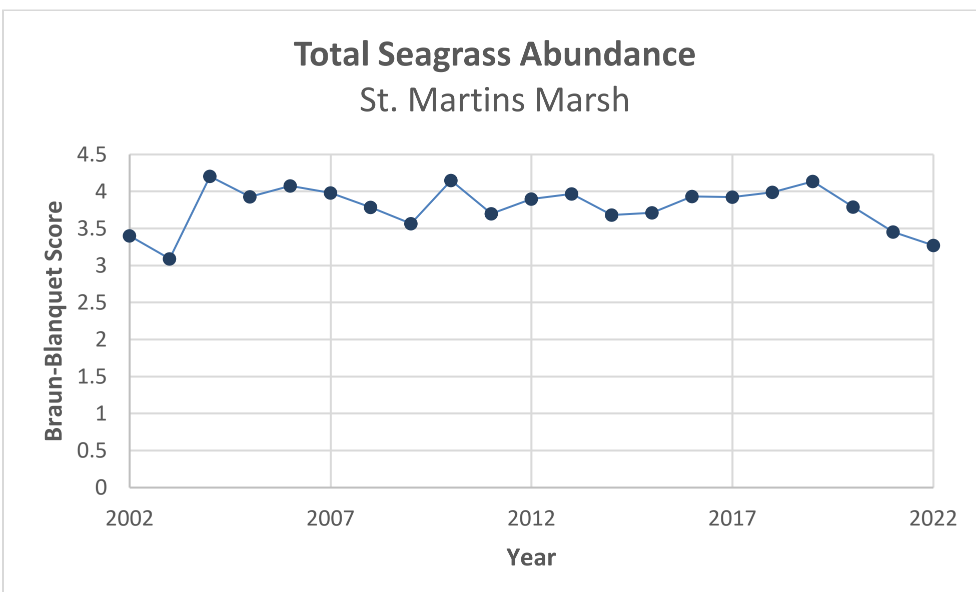

Figure 2. Overall seagrass abundance in St. Martins Marsh over the sampling years.

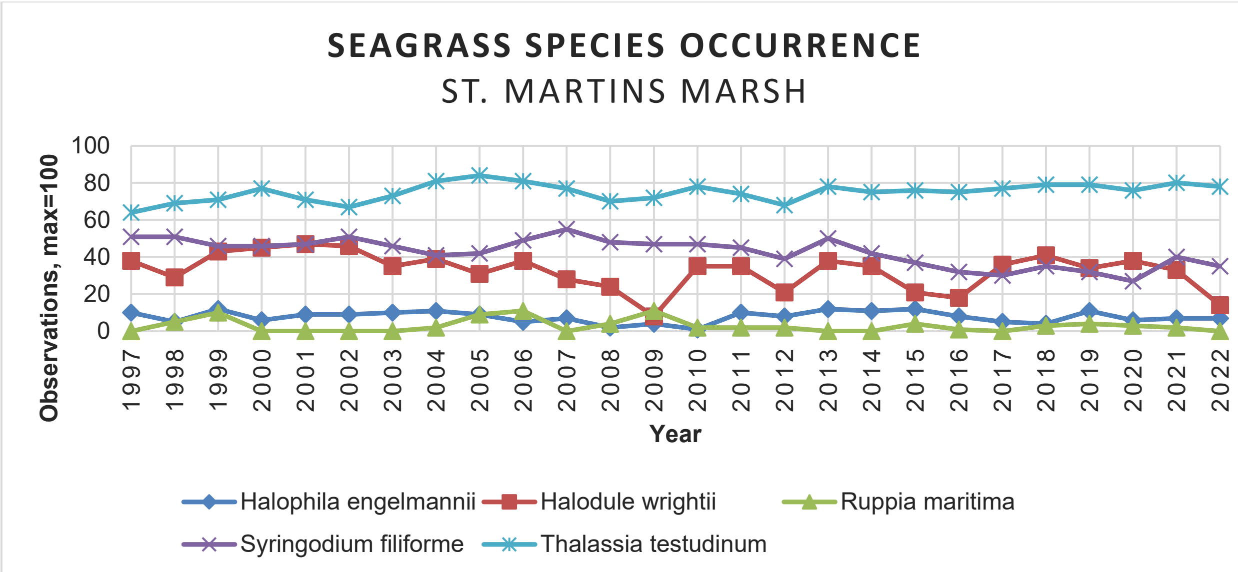

Figure 3. The number of times each species of seagrass occurred (max of 100) in St. Martins Marsh over time.

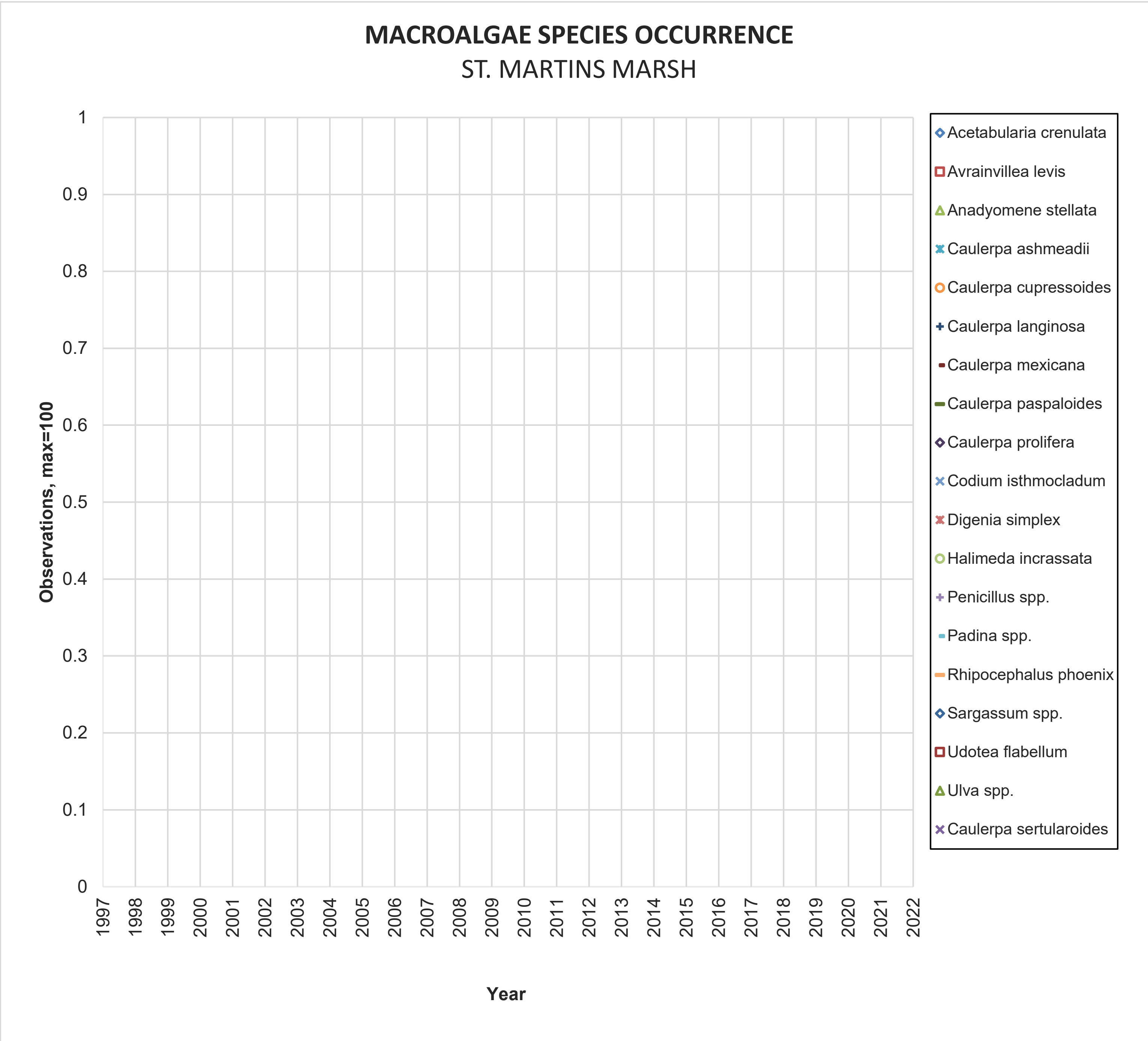

Figure 4. The number of times each species of macroalgae occurred (max of 100) in St. Martins Marsh over time. Although over 20 species of macroalgae have been observed in the St. Martins region, *Caulerpa prolifera*, *Penicillus spp.*, *Udotea flabellum*, and *Halimeda incrassata* have been the most prominent species.

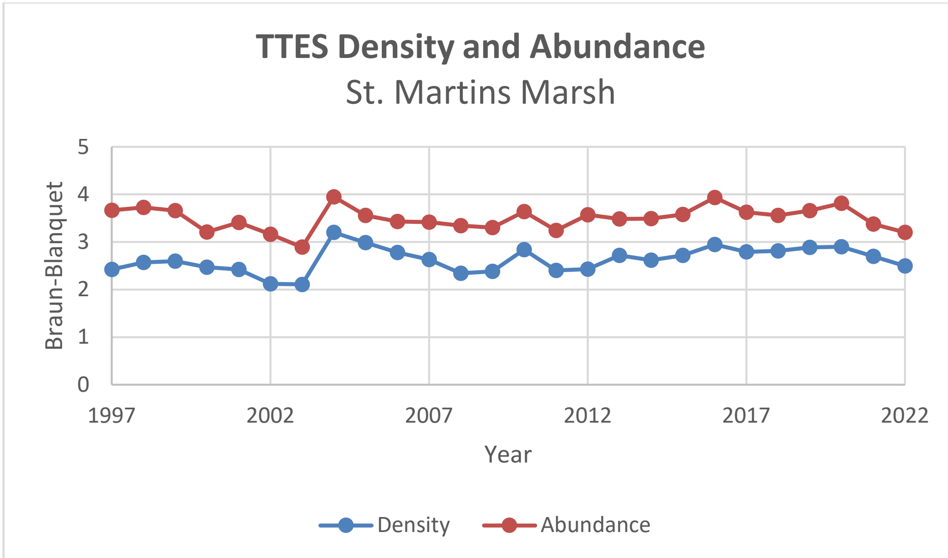

Figure 5. *Thalassia testudinum* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

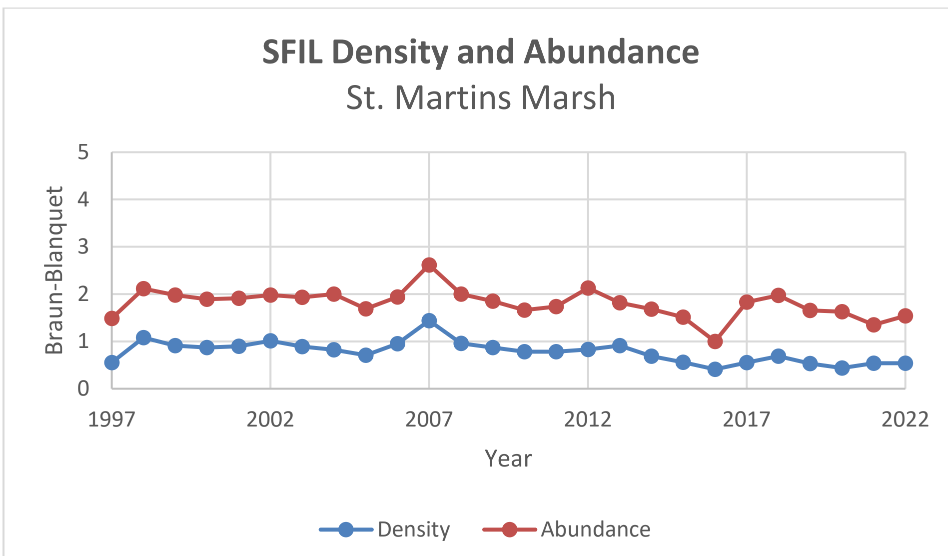

Figure 6. *Syringodium filiforme* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

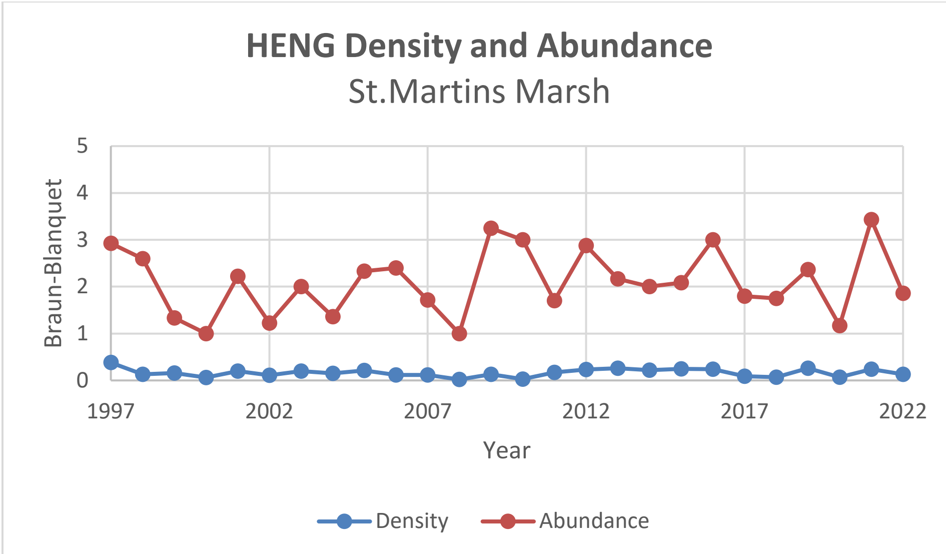

Figure 7. *Halophila engelmannii* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

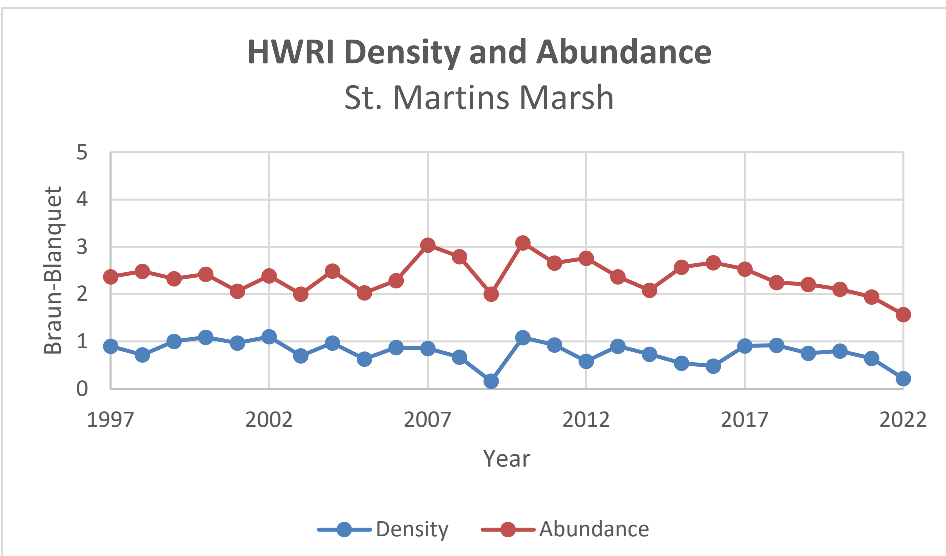

Figure 8. *Halodule wrightii* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

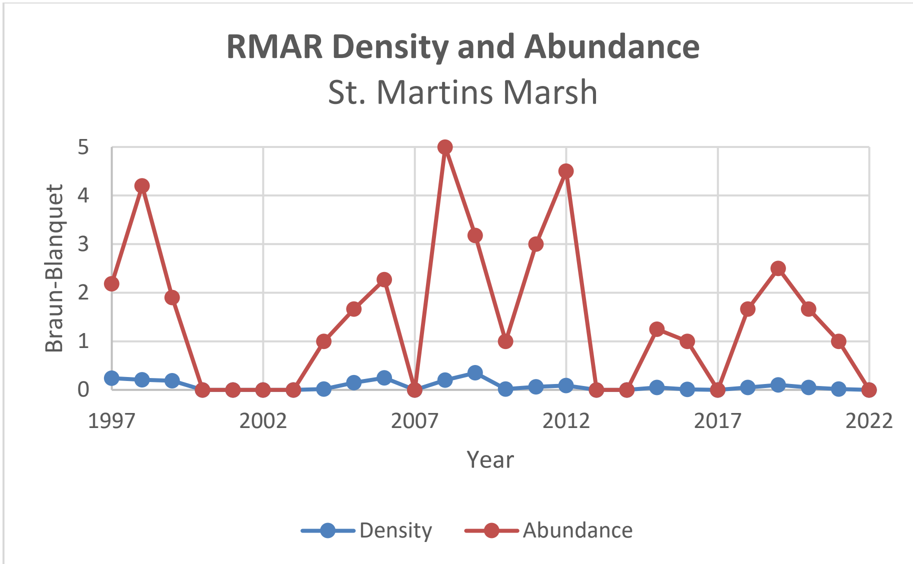

Figure 9. *Ruppia maritima* density (blue) and abundance (red) in St. Martins Marsh over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

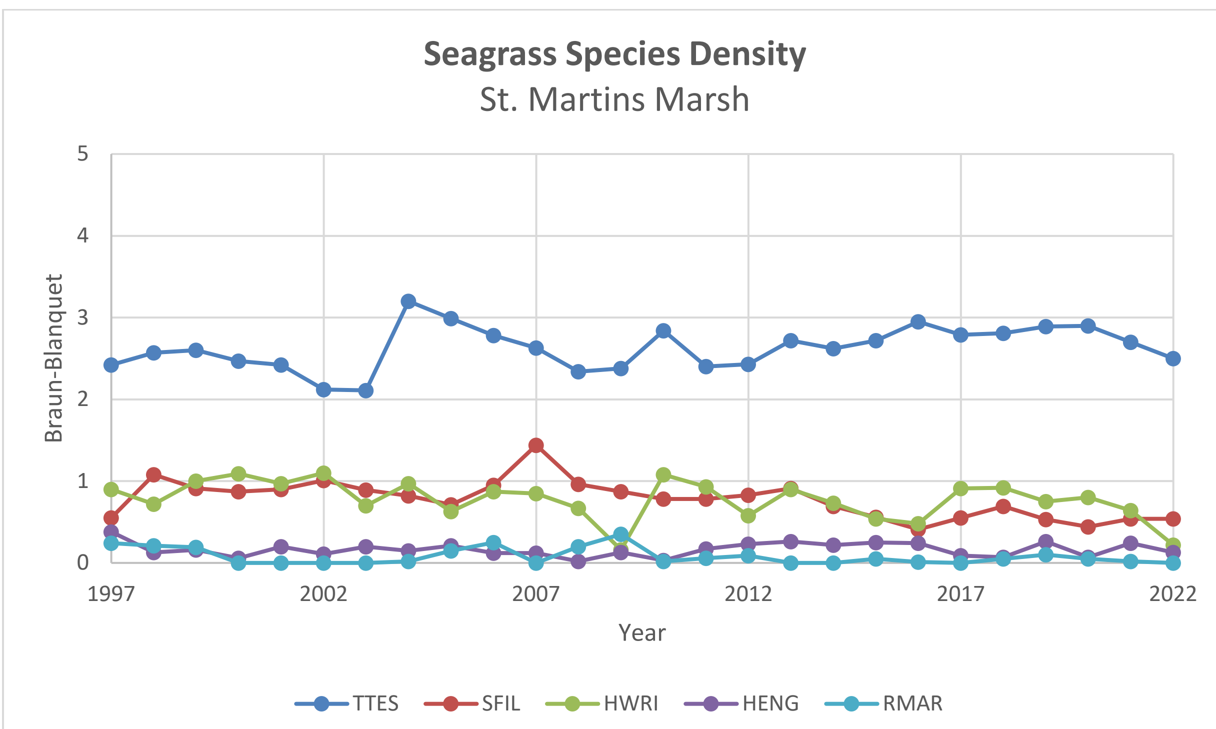

Figure 10. Individual seagrass species densities in St. Martins Marsh over time. Graph shows that *T. testudinum* is the densest seagrass species found in SID.

Cedar Key

Submerged aquatic vegetation monitoring began in Cedar Key in 2006 using Braun-Blanquet method. Percent cover assessment replaced the Braun-Blanquet method in 2022. Staffing shortage and unfavorable weather patterns prevented monitoring in 2011. To date, four species of seagrass and seven 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 commonly occurring 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* were observed between 2006 and 2014.

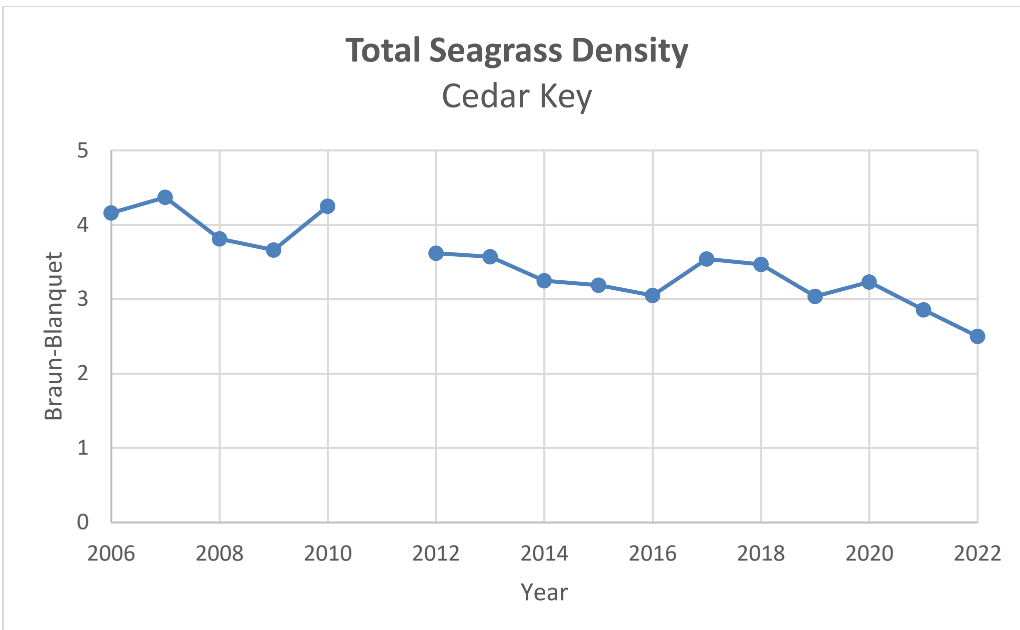

Figure 11. Overall density of all seagrass species combined over time in Cedar Key.

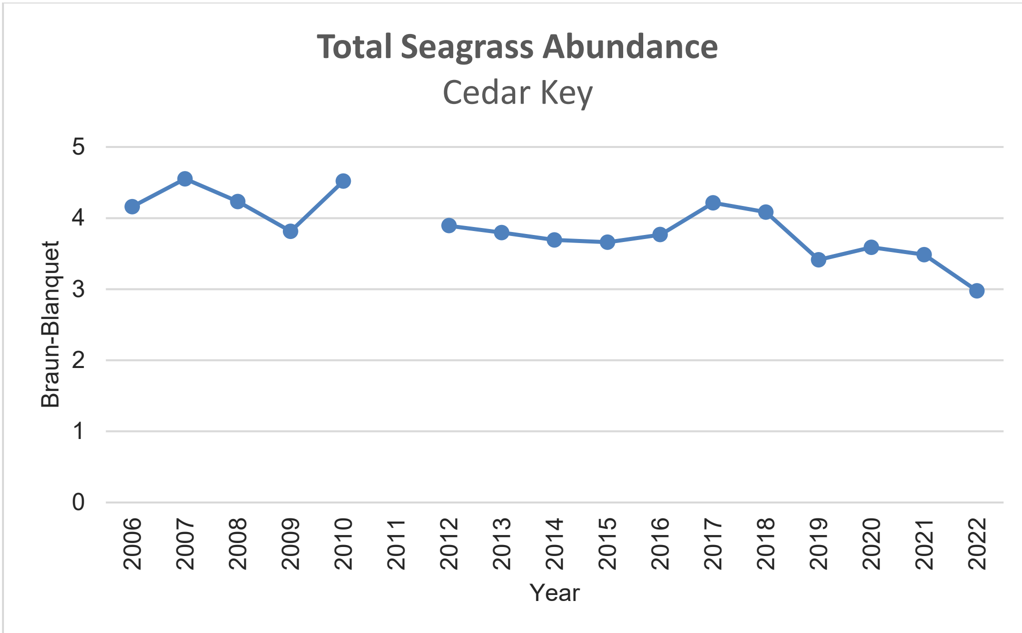

Figure 12. Overall abundance of all seagrass species combined over time in Cedar Key.

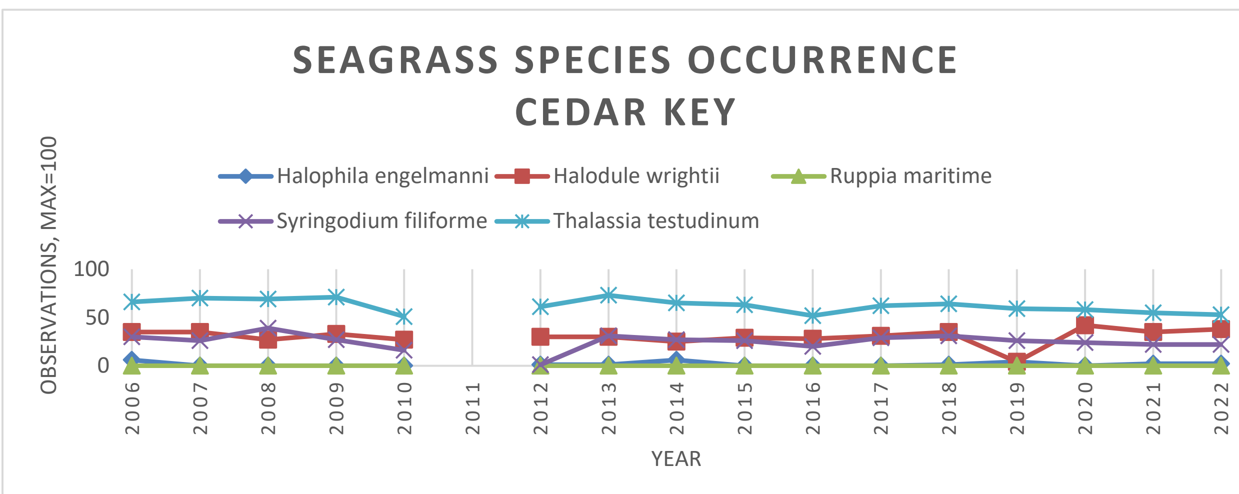

Figure 13. Number of times each seagrass species occurred in quadrats (max of 100) over time in Cedar Key.

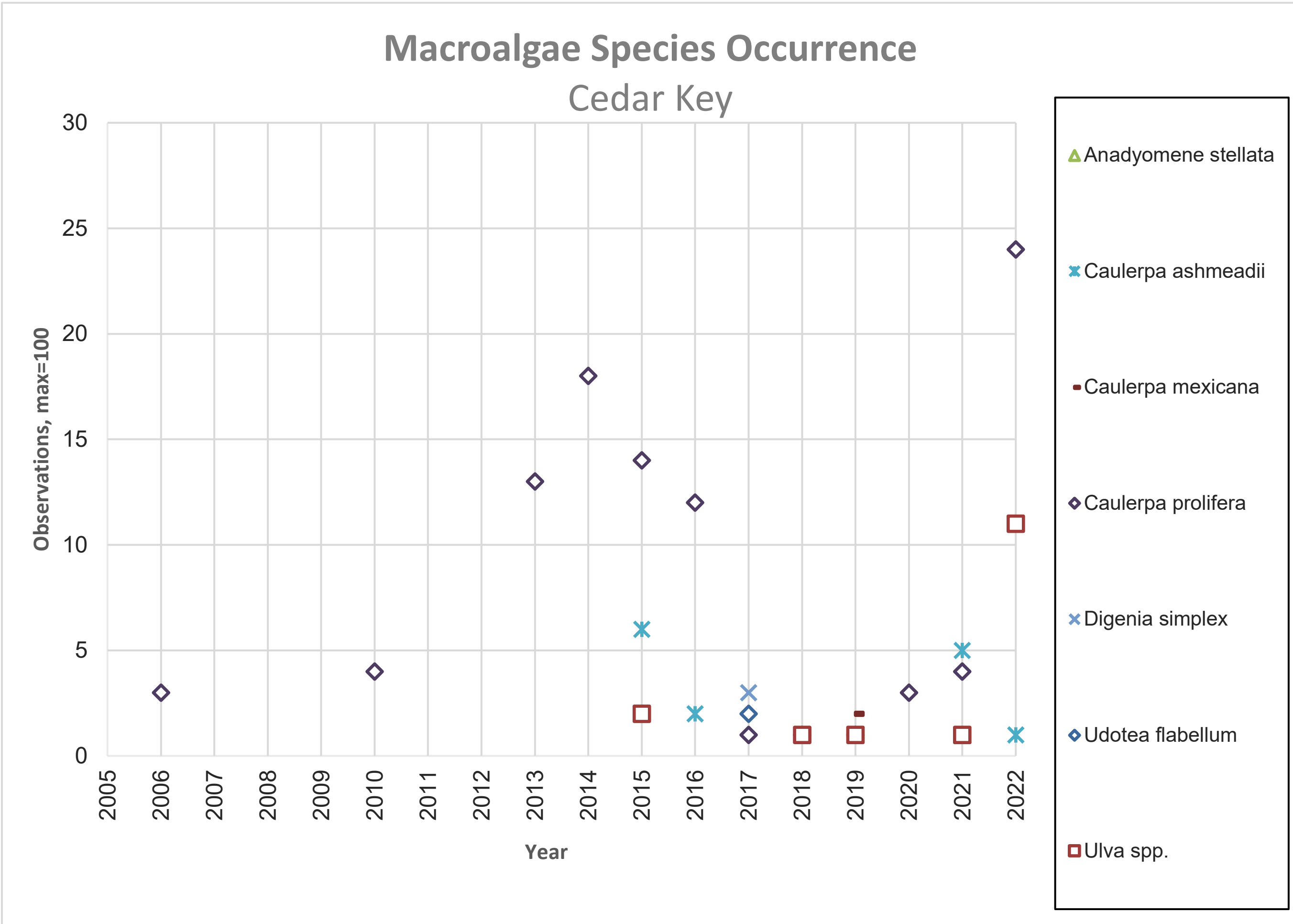

Figure 14. Number of times each macroalgae species was found in a quadrat (max = 100) over time in Cedar Key.

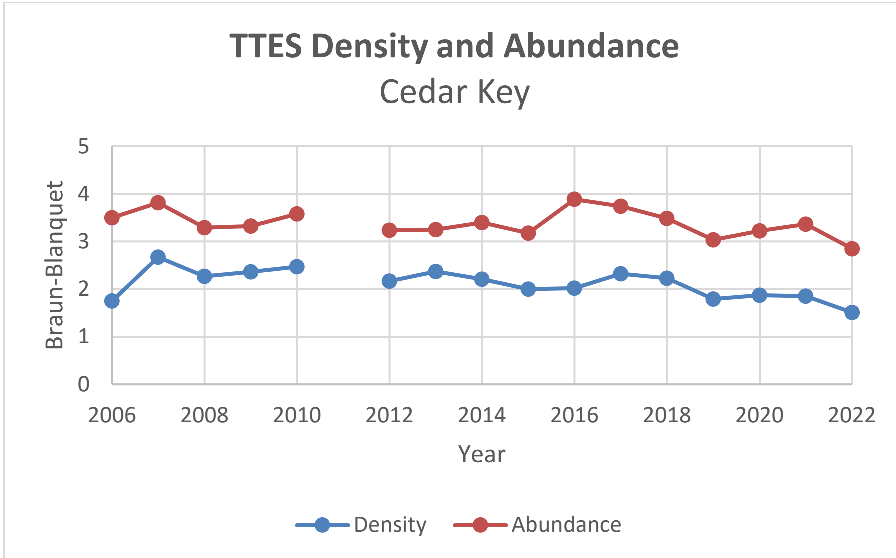

Figure 15. *Thalassia testudinum* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

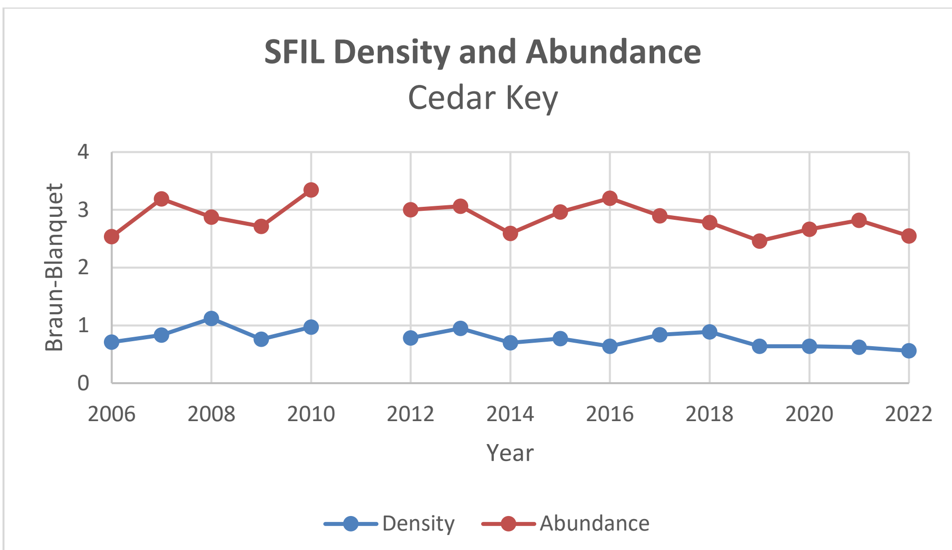

Figure 16. *Syringodium filiforme* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

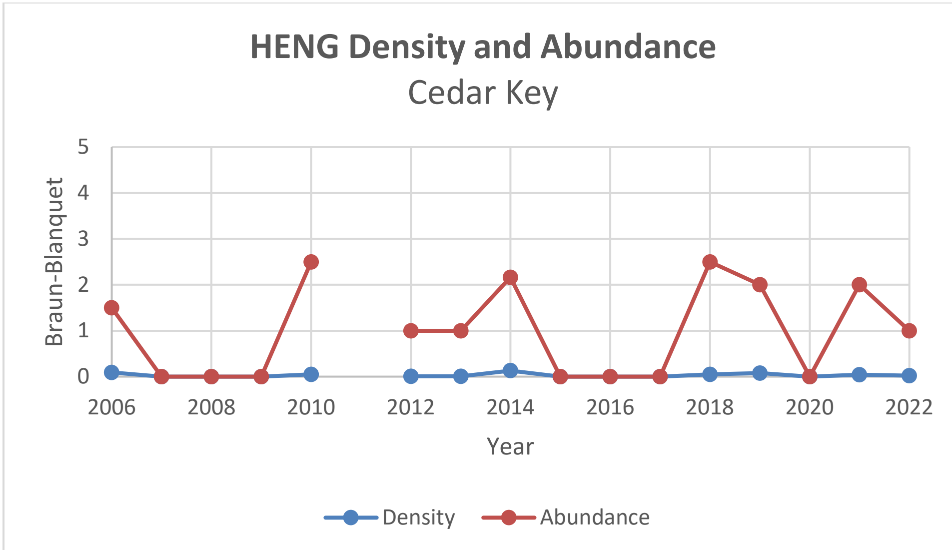

Figure 17. *Halophila engelmannii* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

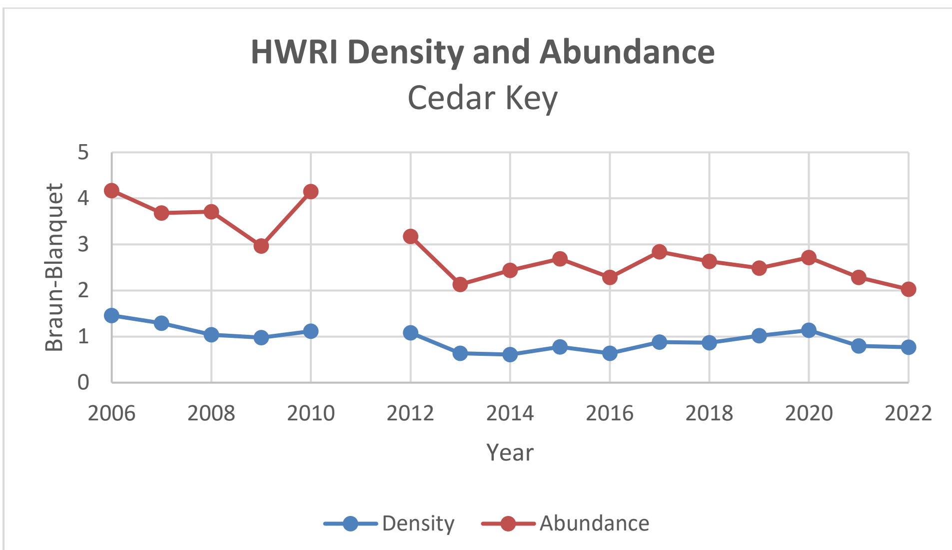

Figure 18. *Halodule wrightii* density (blue) and abundance (red) in Cedar Key over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

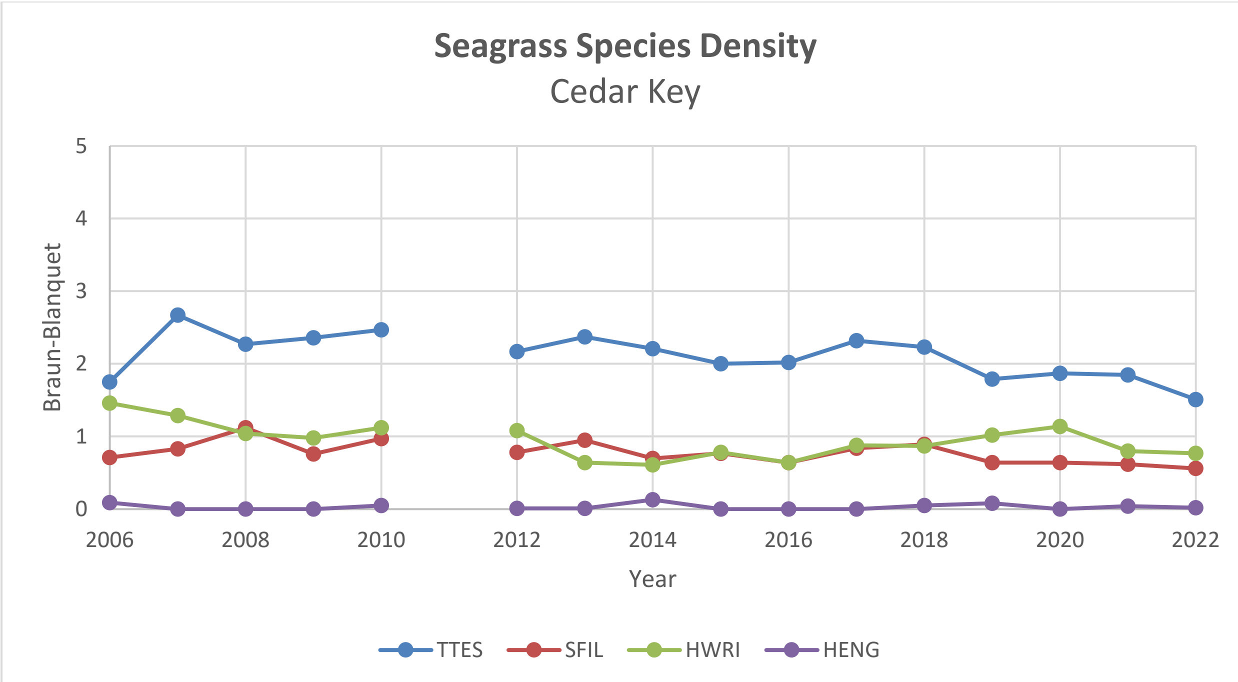

Figure 19. Individual seagrass species densities Cedar Key over time. Graph shows that *T. testudinum* is the densest seagrass species found in CK.

Steinhatchee

Submerged aquatic vegetation monitoring began in Steinhatchee in 2000; however, Braun-Blanquet scores were not recorded until 2003. Percent cover assessment replaced the Braun-Blanquet method in 2022. 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 large turbidity 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.

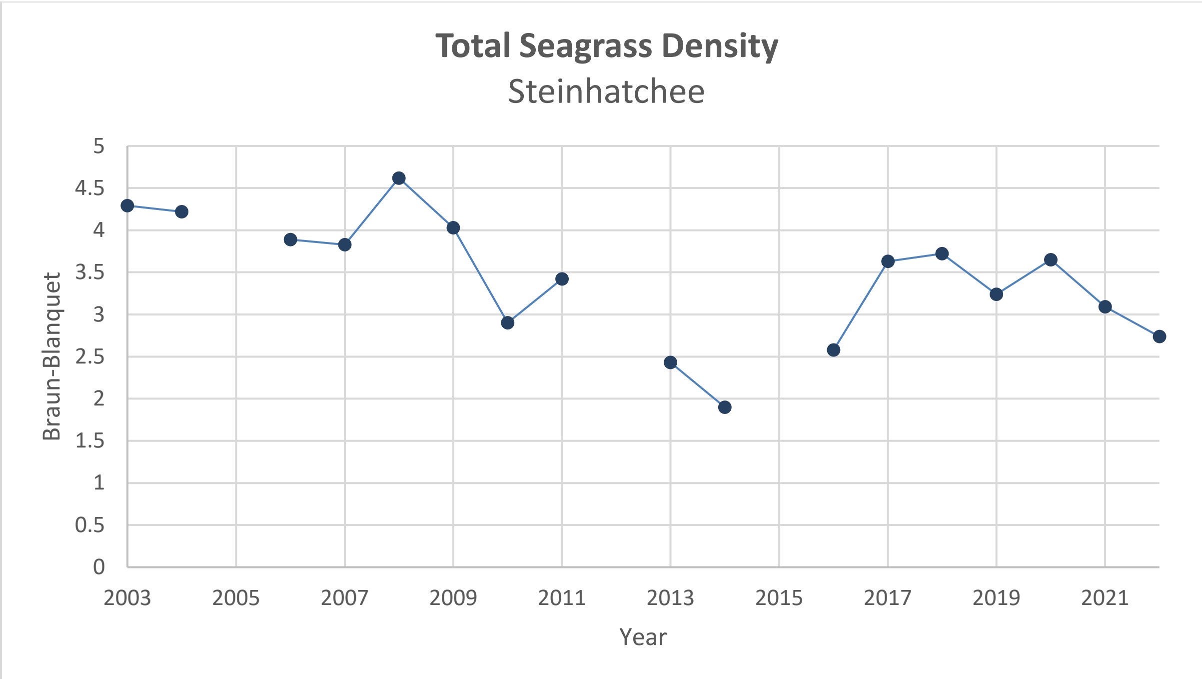

Figure 20. Overall seagrass density in Steinhatchee over the sampling years.

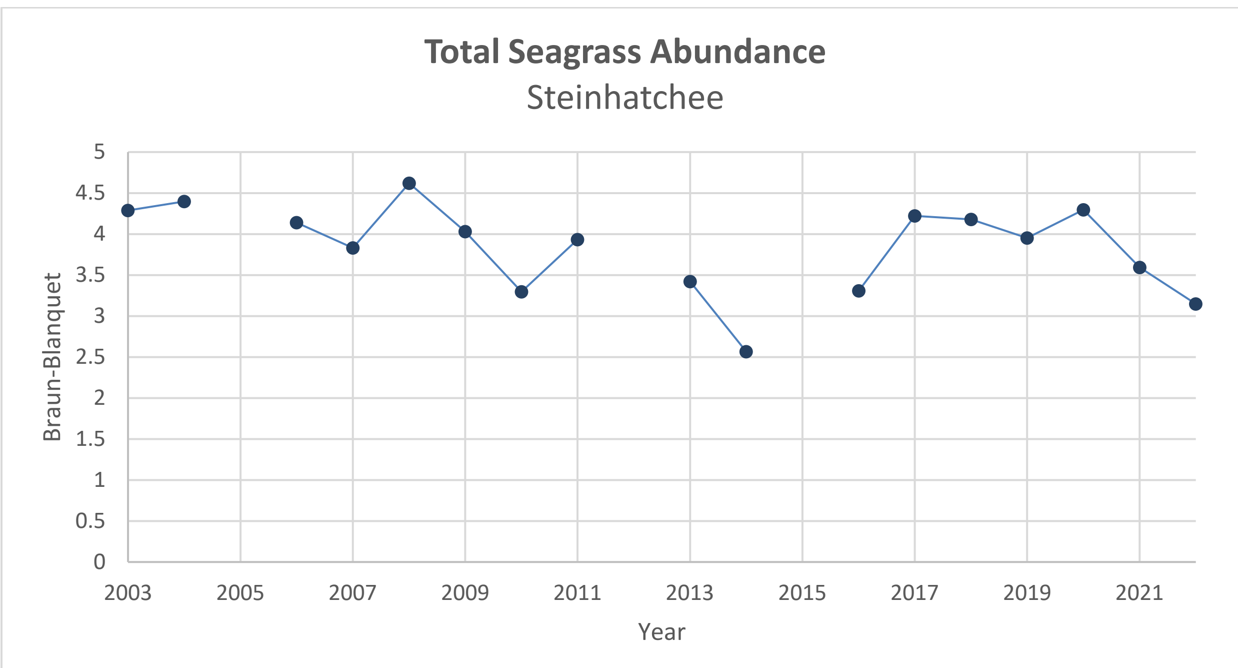

Figure 21. Overall seagrass abundance in Steinhatchee over the sampling years.

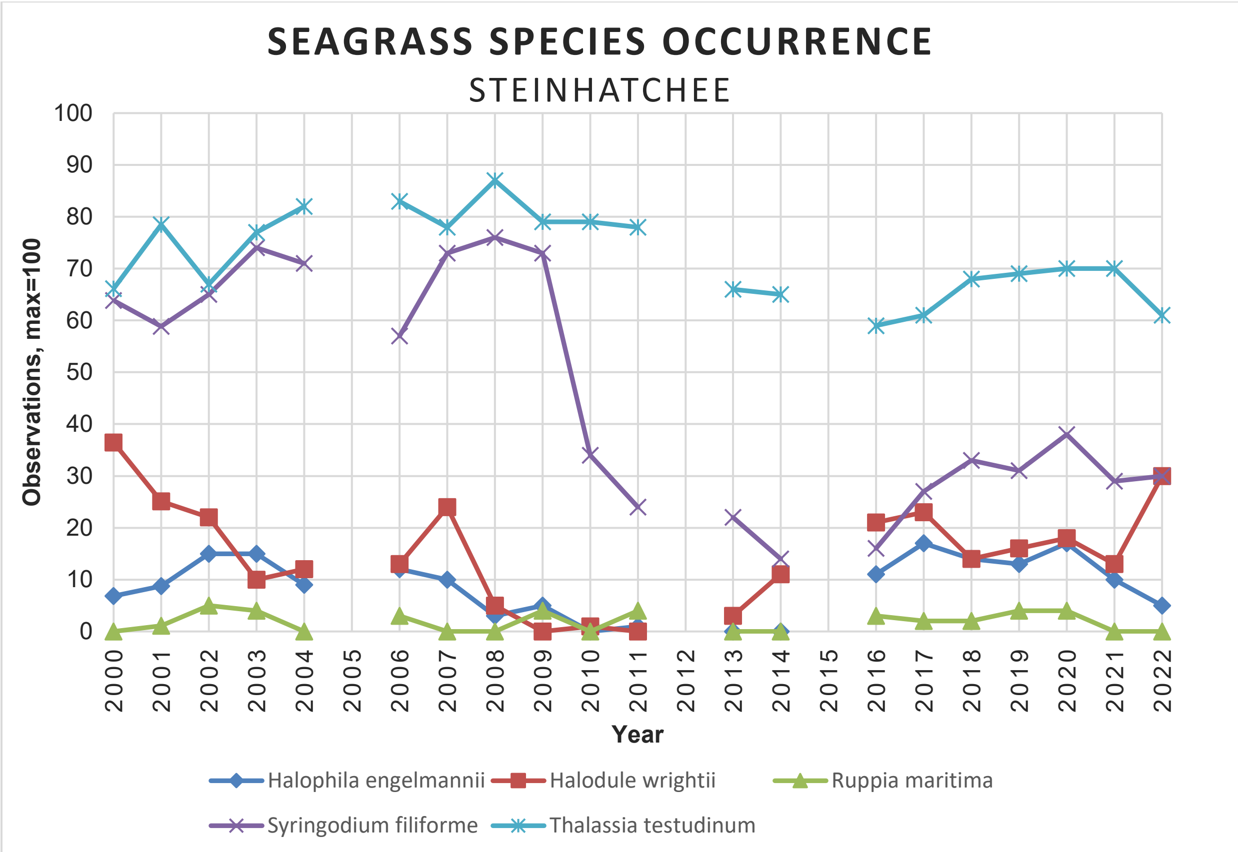

Figure 22. The number of times each species of seagrass occurred (max of 100) in Steinhatchee over time.

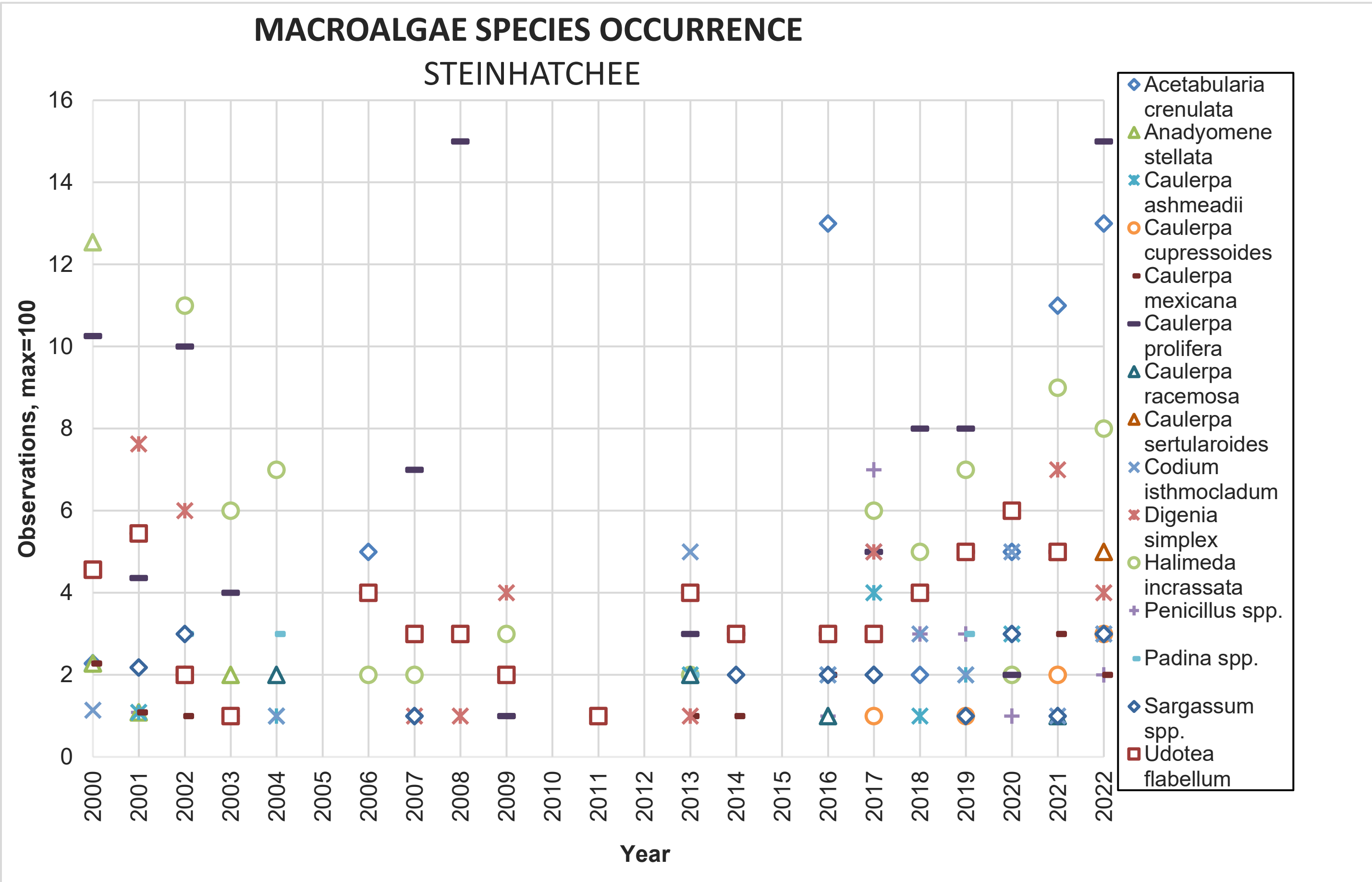

Figure 23. Number of times each macroalgae was observed at each site (max = 100) in Steinhatchee.

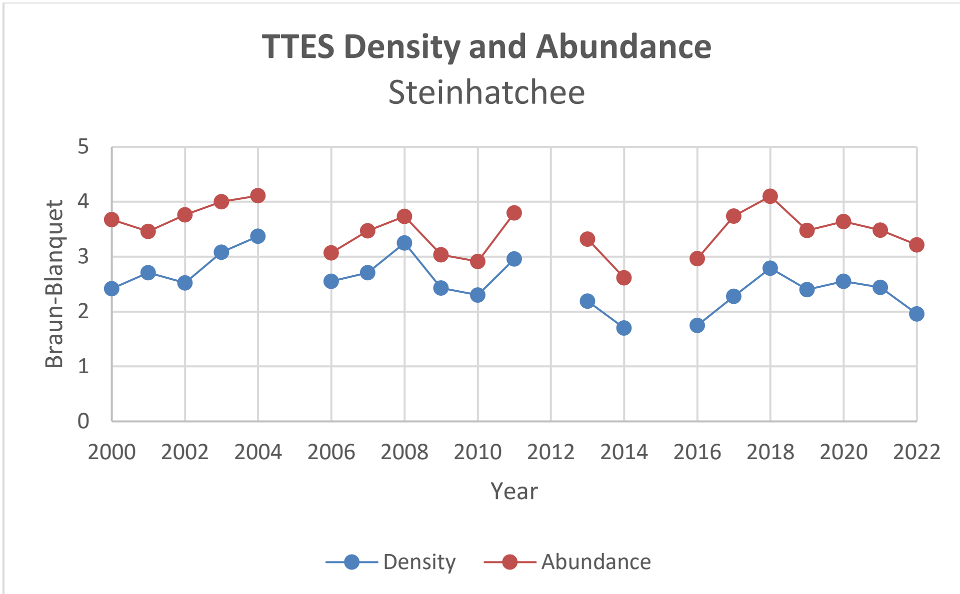

Figure 24. *Thalassia testudinum* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

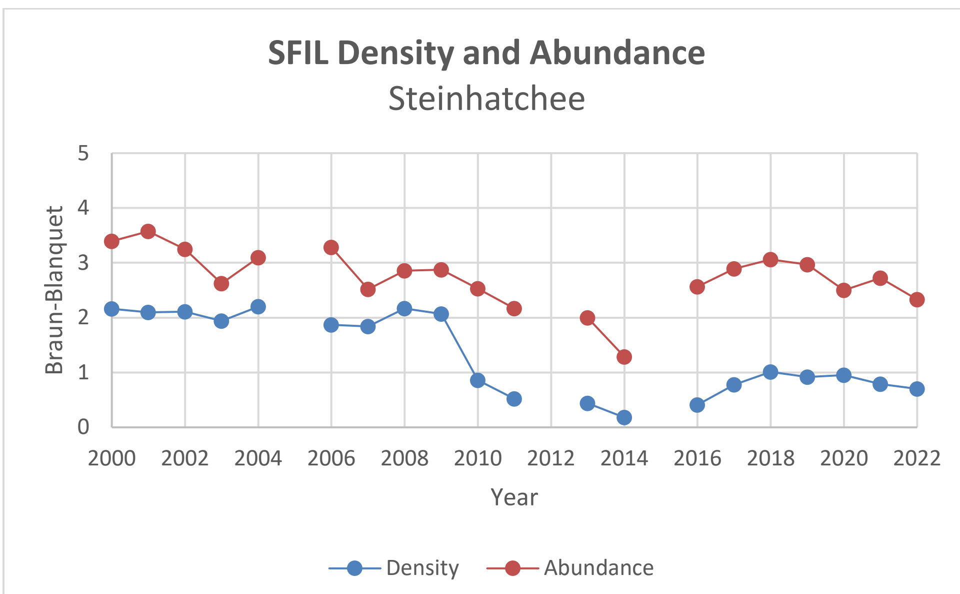

Figure 25. *Syringodium filiforme* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

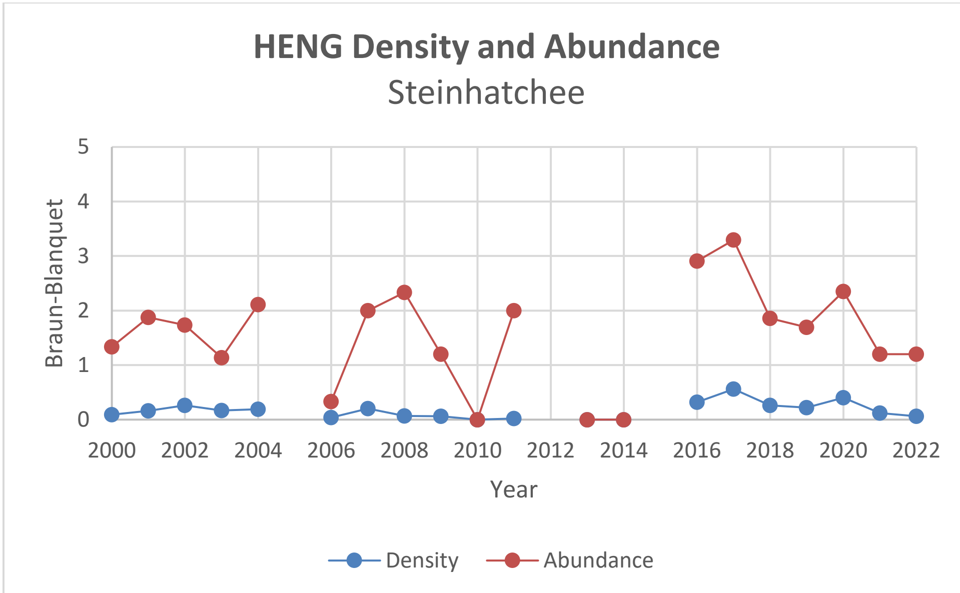

Figure 26. *Halophila engelmannii* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

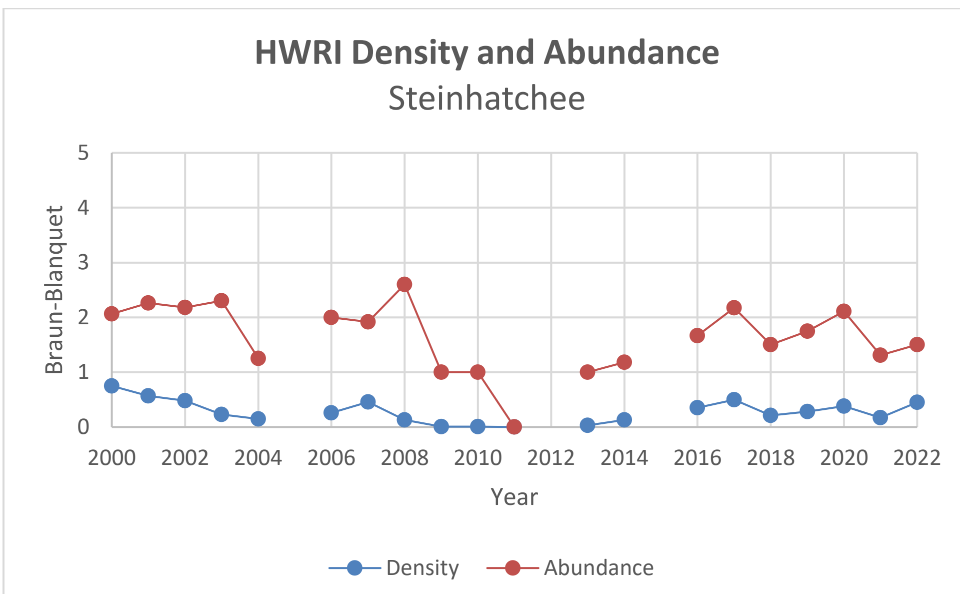

Figure 27. *Halodule wrightii* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

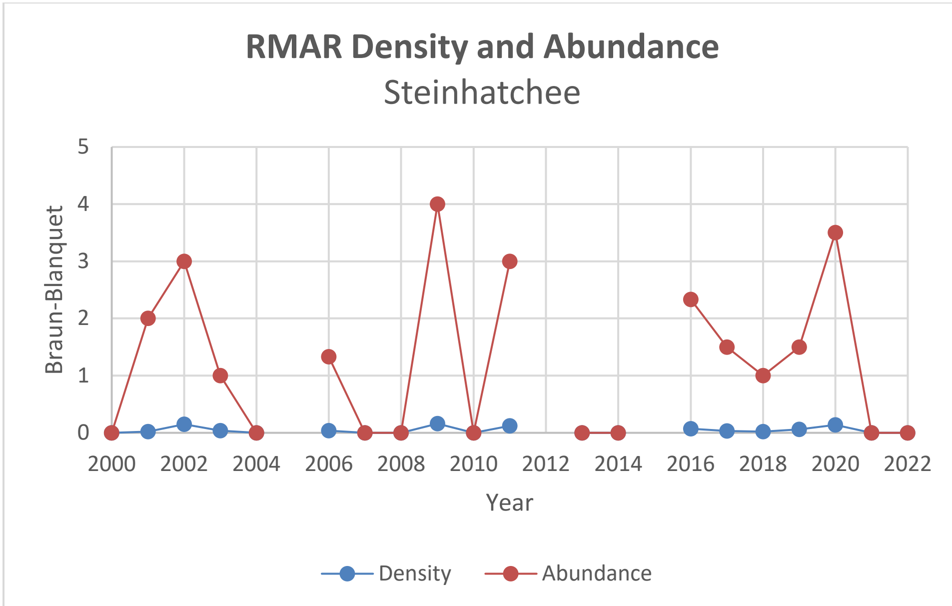

Figure 28. *Ruppia maritima* density (blue) and abundance (red) in Steinhatchee over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

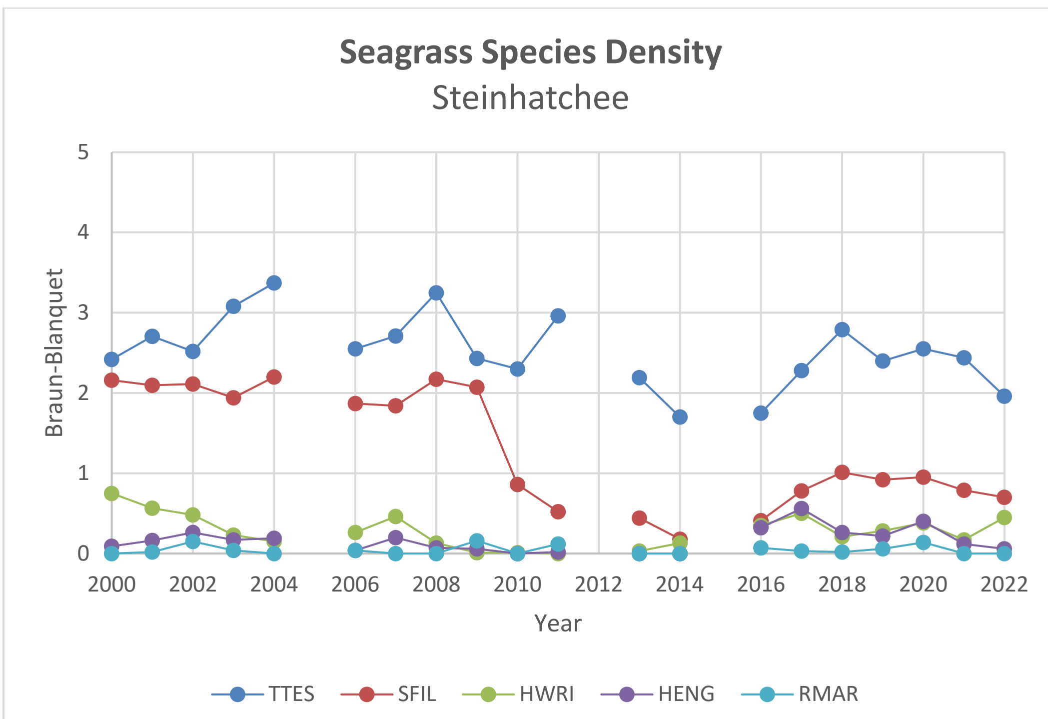

Figure 29. Individual seagrass species densities in Steinhatchee over time. Graph shows that *Thalassia testudinum* is the densest seagrass species found in STCH.

Dekle Beach/Keaton Beach

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. Braun-Blanquet method was used until 2022 when staff switched to percent cover assessments.

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). Data collected after 2016 shows that *T. testudinum* is 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). Data recorded before 2017 should not be used to determine trends over time with sites recorded after, as they are geographically different. 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.

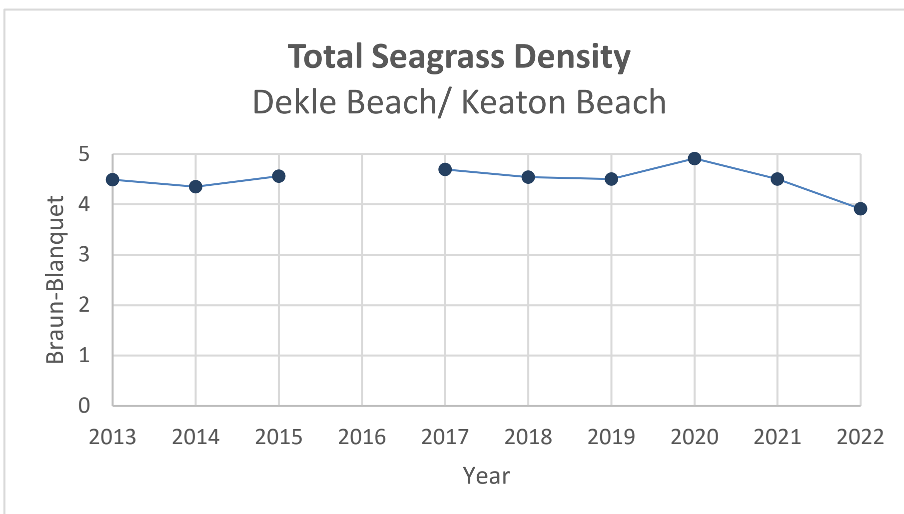

Figure 30. Graph of all seagrass species density combined over time in Dekle Beach/Keaton Beach. Note that sites recorded from 2013-2016 are different locations than 2017-present.

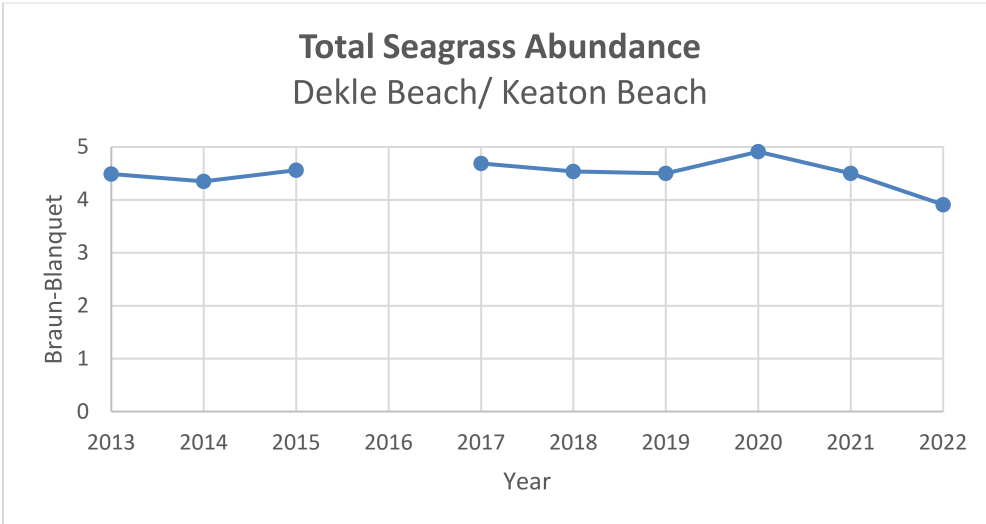

Figure 31. Graph of all seagrass species abundance combined over time in Dekle Beach/Keaton Beach. Note that sites recorded from 2013-2016 are different locations than 2017-present.

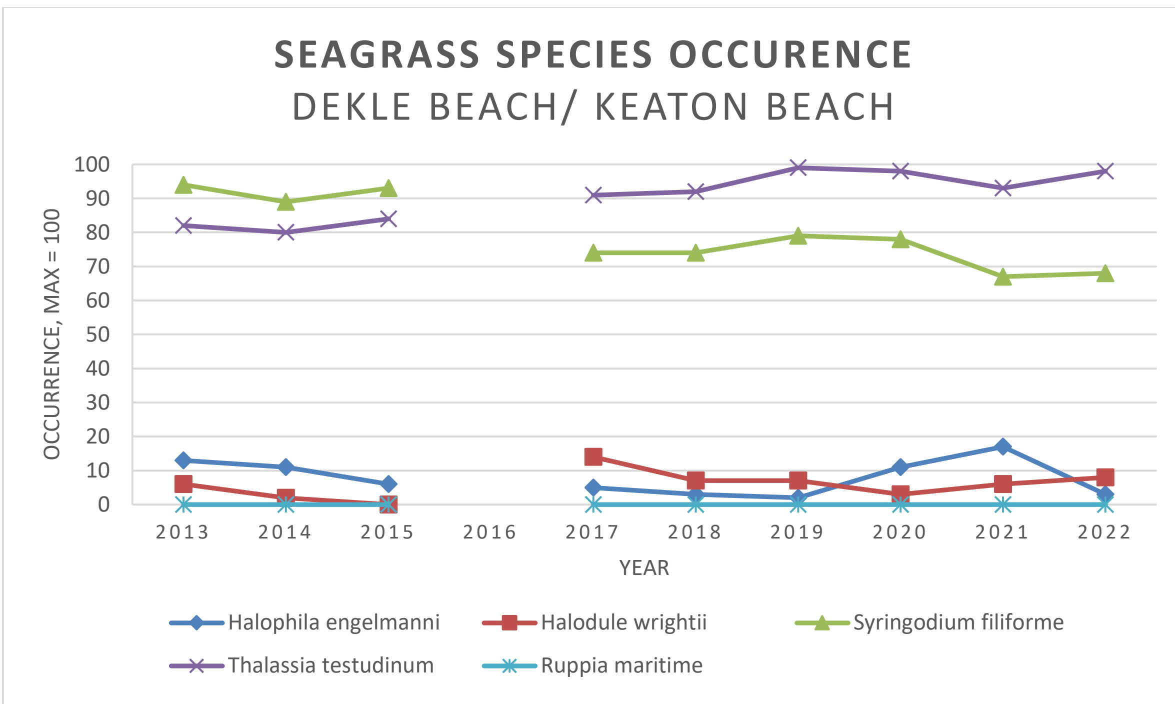

Figure 32. Graph of all seagrass species occurrence (max = 100) over time in Dekle Beach/Keaton Beach. Note that sites recorded from 2013-2016 are different locations than 2017-present.

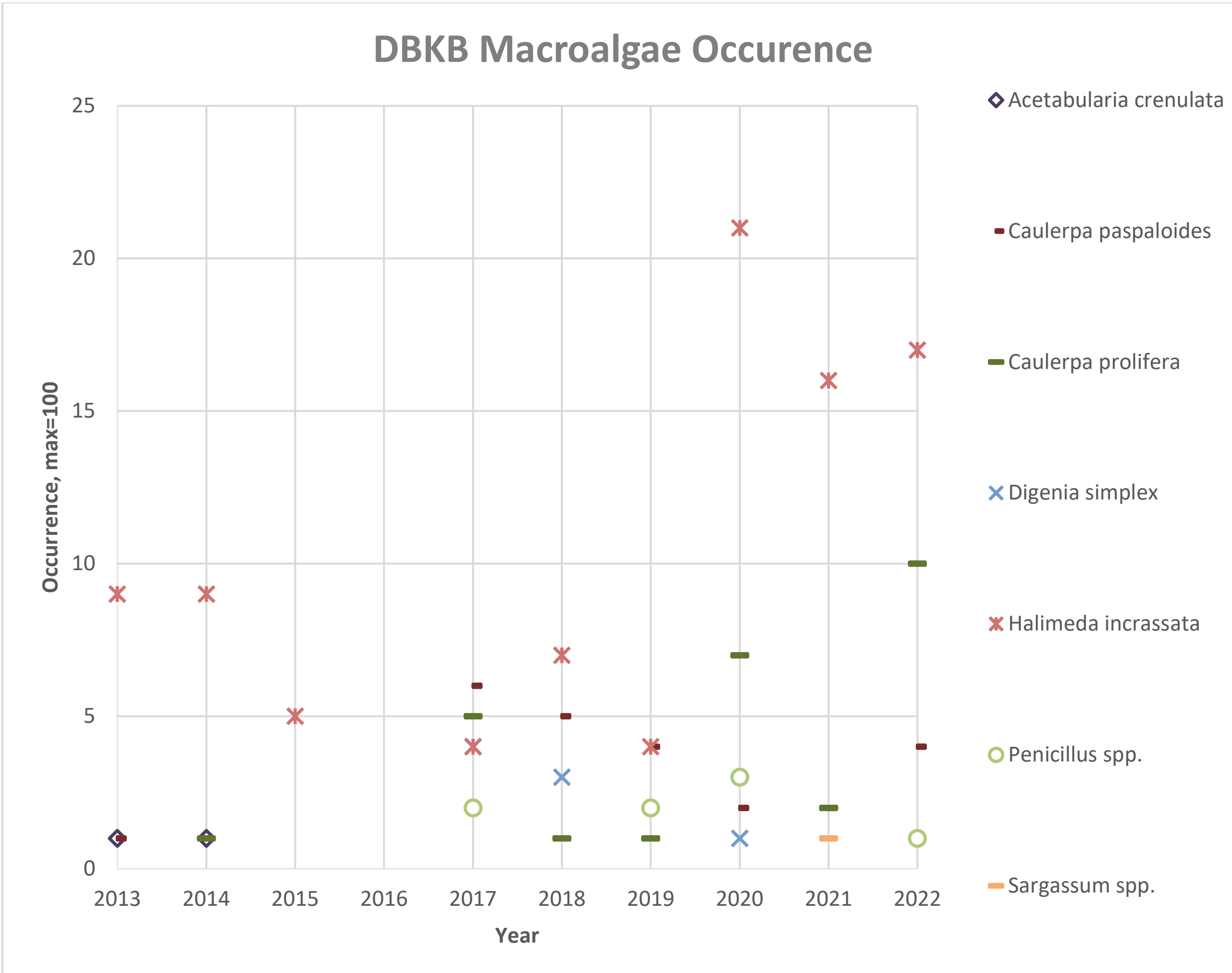

Figure 33. Graph of all macroalgae species occurrence (max = 100) over time in Dekle Beach/Keaton Beach. Note that sites recorded from 2013-2016 are different locations than 2017-present.

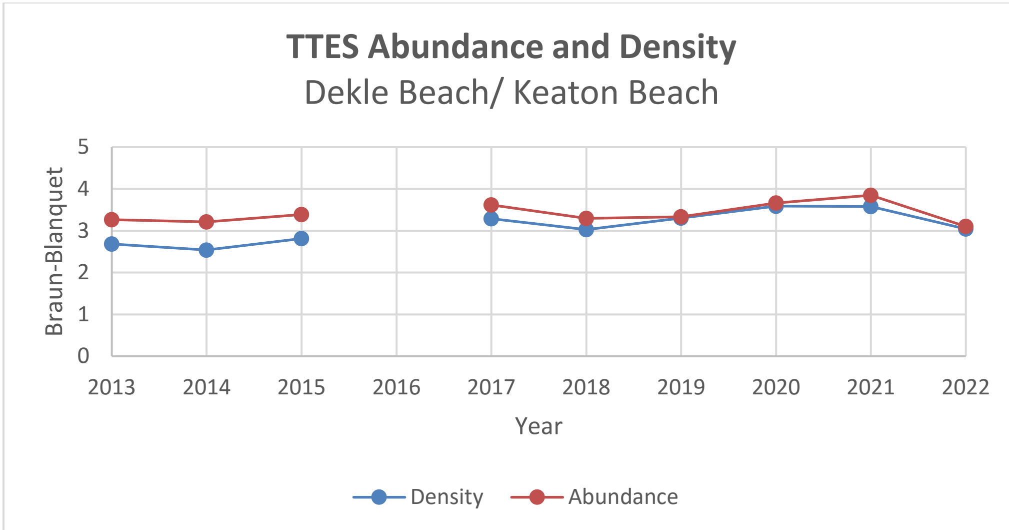

Figure 34. *Thalassia testudinum* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present. Note that sites recorded from 2013-2016 are different locations than 2017-present.

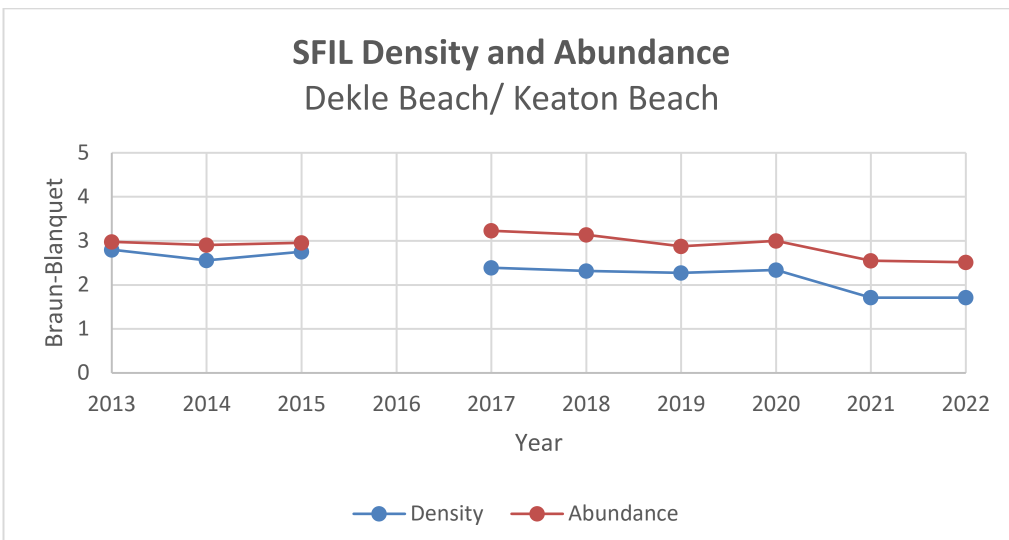

Figure 35. *Syringodium filiforme* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present. Note that sites recorded from 2013-2016 are different locations than 2017-present.

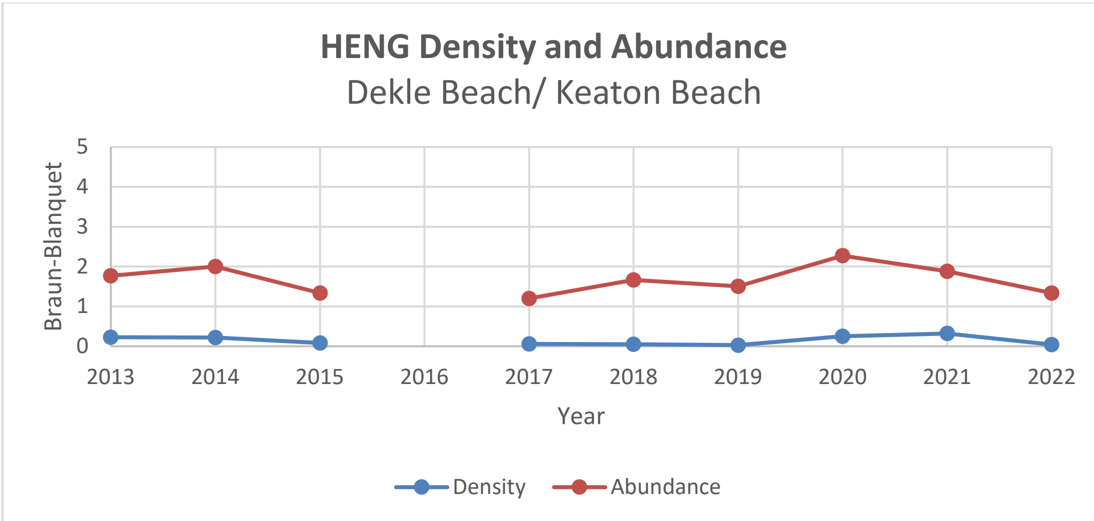

Figure 36. *Halophila engelmannii* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present. Note that sites recorded from 2013-2016 are different locations than 2017-present.

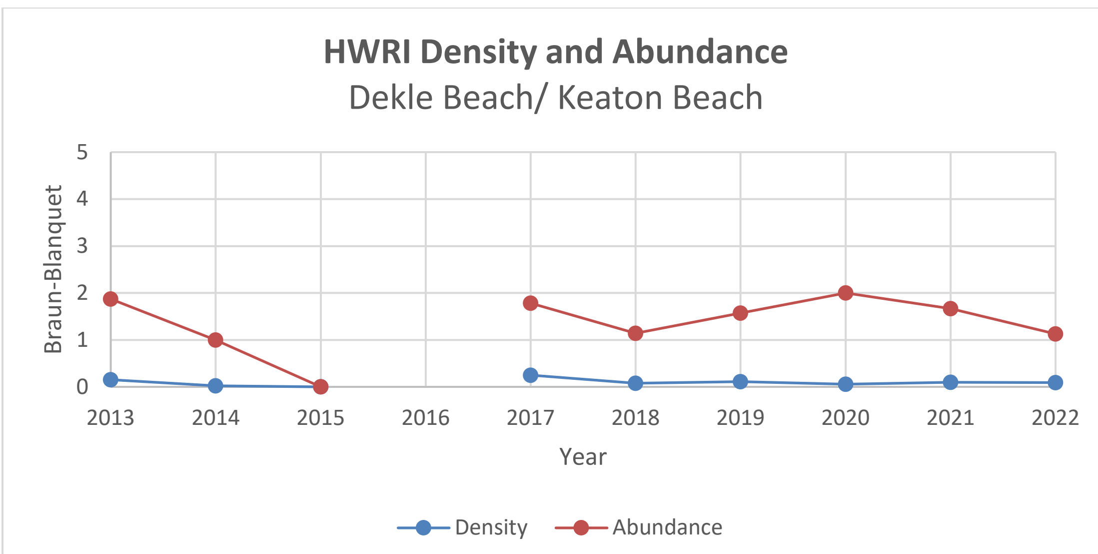

Figure 37. *Halodule wrightii* density (blue) and abundance (red) in Dekle Beach/Keaton Beach over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present. Note that sites recorded from 2013-2016 are different locations than 2017-present.

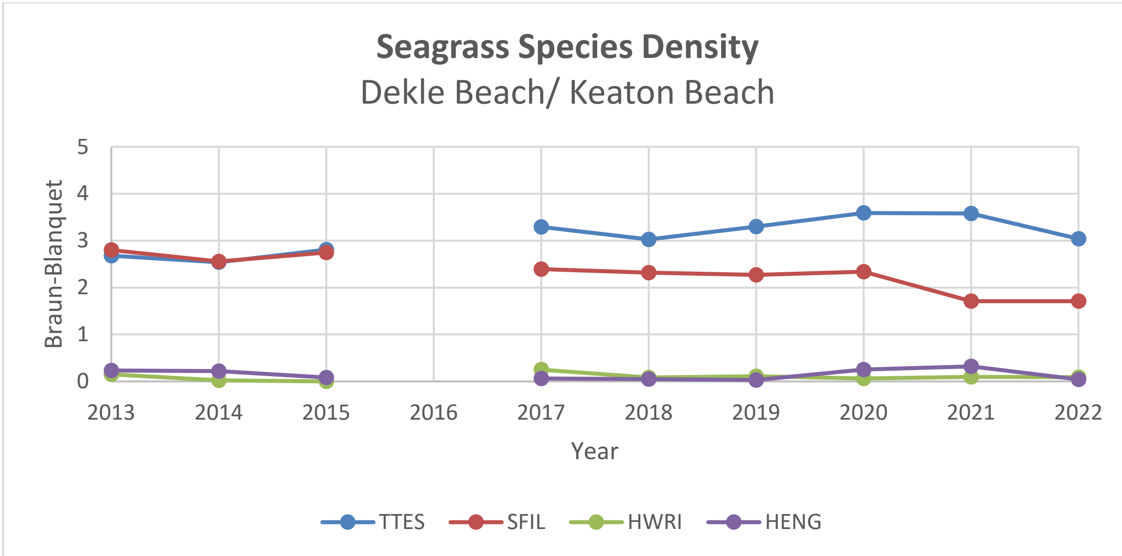

Figure 38. Individual seagrass species densities in Dekle Beach/Keaton Beach over time. Graph shows that *T. testudinum* is the densest seagrass species found in DBKB. *R. maritima* has not been observed in DBKB. Note that sites recorded from 2013-2016 are different locations than 2017-present.

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 turbidity plume in the Gulf of Mexico, and the dark water prevented staff from completing sampling. Staff have documented four species of seagrass and 14 species of macroalgae in St. Marks. Braun-Blanquet assessment was used until 2022, when staff switched to percent cover assessment methods.

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 and sparingly since the initial documentation.

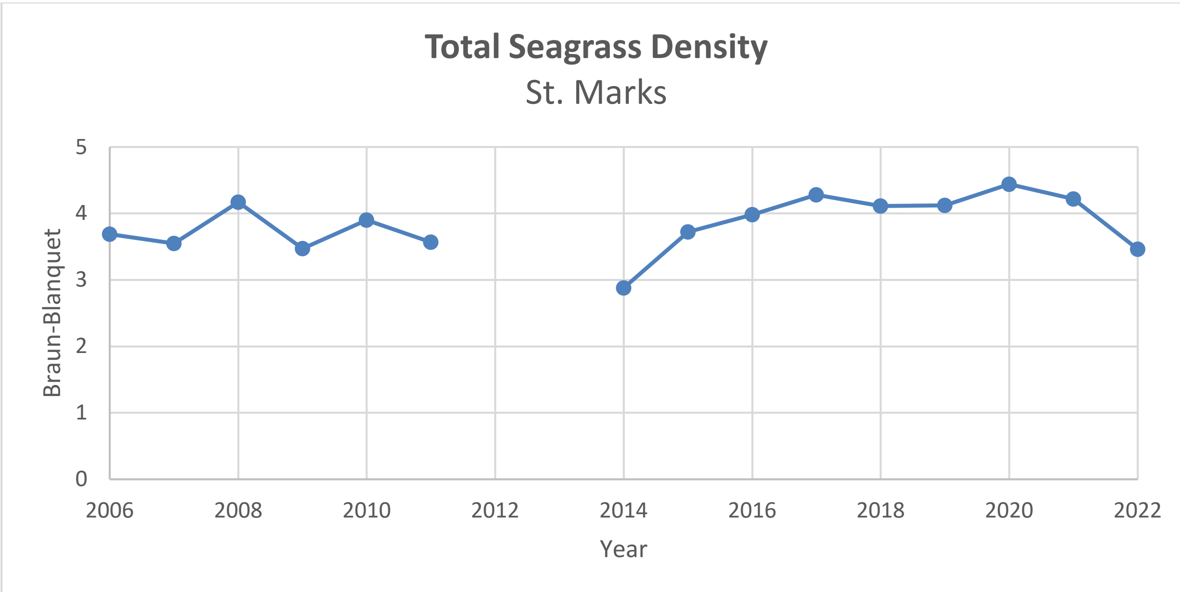

Figure 39. All seagrass species density combined for all sites in St. Marks over time.

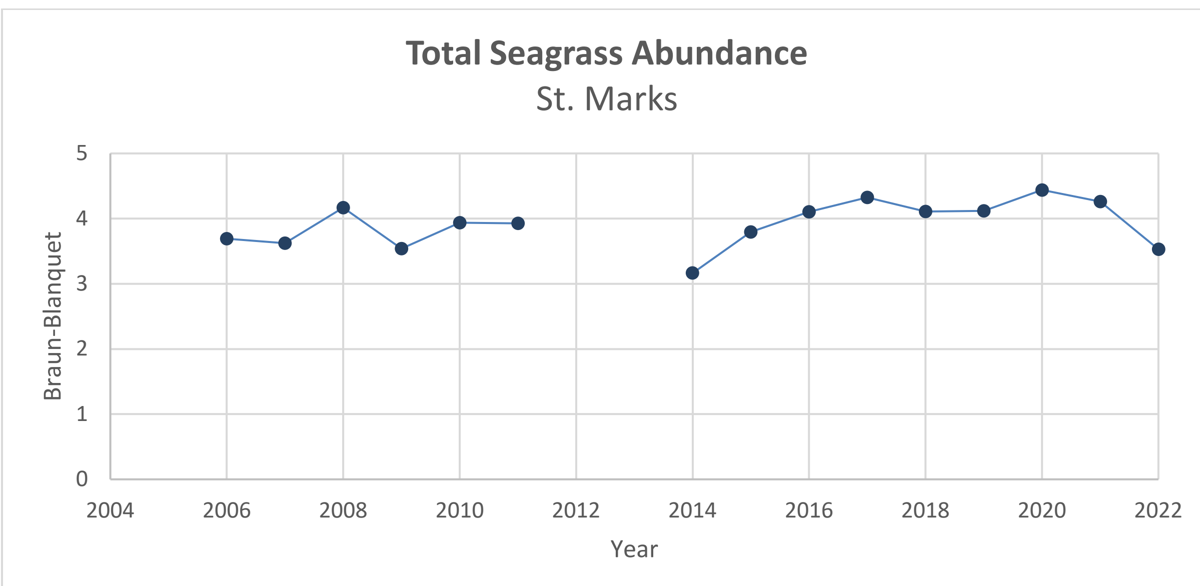

Figure 40. All seagrass species abundance combined for all sites in St. Marks over time.

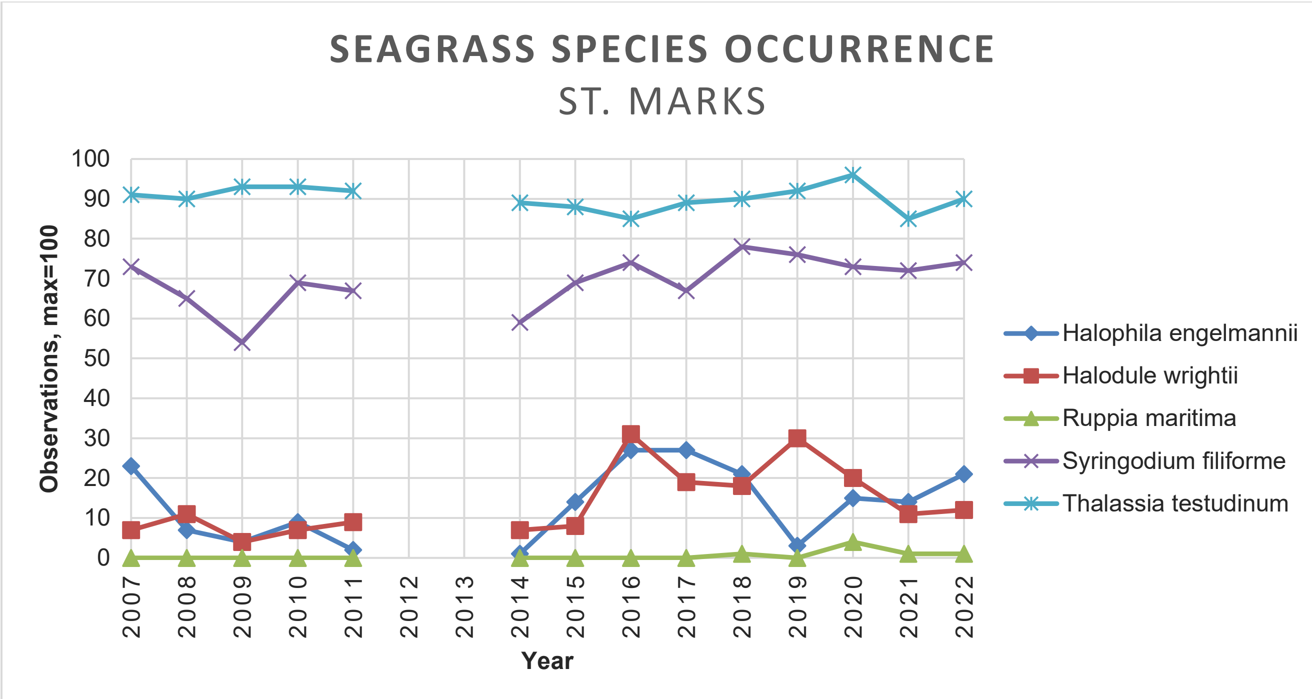

Figure 41. Graph of all seagrass species occurrence (max = 100) over time in St. Marks.

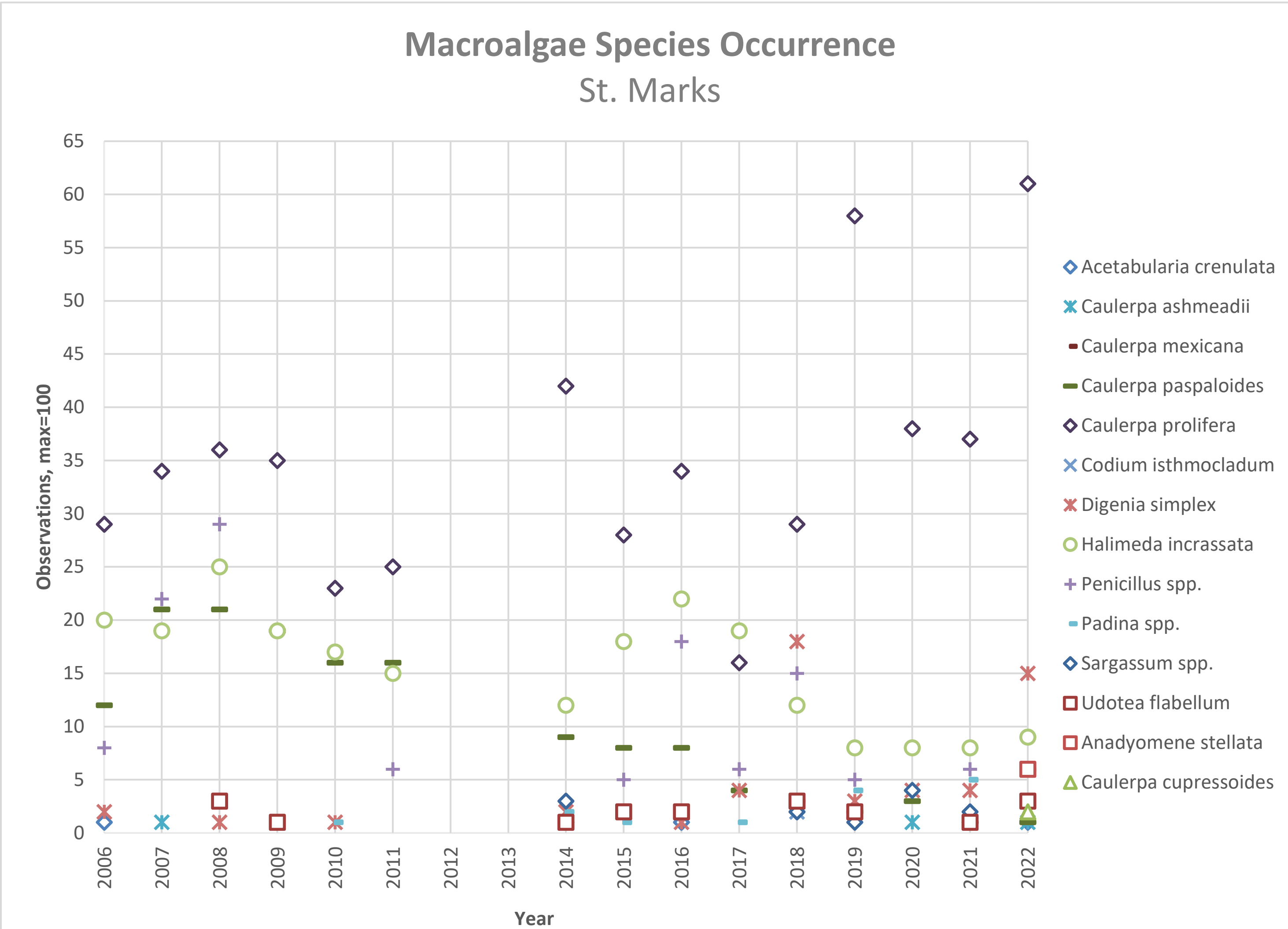

Figure 42. Graph of all macroalgae species occurrence (max = 100) over time in St. Marks.

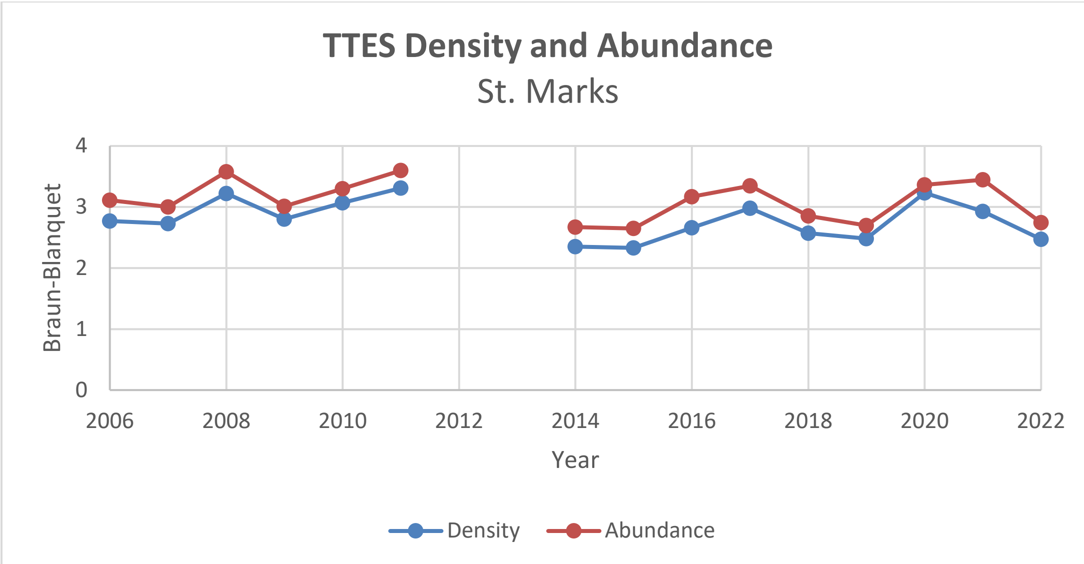

Figure 43. *Thalassia testudinum* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

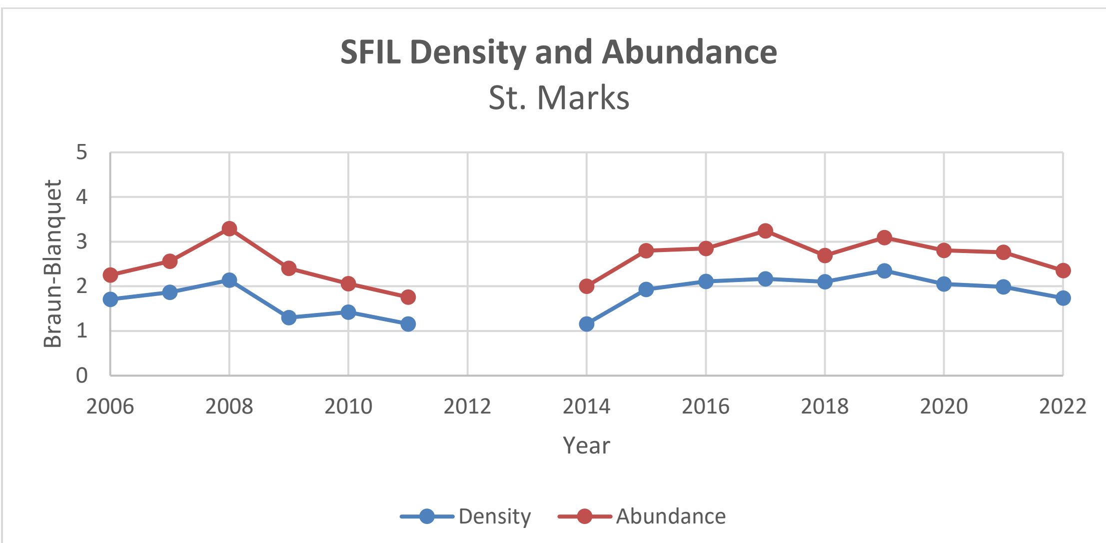

Figure 44. *Syringodium filiforme* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

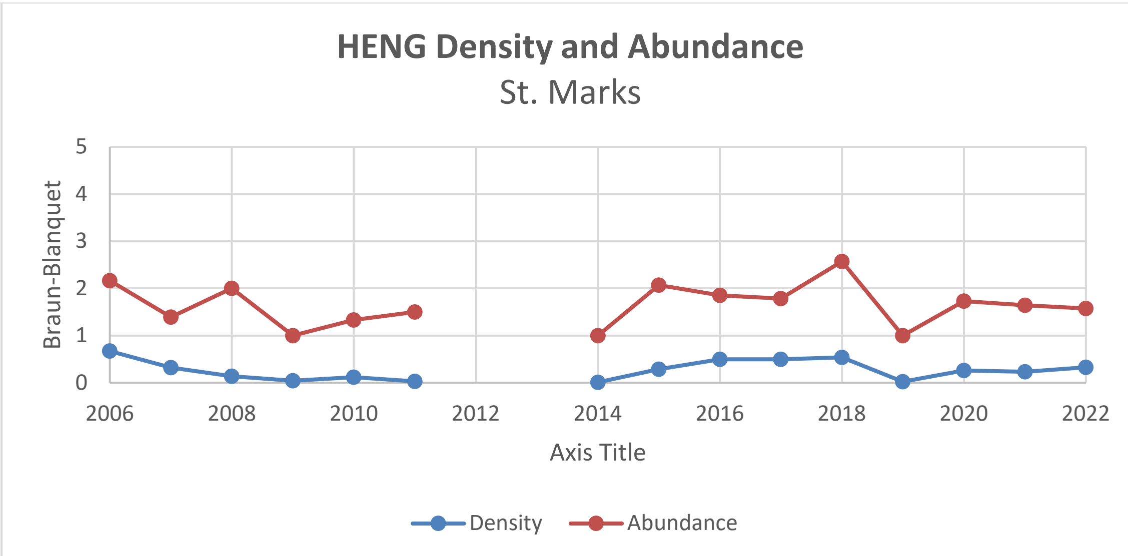

Figure 45. *Halophila engelmannii* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

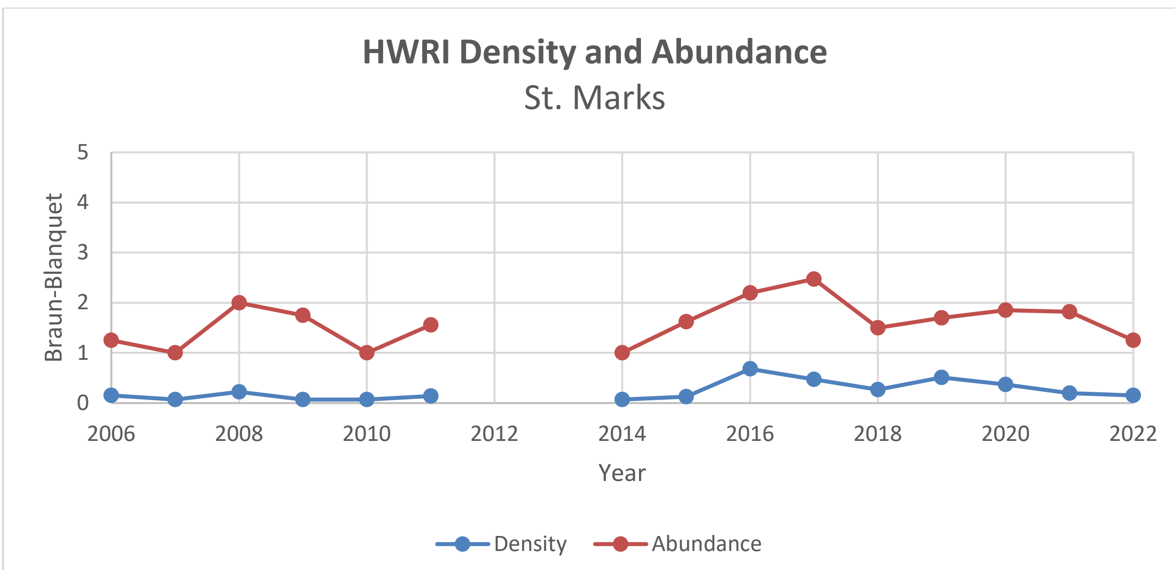

Figure 46. *Halodule wrightii* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

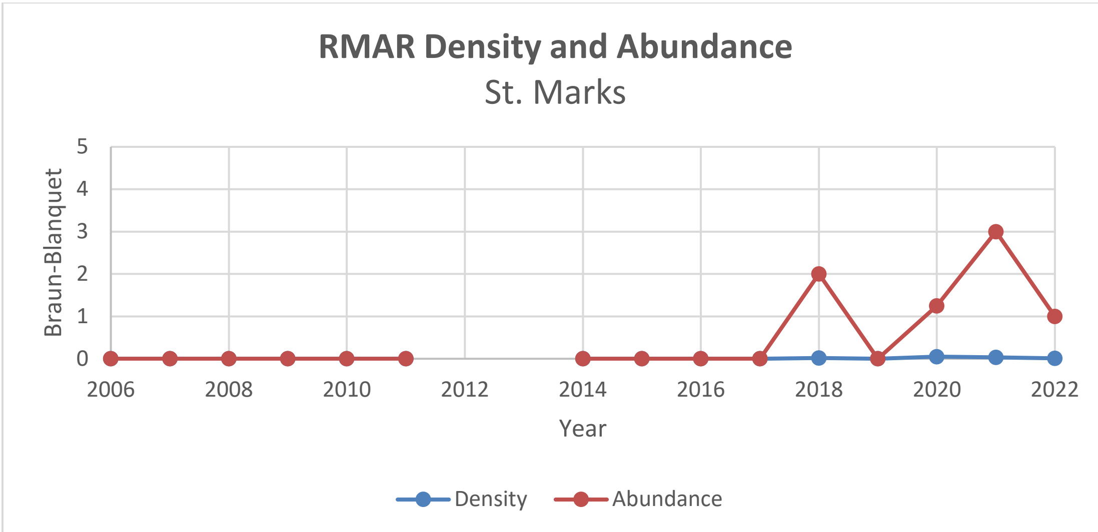

Figure 47. *Ruppia maritima* density (blue) and abundance (red) in St. Marks over time. Abundance is greater than or equal to density because it measures the sum of the BB scores only where that species was present, excluding any quadrats that did not have any of the species present.

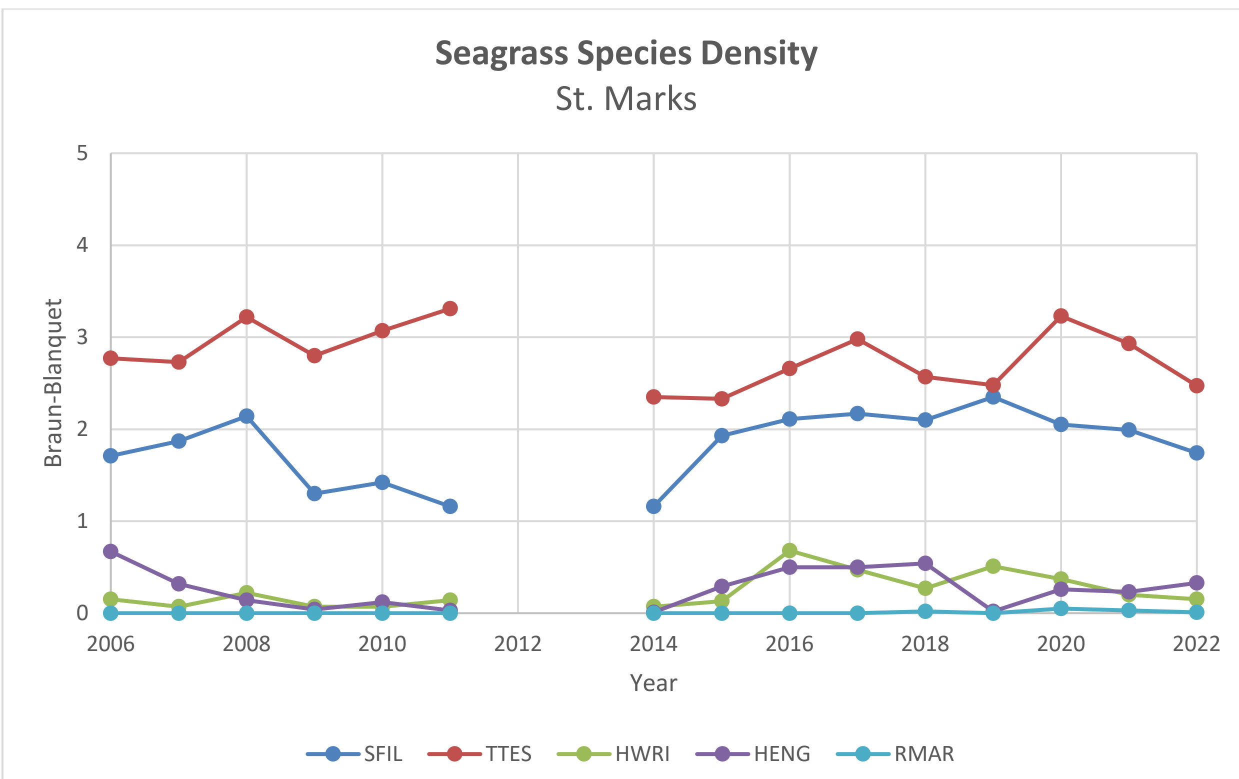

Figure 48. Individual seagrass species densities in SMAR over time. Graph shows that *T. testudinum* is the densest seagrass species found in St. Marks.

Discussion

St. Martins Marsh

There are no notable trends in St. Martins Marsh for the overall seagrass density and abundance from 1997 through 2022. Using the Mann-Kendall trend test for monotonic trends overall seagrass data has no trend and is not considered statistically significant. This should be closely monitored over the next few years to observe if seagrass density and abundance begins to decline in St. Martins Marsh. If needed, management actions should be adjusted to reduce these impacts. There is a significant increasing trend of *T. testudinum* over time in SID (Figure 49). There is a significant decline of *S. filiforme* over time in SID (Figure 50). There is a significant decline of H. wrightii over time in SID (Figure 51).

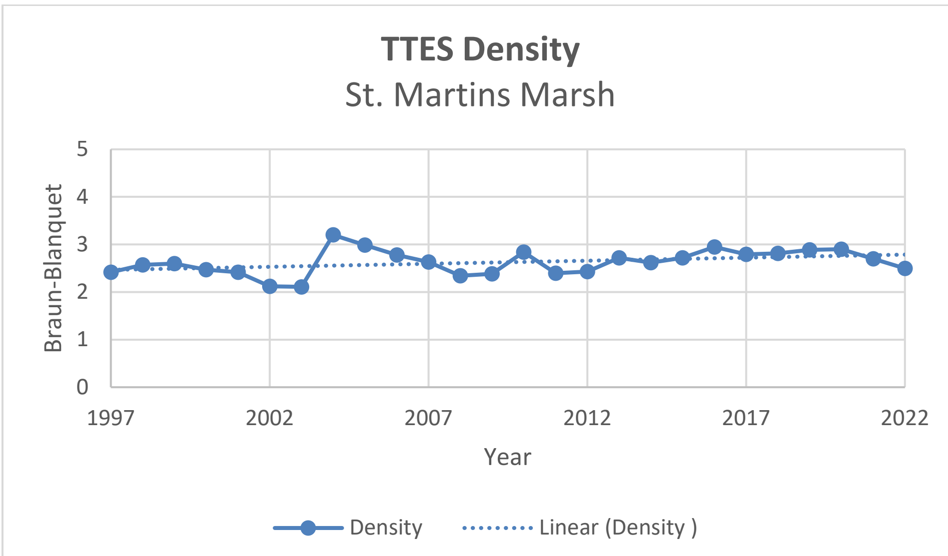

Figure 49. For all collection years in SID, TTES has been experiencing a slight, statistically significant increasing trend using the Mann-Kendall test for monotonic trends. The two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0119. A one-tailed M-K test was run to determine the direction of the trend, the test resulted in a positive trend with p-value of 0.0059. The Sen's Slope is 0.01857, meaning the slope is increasing at that rate on average over time. This shows that there is a slight increase in TTES over time in SID with a significant p-value at a confidence interval of 95%.

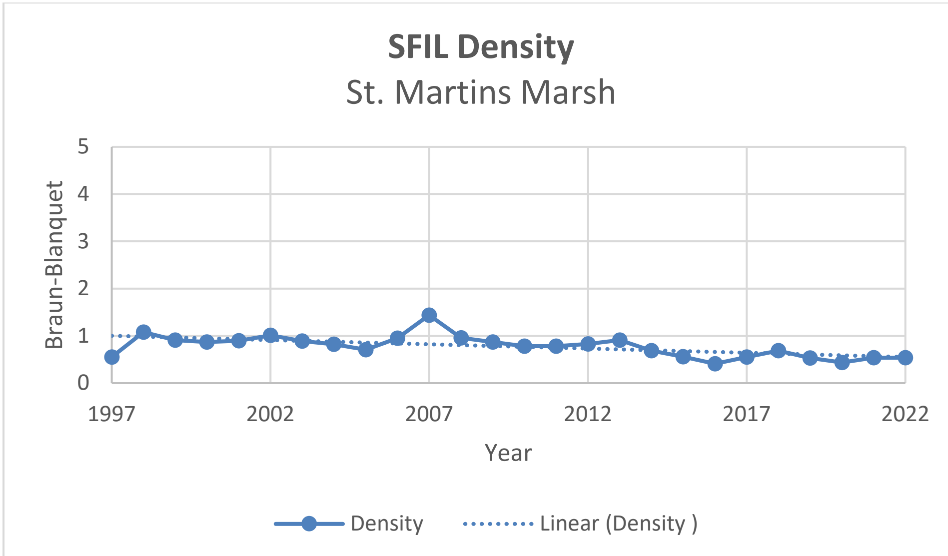

Figure 50. For all collection years in SID, SFIL has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. The two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0002. A one-tailed M-K test was run to determine the direction of the trend, the test resulted in a negative trend with p-value of 0.0001. The Sen's Slope is -0.0194, meaning the slope is decreasing at that rate on average over time. This shows that there is a decrease in SFIL over time in SID with a significant p-value at a confidence interval of 95%.

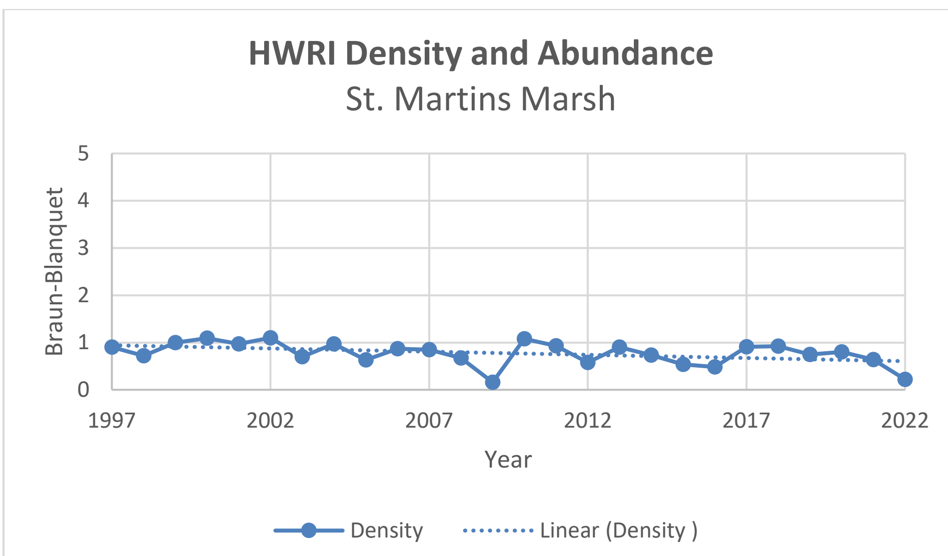

Figure 51. For all collection years in SID, HWRI has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. The two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0245. A one-tailed M-K test was run to determine the direction of the trend, the test resulted in a negative trend with p-value of 0.0122. The Sen's Slope is -0.0133, meaning the slope is decreasing at that rate on average over time. This shows that there is a slight decrease in SFIL over time in SID with a significant p-value at a confidence interval of 95%.

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 such as erosion, strong wave energy, and changes in water quality from increased rainfall and turbid run-off (Wilson, 2020). Every storm has different windspeeds, rainfall, and tracks causing unique effects on each area. Not all areas within the same region may exhibit similar changes from the same storm, some sites may experience more loss than others. Cedar Key has a relatively high frequency of hurricanes and other storms, which may be a main driver of overall seagrass density and abundance loss over time and should be closely monitored (Figure 52). Due to 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. Cedar Key also has significantly trending declines in *T. testudinum* and *S. filiforme* densities over time, which contributes to the total seagrass loss (Figures 53 & 54).

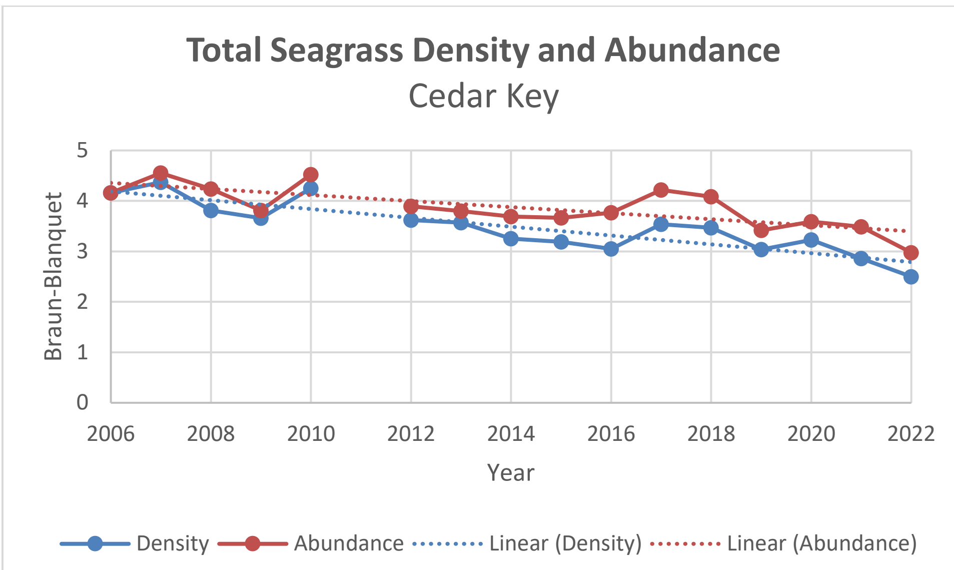

Figure 52. For all collection years in CK, total seagrass density and abundance has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. For density a two-tailed M-K test shows that there is a trend in the data with a p-value of 2.83E-05. A one-tailed M-K test was run to determine the direction of the trend, the test resulted in a negative trend with p-value of 1.41E-05. The Sen's Slope is -0.0958, meaning the slope is decreasing at that rate on average over time. For abundance a two-tailed M-K test shows that there is a trend in the data with a p-value of 0.001. A one-tailed M-K test was run to determine the direction of the trend, the test resulted in a negative trend with p-value of 0.0005. The Sen's Slope is -0.0623, meaning the slope is decreasing at that rate on average over time. This shows that there is a strong decrease in total seagrass density and abundance over time in CK with significant p-values at a confidence interval of 95%.

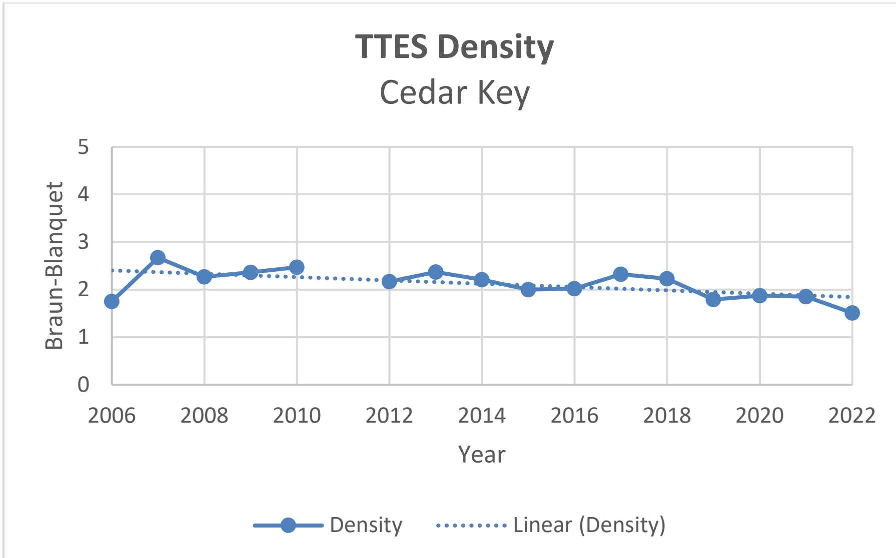

Figure 53. For all collection years in CK, TTES density has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. A two-tailed M-K test shows that there is a trend in the data with a p-value of 0.017. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted in a negative trend with p-value of 0.0085. The Sen's Slope is -0.0485, meaning the slope is decreasing at that rate on average over time. This shows that there is a decrease in TTES density over time in CK with significant p-values at a confidence interval of 95%.

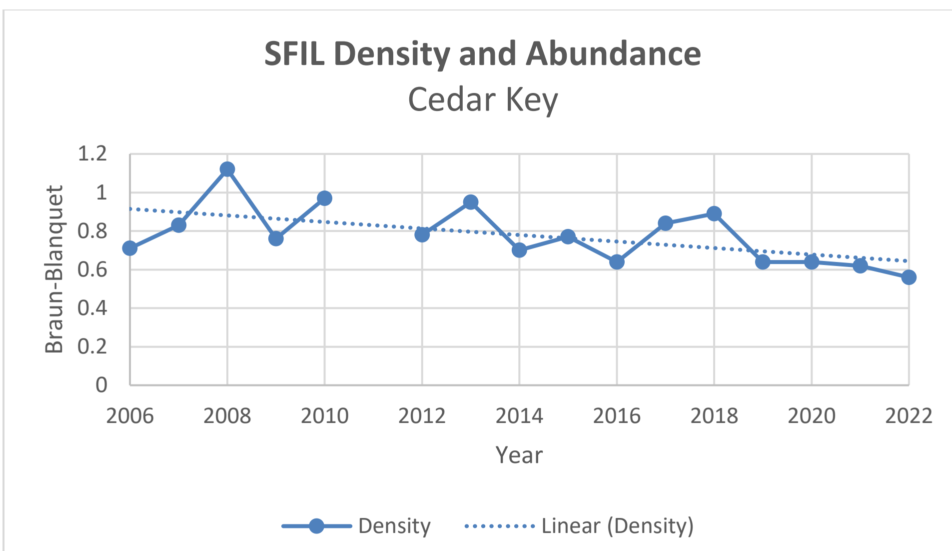

Figure 54. For all collection years in CK, SFIL density has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. A two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0147. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted in a negative trend with p-value of 0.0073. The Sen's Slope is -0.0174, meaning the slope is decreasing at that rate on average over time. This shows that there is a decrease in SFIL density over time in CK with significant p-values at a confidence interval of 95%.

Steinhatchee

Using the Mann-Kendall test significant trends were determined in Steinhatchee. Unfavorable weather conditions caused staff to be unable to record data for three separate years. The M-K test was necessary here due to its ability work with data gaps. Steinhatchee has a significant trend in total seagrass density over time (Figure 55). There are also trends in *S. filiforme* density and abundance over time (Figure 56).

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). Seagrass growth can also be impacted by sea urchin grazing and harmful algal blooms (HAB). Phytoplankton blooms can reduce the amount of light able to reach the seagrass. These blooms can be caused by changes in salinity or excess nutrients from runoff, the frequency of HAB is predicted to increase with climate change. 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 confirm 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 the minimum salinity range. Seagrasses can survive exposure to low salinity, but growth rate is impacted. If low salinity conditions persist for an extended period seagrass habitats can thin and decline, where 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).

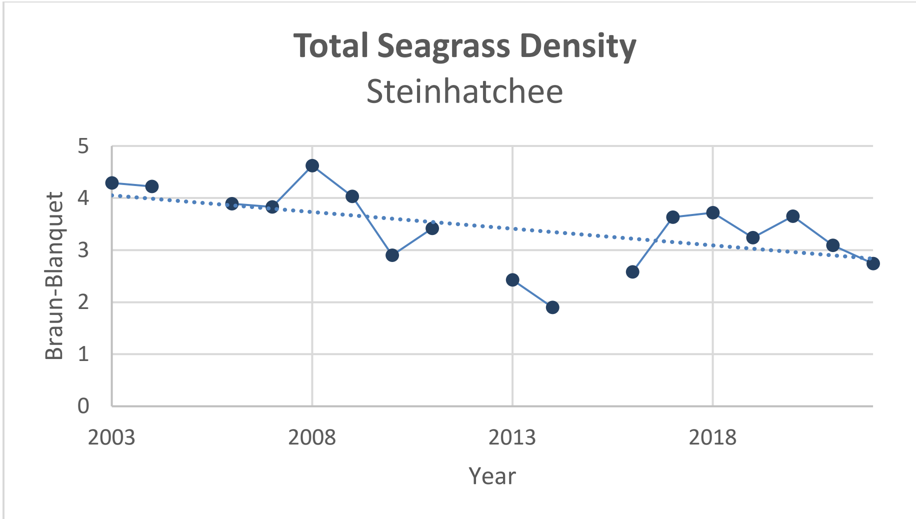

Figure 55. For all collection years in STCH, total seagrass density has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. A two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0151. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted in a negative trend with p-value of 0.0075. The Sen's Slope is -0.08, meaning the slope is decreasing at that rate on average over time. This shows that there is a decrease in total seagrass density over time in STCH with significant p-values at a confidence interval of 95%.

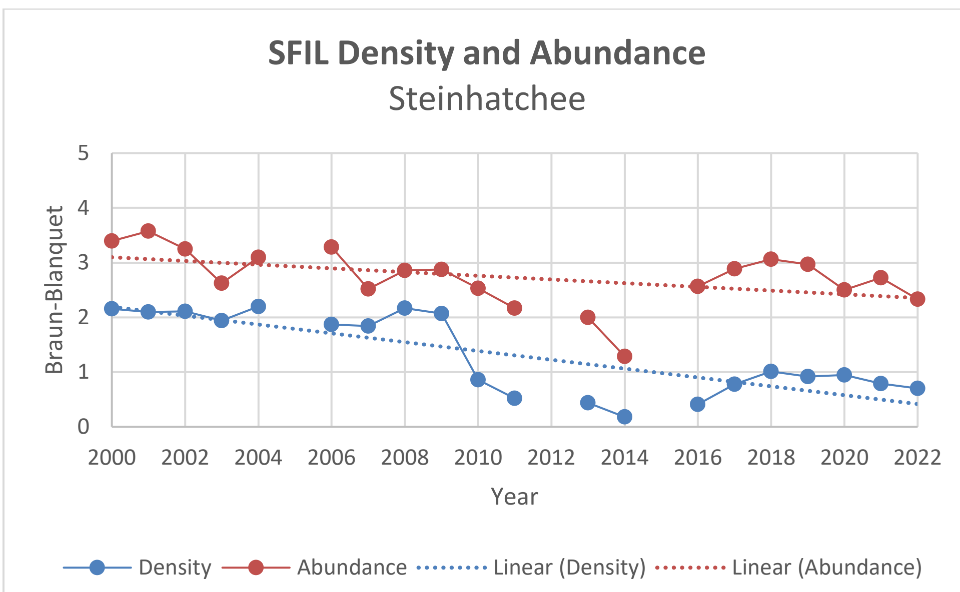

Figure 56. For all collection years in STCH, SFIL density and abundance has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. For density a two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0021. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted in a negative trend with p-value of 0.001. The Sen's Slope is -0.0817, meaning the slope is decreasing at that rate on average over time. For abundance a two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0212. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted

in a negative trend with p-value of 0.0106. The Sen's Slope is -0.0448, meaning the slope is decreasing at that rate on average over time. This shows that there is a decrease in SFIL density and abundance over time in STCH with significant p-values at a confidence interval of 95%.

Dekle Beach/ Keaton Beach

There are no significant trends in total seagrass density and abundance in Dekle Beach/Keaton Beach. Trend analysis can only be conducted for sites recorded after the location change in 2017 for best practices. Data from 2013-2016 is available upon request. There is a significant trend in *S. filiforme* abundance (Figure 57).

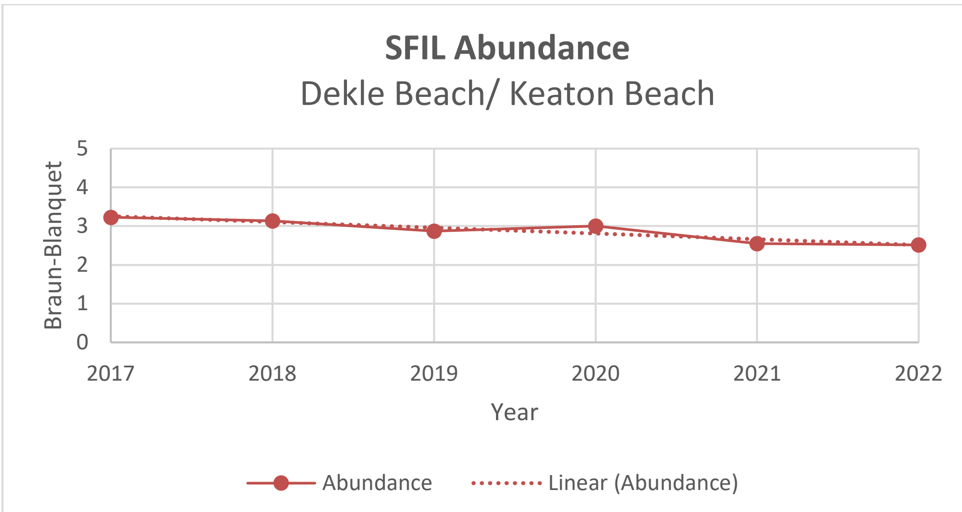

Figure 57. For 2017-2022 in DBKB, SFIL abundance has been experiencing a statistically significant decreasing trend using the Mann-Kendall test for monotonic trends. A two-tailed M-K test shows that there is a trend in the data with a p-value of 0.0242. A one-tailed M-K test was run to determine the direction of the trend. The one-tail test resulted in a negative trend with p-value of 0.0121. The Sen's Slope is -0.1551, meaning the slope is decreasing at that rate on average over time. This shows that there is a strong decrease in SFIL abundance in DBKB with significant p-values at a confidence interval of 95%.

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.

There were no statistically significant trends for any species or overall totals. Further monitoring will be useful to track trends in shifts of species. The protocol switch to percent cover and continuing consistent monitoring could show more notable changes in seagrass species composition in the future.

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 depressions, 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 (4)	125 mph	SID, CK, STCH, DBKB, SMAR
Ivan	September 15-16, 2004	Hurricane (5)	145 mph	SMAR
Jeanne	September 26-27, 2004	Hurricane (3)	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 (1)	70 mph	SID, CK, STCH, DBKB, SMAR
Irma	September 9-12, 2017	Hurricane (5)	155 mph	SID, CK, STCH, DBKB, SMAR
Michael	October 9-10, 2018	Hurricane (5)	160 mph	SID, CK, STCH, DBKB, SMAR
Eta	November 11-13, 2020	Hurricane (4)	130 mph	CK
Elsa	July 7-8, 2021	Hurricane (1)	85 mph	SID, CK, STCH, DBKB, SMAR
Fred	August 15-16, 2021	Tropical Storm	65 mph	SMAR
Ian	September 28-30, 2022	Hurricane (5)	150 mph	SID, CK, STCH, DBKB
Nicole	November 10, 2022	Hurricane (1)	75 mph	SID, CK, STCH, DBKB, SMAR

*Category from Saffir-Simpson score is from the strongest point in the storm

**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.

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