Citizen Science Seagrass Monitoring Report 2022

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Executive Summary

Seagrass beds are important habitats in many shallow coastal environments. They provide refuge, foraging and nursery areas for a diverse faunal community including many commercially important and endangered species. Historically and in the present, the largest and most extensive seagrass beds occur in Santa Rosa Sound and Big Lagoon. The report describes results from 2022 and synthesizes the 6 years of the Citizen Science Seagrass Monitoring program by citizen scientists and UWF students. In addition, it provides an in-depth summary of water quality conditions in Santa Rosa Sound.

Most of the sampling effort has been focused on locations in Big Lagoon and Santa Rosa Sound. Citizens interested in the Pensacola urban bayous (Grande, Chico and Texar) and Project Greenshores in Pensacola Bay have collected samples at these locations as well. Citizens sampled monthly at their chosen location during the seagrass growing season between May and either September or October. Grab water samples were collected and refrigerated until they were sent to UWF for processing for total suspended solids and salinity. Once or twice per year water quality measurements including light attenuation and water samples were collected by UWF students for analysis of dissolved inorganic nutrients, chlorophyll a and total suspended solids.

Twenty-three citizen volunteers participated in 2022, sampling at 11 different locations. Three new sampling areas (Choctawhatchee Bay, Bayou Texar, and Project Greenshores in Pensacola Bay) were added in 2022. Seagrass cover was generally above 80% in Big Lagoon and 53% in Santa Rosa Sound. *Halodule wrightii* (Shoal grass) was the dominant species at most locations. At Big Lagoon State Park, seagrass cover was higher in 2022 than previous years. *Ruppia maritima* dominated in Bayou Grande, Project Greenshore and in Choctawhatchee Bay, while the freshwater species, *Vallisneria americana*, dominated in Bayou Texar. The occurrence of drift macroalgae was highly variable.

Salinity in Big Lagoon and Santa Rosa Sound was low in 2017 and 2021 reflecting higher freshwater inputs during those years. Total suspended solids were usually less than 20 mg/L at all locations (Big Lagoon, Santa Rosa Sound and urban bayous), although 2022 had higher values than previous years, particularly in Santa Rosa Sound. Light attenuation reflects the light availability at different water depths. It is influenced by particulates (inorganic and organic) and colored dissolved organic matter. Average light attenuation was 0.87 m^{-1} in Big Lagoon and 0.7 m^{-1} in Santa Rosa Sound. Chlorophyll a concentrations are a measure of phytoplankton biomass. In Big Lagoon and Santa Rosa Sound values were usually less than 10 µg/L. Nutrient levels were usually low in both Big Lagoon and Santa Rosa Sound.

Introduction

Seagrass beds are important habitats in many shallow coastal environments. They provide refuge, foraging and nursery areas for a diverse faunal community including many commercially important and endangered species. Seagrasses are a dominant component of the diet of manatees and sea turtles. Carbon fixed by seagrasses flows through food webs and can be stored in sediments, which has been termed "blue carbon". Seagrasses alter nutrient levels directly by uptake and indirectly altering redox conditions in sediments which in turn, affects nutrient cycling by microbial communities.

The first systematic assessment of submerged aquatic vegetation (SAV) and seagrasses in the Pensacola Bay system occurred with the publication of the Escambia Bay Recovery Report (EPA 1975). Florida Department of Transportation aerial photographs were used to map historical coverage. Overflights in 1974 and 1975 were used to survey existing beds. Further mapping efforts by the US Geological Survey (Schwenning et al 2007), US Environmental Protection Agency (Lores et al. 2000, Lewis et al. 2008) and the Florida Wildlife Research Institute (Harvey et al. 2015, Byron et al. 2018) provide more recent assessments of SAV and seagrass coverage in the Pensacola Bay system. Historically and in the present, the largest and most extensive seagrass beds occur in Santa Rosa Sound and Big Lagoon (Schwenning et al. 2007, Byron et al. 2018). Extensive beds of freshwater species, particularly, *Vallisneria americana*, occur in the Escambia, Blackwater and Yellow River deltas.

Escambia, East and Pensacola Bays had an 80% decline in seagrass acreage between 1960 and 1980 (Schwenning et al. 2007). Seagrass acreage declined by 43% in Santa Rosa Sound and 13% in Big Lagoon over this same period (Schwenning et al. 2007). Seagrass acreage since 1992 has been stable with some increases (Schwenning et al. 2007), particularly between 2010 and 2015 (Byron et al. 2018). The dominant seagrasses are *Halodule wrightii*, shoal grass; *Thalassia testudinum*, turtlegrass; and *Ruppia maritima*, widgeon grass. *T. testudinum* is a climax species which has the highest productivity when salinities are between 30 and 40, but rapidly declines at salinities less than 15 (Lirman and Cropper 2003). *H. wrightii* is a pioneering species, capable of colonization when light and nutrients are high with a broad salinity tolerance (10-35 PSU)

(Dunton 1996, Lirman and Cropper 2003). *R. maritima* occurs in both freshwater and marine environments.

Periodic monitoring of seagrass cover in Gulf Islands National Seashore (GUIS) began in 1993 by Dauphin Island Sea Lab (Heck and Byron 2014). Other organizations (FWRI, Dauphin Island Sea Lab (DISL), and the University of West Florida) have also periodically monitored seagrass cover outside of GUIS. In 2016, percent cover in *H. wrightii* and *T. testudinum* beds ranged from 34 to 57% (Byron et al. 2018). This was one component of an extensive study of seagrasses that was conducted FWRI, DISL and UWF researchers as part of the Roadblocks to Seagrass Recover project funded by the National Fish and Wildlife Foundation (FWRI 2020). After the completion of this project, we established the citizen science seagrass monitoring program to support two goals: to develop a network of citizen scientists in the community and establish a long-term monitoring program for seagrass beds outside of GUIS.

The report describes results from 2022 and synthesizes the 6 years of the Citizen Science Seagrass Monitoring program by citizen scientists and UWF students. In addition, it provides an in-depth summary of water quality conditions in Santa Rosa Sound drawing on thesis research by Rachel Presley (Capps 2017, Presley and Caffrey 2021) and Mackenzie Rothfus (Rothfus 2022), data collected as part of the Navarre Beach Marine Science Station BWet grant from NOAA and preliminary results from Caffrey's Distinguished University Professorship project funded by UWF.

Methods

Locations

Most of the sampling effort has been focused on locations in Big Lagoon and Santa Rosa Sound. Citizens interested in the Pensacola urban bayous (Grande, Chico and Texar) and Project Greenshores in Pensacola Bay have collected samples at these locations as well. (Fig. 1).

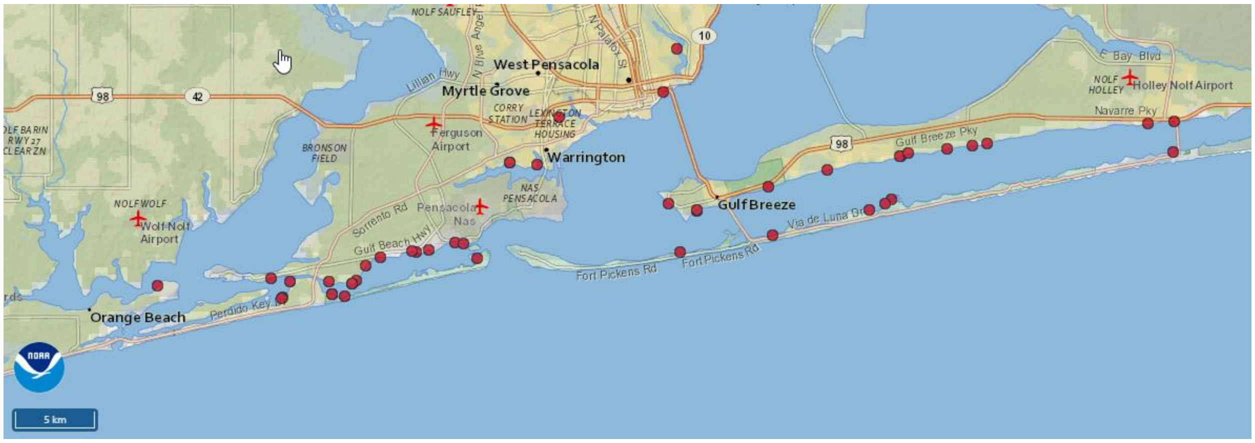

Figure 1 - Location of Citizen Science Seagrass Monitoring Program sampling sites in Pensacola Bay from 2017 to 2022. Image created in NOAA ERMA.

Citizen training

Citizens were recruited by Sea Grant Extension and trained in data collection, sample handling and safety procedures. They sampled monthly at their chosen location during the seagrass growing season between May and either September or October. Each month, citizens used 0.25 m^2 quadrats to measure percent coverage of seagrass and drift macroalgae at 4 locations at their sampling site. They identified seagrass species present and noted whether drift algae were present. Drift algae refers to macroalgae that is in and amongst the seagrass beds. It is often free floating and easy to remove before estimating seagrass cover. It does not include small epiphytic algae attached to seagrass blades. Cover for each seagrass species and drift macroalgae was estimated in 10% increments. Citizens recorded the water depth at each of the four locations along with the maximum length of seagrass blades at that location. All data were recorded on a data sheet. Grab water samples were collected and refrigerated until they were sent to UWF for processing for total suspended solids and salinity.

All water samples were analyzed for Total Suspended Solids (TSS) utilizing EPA method 160.2. Salinity was directly measured using YSI multimeter. UWF students and faculty conducted additional sampling from some sites in Big Lagoon and Santa Rosa Sound several times each year. Water quality measurements (temperature, salinity, dissolved oxygen and pH) were made using a YSI multimeter at the surface and bottom (if the depth was greater than 1 m). Water depth and light attenuation were measured using a secchi disk and light profiles using a LiCor 4 Pi sensor. Grab surface water samples were collected for TSS, nutrients: dissolved inorganic phosphate (DIP), ammonium, nitrite and nitrate, and chlorophyll a. Nutrient and chlorophyll samples were filtered through GF/F filters with filtrate and filters frozen until analysis.

Chlorophyll a was determined on filters extracted with 90% acetone for 24 hours. Samples were centrifuged and filtrate was read on a Turner Designs fluorometer as in Welshmeyer (1994). Filtrate was analyzed for nitrate+nitrite using vanadium reduction as in Schnetger and Lehners (2014). Ammonium analysis followed Holmes et al. (1999) and nitrite and DIP as in Parsons et al. (1984).

Seagrass cover values for 2022 are reported as the average of the 4 quadrats from each individual location. Long term trends in cover have been averaged over the peak growing season (June through August) for each year from all Big Lagoon State Park (BLSP) sites. BLSP has the longest and most consistent records in the program. Similar yearly summer averages were calculated for West Santa Rosa Sound sites which included Shoreline Park, Naval Live Oaks, #3/Park west and Malaga. Seagrass cover in Bayou Grande between 2018 and 2022 was also reported.

Results

Twenty-three citizen volunteers participated in 2022, sampling at 11 different locations. There were 89 citizen volunteers over the 6 years of this program (Table 1, Appendix Table 1). Six have volunteered for at least 4 years while 14 have volunteered for 2 or 3 years. Bayou Grande, Big Lagoon and Santa Rosa Sound were sampled most consistently. Old River in Perdido Bay was sampled the first two years of the program. Several sites were sampled in Bayou Chico and lower Perdido Bay in 2021. Bayou Chico and the other urban bayous can only be sampled when Department of Health *Enterococcus* values are in the good range. Three new sampling areas (Choctawhatchee Bay, Bayou Texar, and Project Greenshores in Pensacola Bay) were added in 2022. In the Choctawhatchee Bay area, samples were collected from Rocky Bayou State Park in the Bay proper and Liza Jackson Park at the eastern end of Santa Rosa Sound.

In Big Lagoon, the most consistent sampling effort has been at Big Lagoon State Park and Johnson Beach in GUIS. There has also been regular sampling in the eastern end of Big Lagoon either just outside or inside Naval Air Station Pensacola. Shoreline Park, Naval Live Oaks (part of GUIS) and near Park West on Santa Rosa Island all in western Santa Rosa Sound have been sampled most frequently. Oriole Beach, Big Sabine Point and several Soundside locations in mid Santa Rosa Sound have been sampled intermittently over the 6-year period. Santa Rosa Sound in the Navarre area was primary sampled in 2019 and 2021.

Table 1 - Citizen Science Volunteer Effort

Estuary	Number of volunteers	Number of times sampled	Years sampled
Bayou Chico	2	2	2021
Bayou Grande	3	18	2018-2022
Bayou Texar	2	4	2022
Big Lagoon	38	93	2017-2022
Choctawhatchee Bay	4	1	2022
Old River	2	9	2018-2019
Pensacola Bay	2	5	2022
Perdido Bay	2	3	2021
Santa Rosa Sound	38	51	2017-2022

Numerous UWF students have participated in the program, with 6 students being supported by the Hal Marcus College of Science and Engineering Summer Undergraduate Research Program. Fifteen undergraduate students have participated as interns, volunteers, or received credit for a directed independent study. In addition, 7 graduate and undergraduate classes have used these locations for collecting samples. Santa Rosa Sound was the primary study location for two completed masters theses (Capps 2017, Rothfus 2022). Big Lagoon was the primary study site for an honors thesis (Figueroa, in prep).

Seagrass Cover estimates

2022 results

Seagrass cover across Big Lagoon was generally above 80%, except at Seaglades which had less than 30% seagrass cover (Fig. 2). *Halodule wrightii* (Shoal grass) was the dominant species at most locations, except for Seaglades which was dominated by *Thalassia testudinum* (turtle grass). The apparent disappearance of *T. testudinum* at the BLSP Observation tower in August was a result of very high water, so the two deeper quadrat locations could not be sampled. The three locations with monthly monitoring (BLSP Grid #2, BLSP Observation Tower, and Fort McRee) had increases in percent cover over the growing season with the highest cover in July or August.

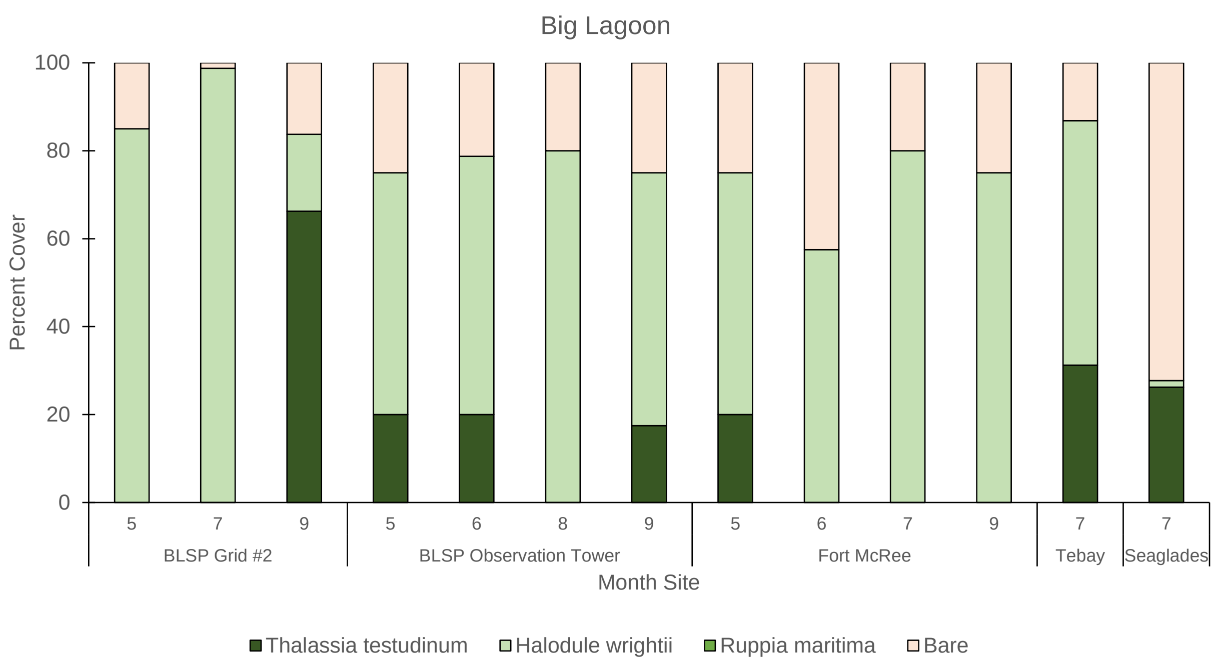

Figure 2 - Seagrass cover in Big Lagoon between May and September 2022. BLSP – Big Lagoon State Park

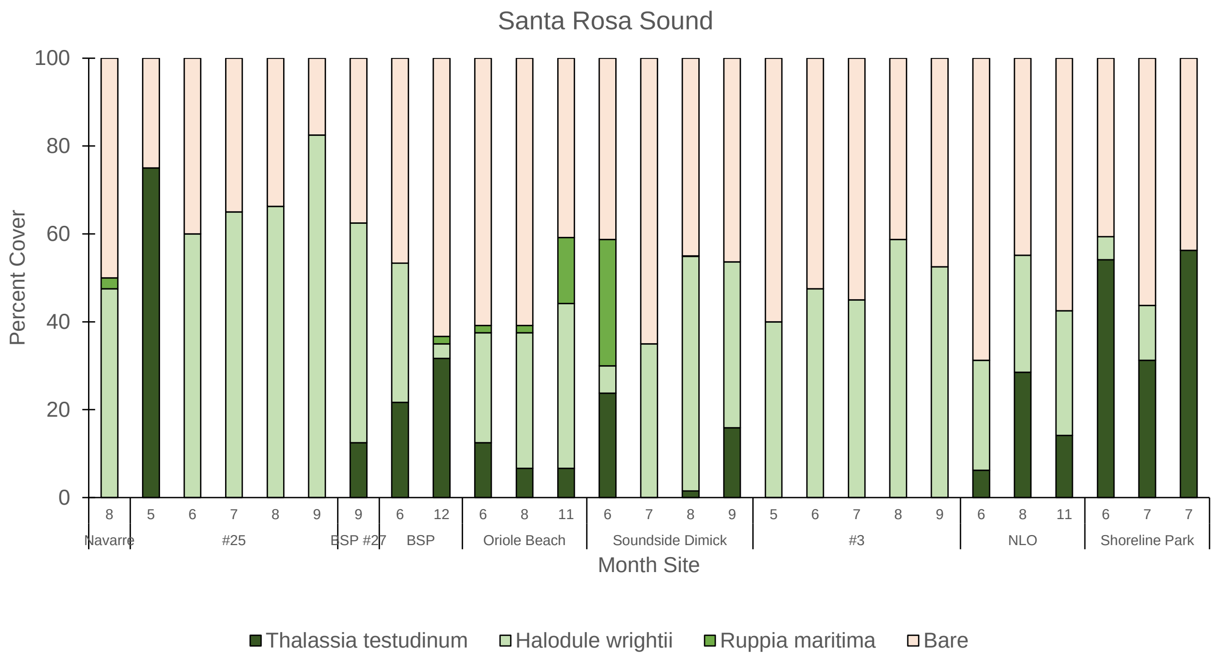

Figure 3 - Seagrass Cover in Santa Rosa Sound between May and December 2022

Seagrass cover in Santa Rosa Sound was lower than in Big Lagoon, averaging 53% over the growing season (Fig. 3). *H. wrightii* was also the dominant species. *T. testudinum* was only observed in water depths greater than 50cm (data not shown). In contrast to Big Lagoon, *Ruppia maritima* (widgeon grass) occurred at several locations in mid Sound (Oriole Beach and Soundside Dimick). Similar to Big Lagoon, seagrass cover increased over the growing season at sites with monthly records (#25- Big Sabine Point, #3/Park west, and NLO - Naval Live Oaks).

Two urban bayous were sampled in 2022, Bayou Grande and Bayou Texar (Table 2). The Bayou Grande site near Navy Point had consistently high coverage of *R. martima* increasing slightly between the beginning and end of September. Similarly, the freshwater species, *Vallisneria americana* (eelgrass or tape grass) was present at 100% coverage at Bayou Texar near Scott St.

Table 2 -Submerged aquatic vegetation (SAV) or seagrass cover in 2022

Location	Month	SAV/Seagrass cover %	Species present
Bayou Grande	June	95	*Ruppia maritima*
	early September	96	*Ruppia maritima*
	late September	98	*Ruppia maritima*
Bayou Texar	May	100	*Vallisneria americana*
	June	100	*Vallisneria americana*
	August	100	*Vallisneria americana*
	September	100	*Vallisneria americana*
Project Greenshores/ Lower Pensacola Bay	May	10	*Ruppia maritima*
	June	11	*Ruppia maritima*
	July	11	*Ruppia maritima*
	August	12	*Ruppia maritima*
	September	9	*Ruppia maritima*
Rocky Bayou State Park/Choctawhatchee Bay	July	11	*Halodule wrightill*
Liza Jackson Park/Santa Rosa Sound	July	26	*Halodule wrightill*

R. maritima was the only seagrass found at Project Greenshores. Coverage was low with a slight increase over the growing season from 10% coverage in May to 12% by August (Table 2). This location is next to the Three-mile Bridge which was under construction during the sampling period.

Samples from the two Choctawhatchee Bay locations had a much lower coverage of seagrasses compared to the Pensacola Bay locations (Table 2). Coverage of *H. wrightii* was 11% in Rocky Bayou State Park, in the northwestern region of the Bay, and 26% at Liza Jackson Park in the eastern end of Santa Rosa Sound. These estimates are similar to seagrass cover monitoring by the Choctawhatchee Basin Alliance and Fish and Wildlife Research Institute (McDowell et al 2018).

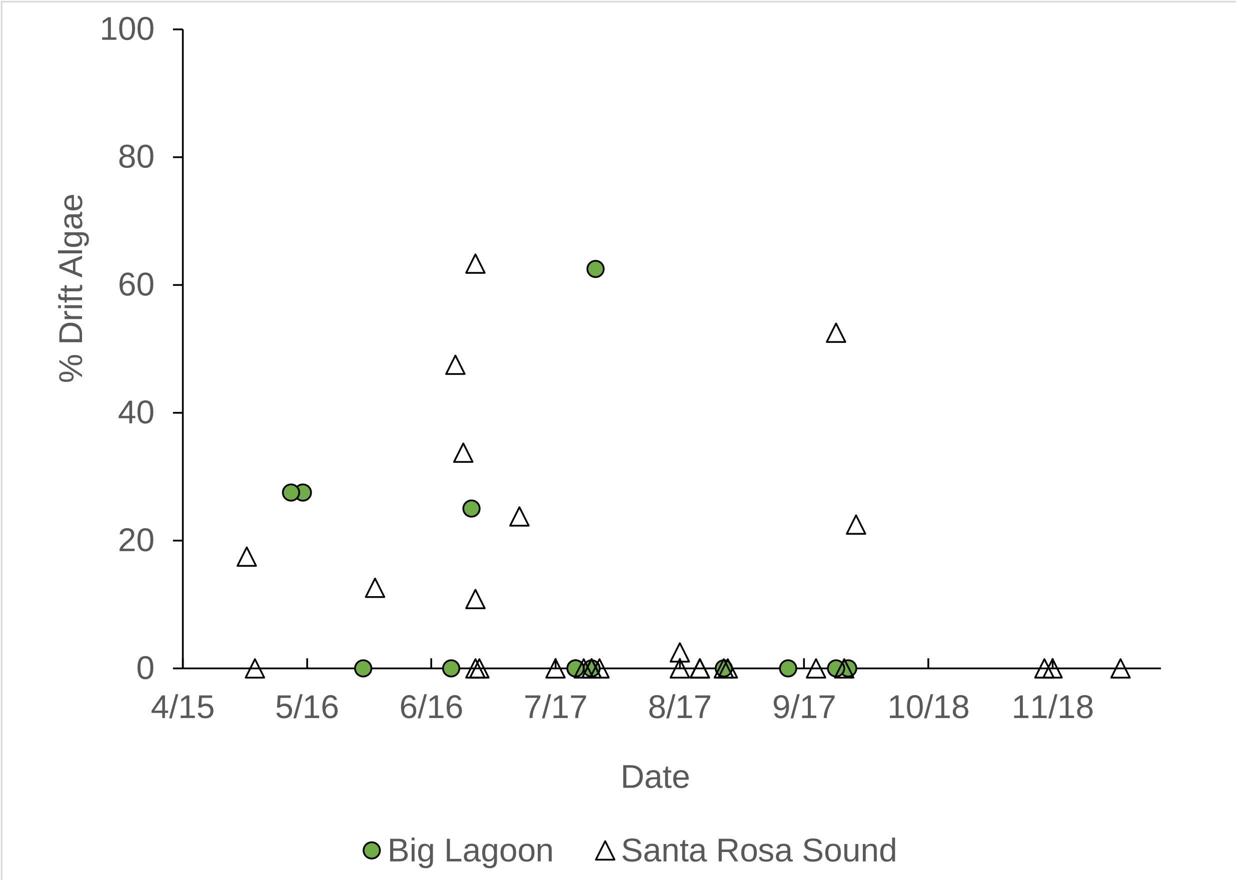

Figure 4 - Cover of drift macroalgae in Big Lagoon and Santa Rosa Sound between May and September 2022

Drift macroalgae did not have a consistent seasonal pattern, with many sites often having no macroalgae, particularly in August and September (Fig. 4). Occasional high values occurred in Big Lagoon in August at one location and high in May at two locations. In Santa Rosa Sound, drift algae was highest at most locations in late June and early July, up to 63% at Oriole Beach. Some locations at Big Sabine Point (#25 and Big Sabine Site #27) were also high in September. In contrast, site #3 near Parkwest on Santa Rosa Island had no macroalgae. No macroalgae was observed at Project Greenshores or either urban bayou.

Long-term trends

The most consistent sampling of seagrass cover has occurred at Big Lagoon State Park in western Big Lagoon. At least 2 locations have been monitoring in the park since 2017 for a total of 56 unique sampling events (Appendix Table 1). Sampling in the eastern portion of Big Lagoon either near or on Pensacola Naval Air Station occurred through 2021. In 2022, sampling began near Fort McRee. Two locations in Old River were sampled in 2018 and 2019. Sampling in Santa Rosa Sound has not been as consistent with 18 sampling events at Big Sabine Point, 16 events at Shoreline Park, 12 events at Naval Live Oaks and 11 at site #3 near Parkwest. Bayou Grande is the most consistently sampled urban bayou with 8 events between 2018 and 2020 near Blackwell and 9 events starting in 2021 near Navy Point.

Seagrass cover at Big Lagoon State Park was consistently above 60% during the peak of the growing season in July and was highest in 2022 at 86% (Fig. 5). *H. wrightii* was the dominant species observed. Over the growing season *T. testudinum* usually increased (data not shown). *R. maritima* was occasionally observed at sampling sites. Damage from Hurricane Sally in 2020 closed the park during September and October. Four different locations were sampled in mid Big Lagoon between 2017 and 2019. One of those locations (Seaglades) was revisited in July 2022. Seagrass coverage was generally similar to Big Lagoon State Park (data not shown). Coverage was highest in 2019 and usually evenly split between *H. wrightii* and *T. testudinum*. In the east side of Big Lagoon, four different locations were sampled. Between August 2017 and August 2020 and in July 2022, cover estimates were made just outside of NAS Pensacola (water depth ~35 cm). In 2021, two locations inside NAS Pensacola were monitored at water depths 35 and 70 cm, respectively. In 2022, Fort McRee was the monitoring location. Seagrass cover in the East side of Big Lagoon was lower than at Big Lagoon State Park, particularly in 2018 and early 2019.

The relative distribution between *H. wrightii* and *T. testudinum* depends on water depth. Most sampling locations are less than 50cm water depth which is where *H. wrightii* dominates. *T. testudinum* is more common at water depths above 60 cm (Fig. 6). Determining accurate water depths can be a challenge since citizens often use different measuring devices with different units or may not record water depth. Data in this report has not been correct for tide level since time of sampling has not been consistently reported by citizens.

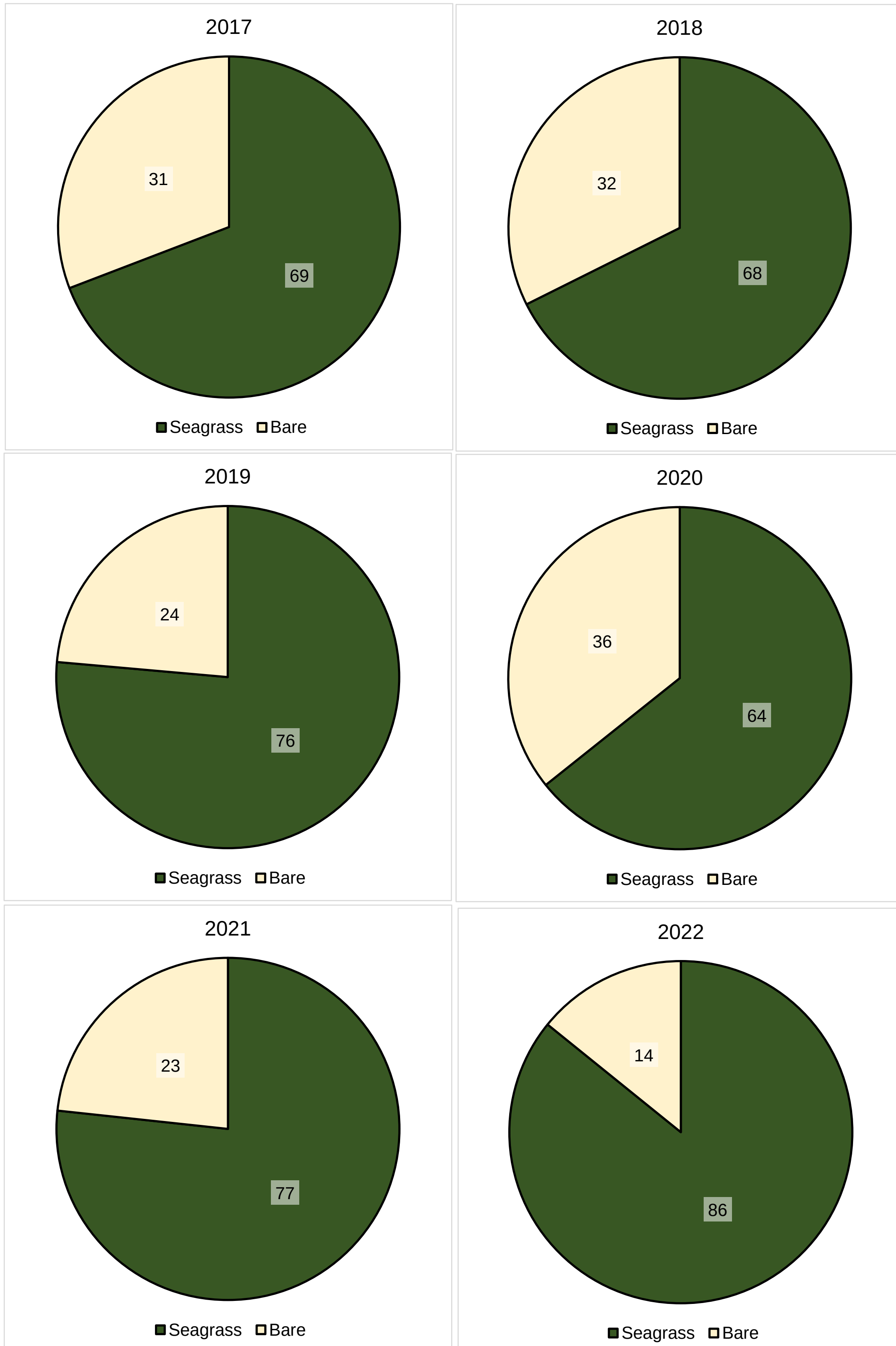

Figure 5 -Average summer (June-August) seagrass cover at Big Lagoon State Park between 2017 and 2022

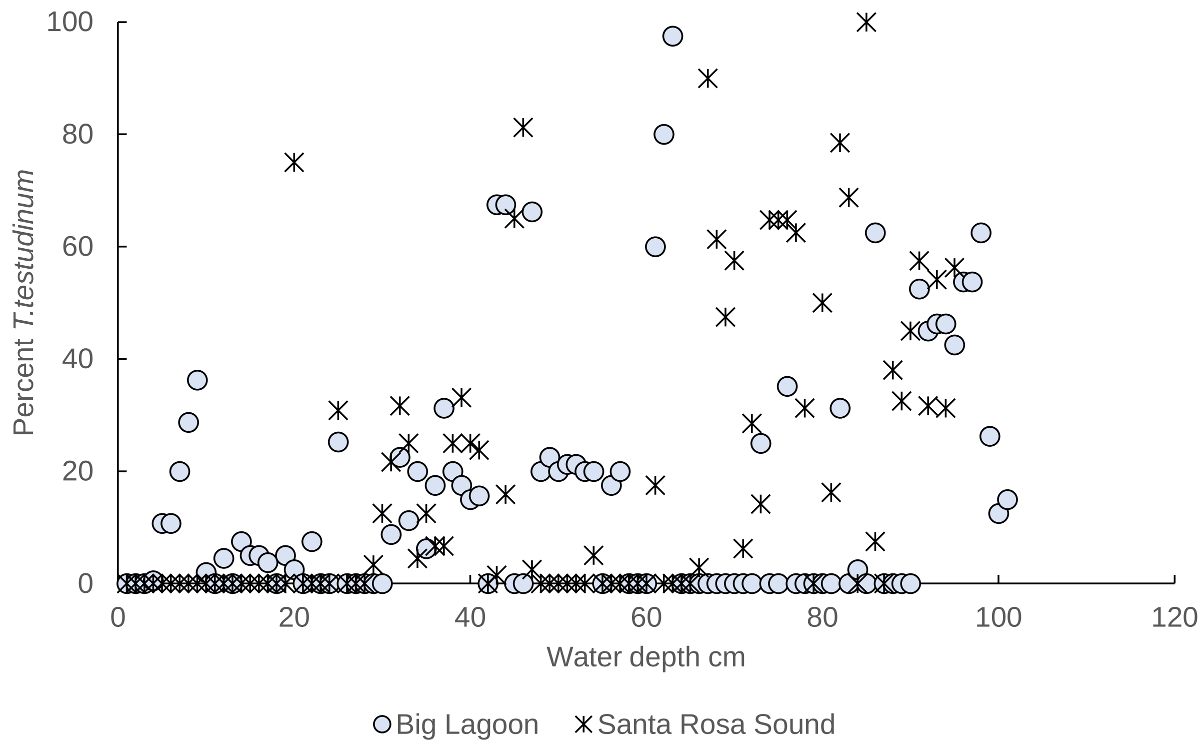

Figure 6 - Percent cover of T. testudinum versus water depth in Big Lagoon and Santa Rosa Sound between June 2017 and December 2022

Site locations from the west side of Santa Rosa Sound included Shoreline Park, Naval Live Oaks, Malaga, #3/Parkwest and Panferio Drive. Average seagrass cover in this region was highest in 2018 and 2021 (Fig. 7). Cover was usually at a maximum in August. In 2020, only the Malaga site was sampled due to COVID restrictions. The average cover reported in Figure 7 combines different site locations, thus, differences between years should not be considered significant. The mid Santa Rosa Sound stations included Oriole Beach, Soundside, and Woodlawn Beach along the north side of the sound and Big Sabine Point along the south side. Consistent sampling occurred at Big Sabine Point in 2021 and 2022. As in Big Lagoon, shallower sites are dominated by *H. wrightii* and deeper sites by *T. testudinum.* East Santa Rosa Sound near Navarre was sampled most often in 2019. *H. wrightii* dominates in this region with occasional patches of *R. maritima.* Seagrass cover in mid and east Santa Rosa Sound over the 6-year period was often 50%.

Figure 10 – Average summer (June-August) seagrass cover in the west side of Santa Rosa Sound between 2017 and 2022

R. maritma was the only species observed in the two Bayou Grande locations with cover often above 50% (Fig. 8). Cover was higher early in the growing season in June and July compared to August or September. Because one location was sampled between 2018-2020 and a different location between 2021-2022, it is not possible to determine any trends.

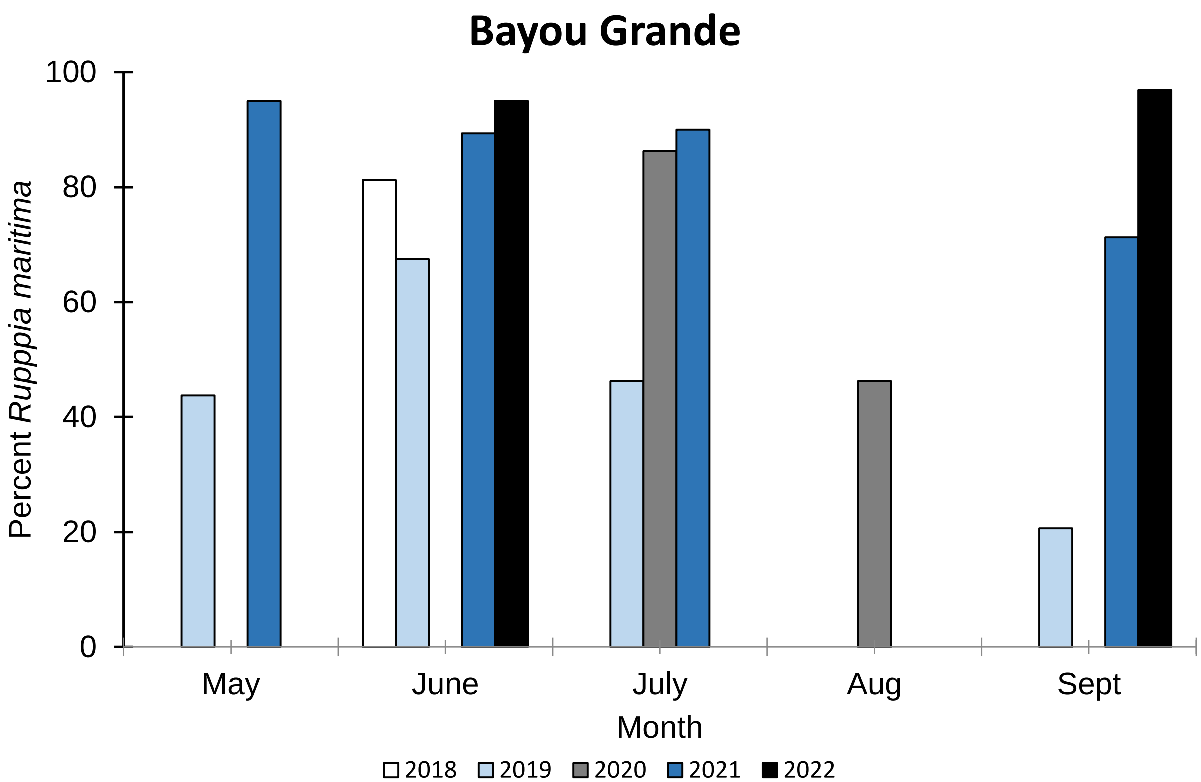

Figure 8 - Average cover of Ruppia maritima in Bayou Grande between 2018 and 2022

The action of wind, waves and currents can transport macroalgae. Thus, drift algae are very patchy with some locations having a high accumulation during the spring and summer (Fig. 9). While accumulation occasionally extends throughout the entire growing season, in Big Lagoon late spring (April & May) had the highest accumulation while June had the highest accumulation in Santa Rosa Sound. No drift algae was observed at other locations.

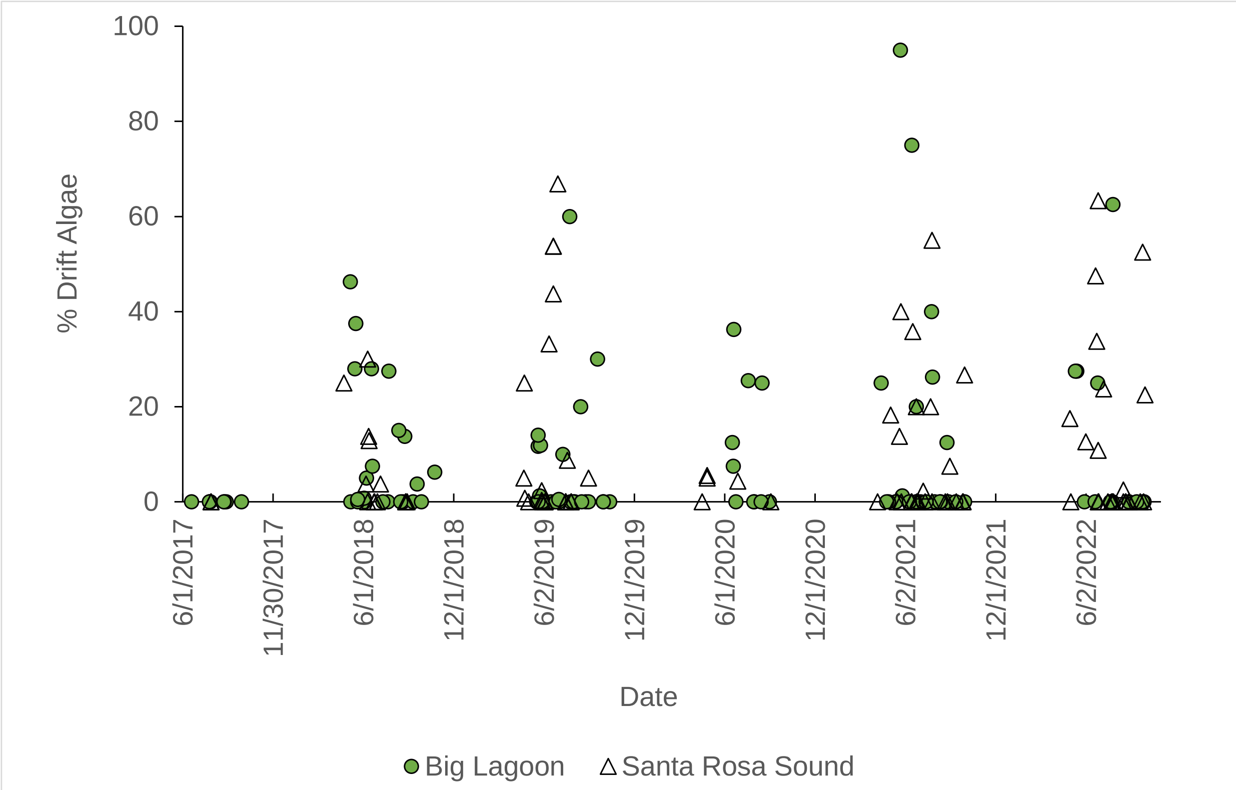

Figure 9 - Average drift macroalge in Big Lagoon and Santa Rosa Sound between 2017 and 2022

Salinity is influenced by precipitation and freshwater discharge. Freshwater discharge from the rivers in the Pensacola Bay system is usually highest in the winter and spring when evapotranspiration is lowest (Fig. 10). However, tropical storms and other extreme rain events can lead to high runoff during the growing season. June 2017 and July 2021 had higher precipitation (NOAA) and runoff than those months in the other years (Fig 10).

Salinity in Big Lagoon and Santa Rosa Sound was low in 2017 and 2021 reflecting higher freshwater inputs during those years (Fig. 11). Salinity levels below 20 often lead to lower productivity of *T. testudinum* (Lirman and Cropper 2003). In contrast, *H. wrightii* has a wider salinity tolerance (Dunton 1996) and can survive extended periods at 5 PSU (Biber 2022). Salinity measured in grab water samples had good agreement with *in-situ* field measurements (Fig. 12). Thus, the grab water samples collected by citizen scientists reflect conditions during their seagrass survey and provide greater spatial and temporal resolution of salinity in these systems.

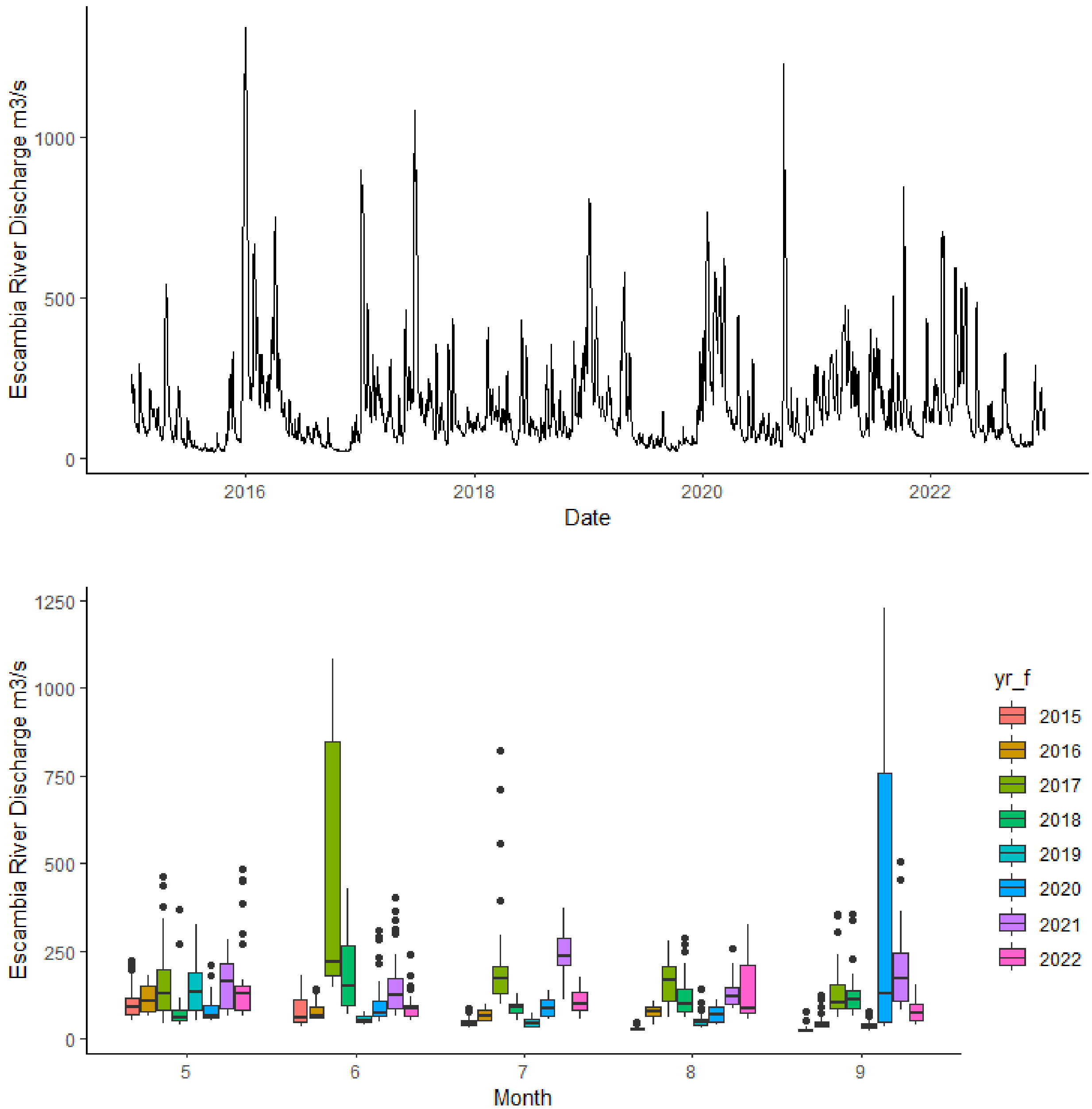

Figure 10 - Escambia River discharge (m3/s) between 2015-2022 with daily discharge in top panel and average monthly discharge between May and September in bottom panel

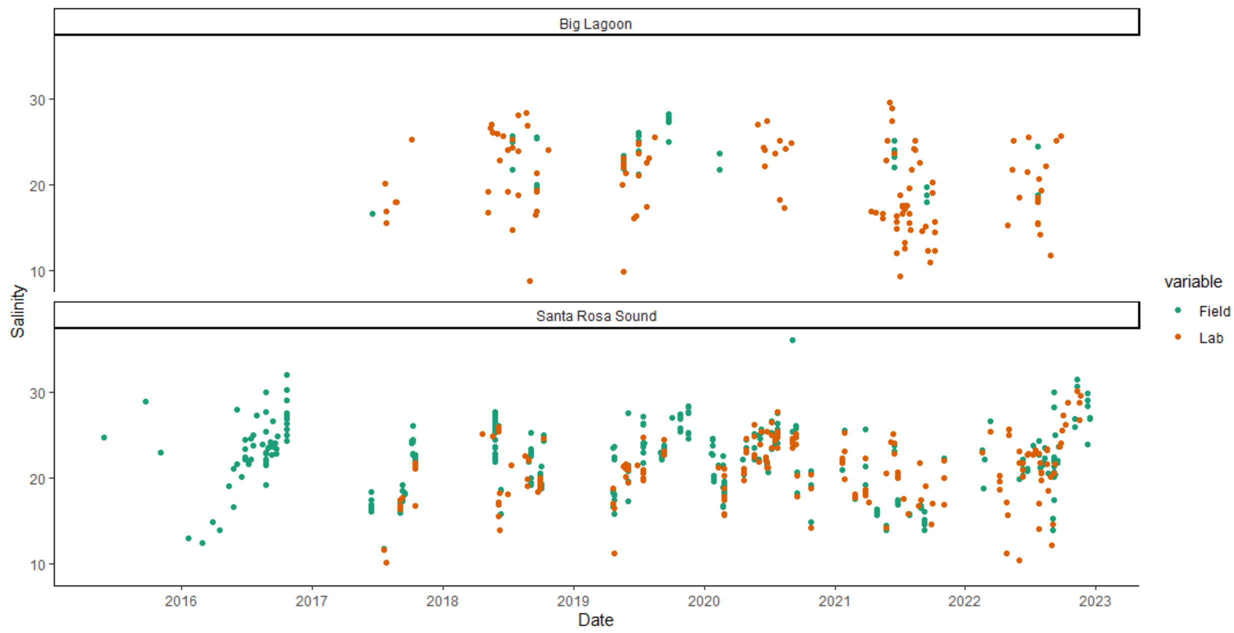

Figure 11 - Salinity in Big Lagoon and Santa Rosa Sound between 2015 and 2022

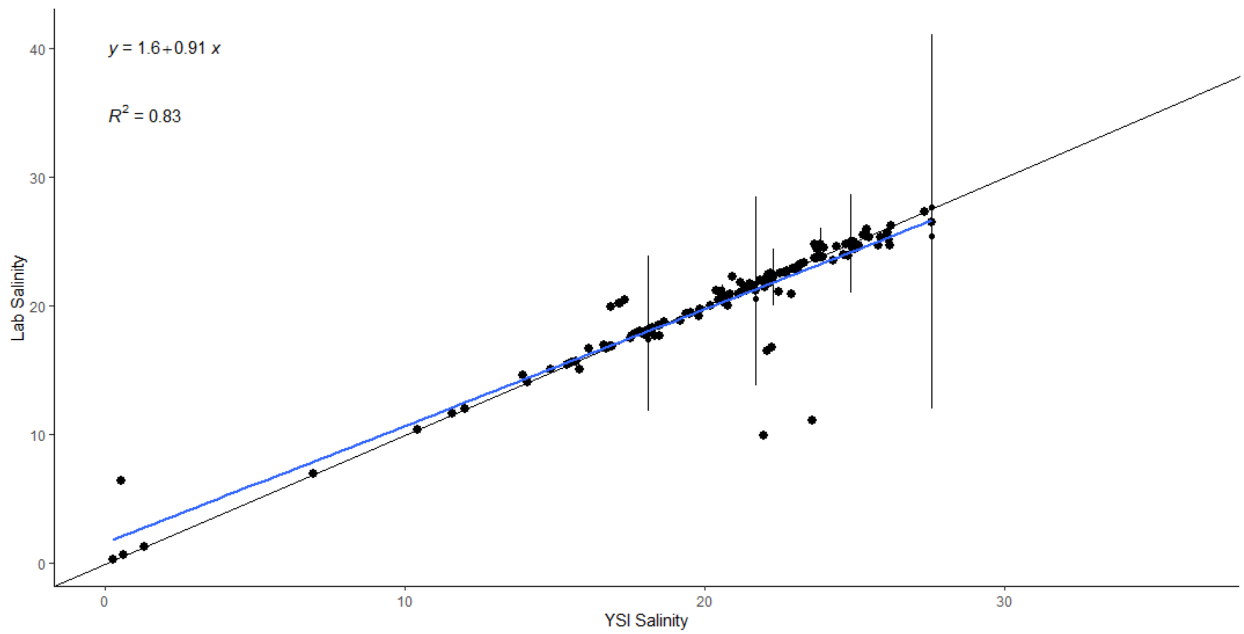

Figure 12 - Salinity measured in lab versus salinity measured on site with YSI multimeter.

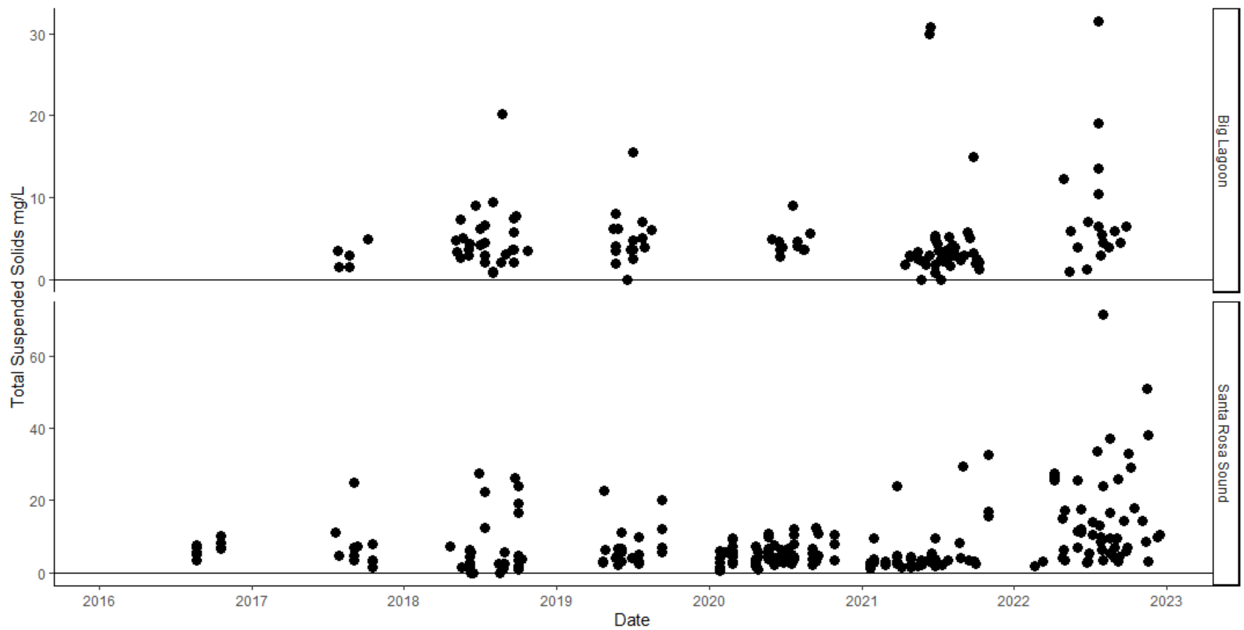

Figure 13 - Total Suspended Solids in Big Lagoon and Santa Rosa Sound between 2016-2022. Note change in scale for y axis for Santa Rosa Sound.

Total suspended solids were usually less than 20 mg/L at all locations (Big Lagoon, Santa Rosa Sound and urban bayous). The average value was higher in Santa Rosa Sound than Big Lagoon, 5.6 and 8.0 mg/L, respectively (Fig. 13). 2022 had much higher values than previous years, particularly in Santa Rosa Sound which had an average of 14.8 mg/Land some values above 60 mg/L. Sediments were easily resuspended at Oriole Beach and Soundside Dimick in Santa Rosa Sound during surveys (pers. Obs.).

Light attenuation reflects the light availability at different water depths. It is influenced by particulates (inorganic and organic) and colored dissolved organic matter. Average light attenuation was 0.87 m^{-1} in Big Lagoon and 0.7 m^{-1} in Santa Rosa Sound (Fig. 14). Based on these averages and assuming that seagrasses require about 20% of the surface irradiance to maintain the beds, the deepest edge of the bed would be 1.8m in Big Lagoon and 2.3m in Santa Rosa Sound. While seagrasses may be able to colonize deeper water depths than this, they would be subject to light limitation. Total suspended solids and light attenuation were positively correlated ($r=0.33$, $p<0.01$) as were chlorophyll a and light attenuation ($r=0.22$, $p<0.05$) (Fig. 15). While these are relatively weak correlations, they do indicate that water with higher particulate and chlorophyll levels had high light attenuation. Other factors such as color may also be important.

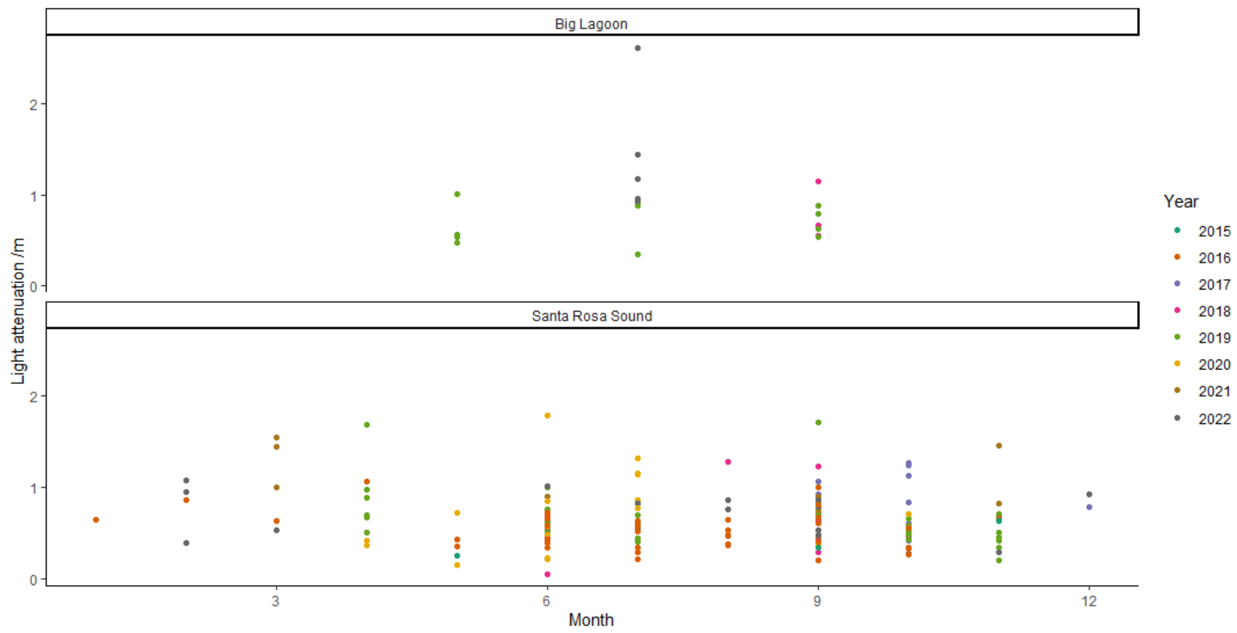

Figure 14- Light attenuation in Big Lagoon and Santa Rosa Sound between 2015-2022

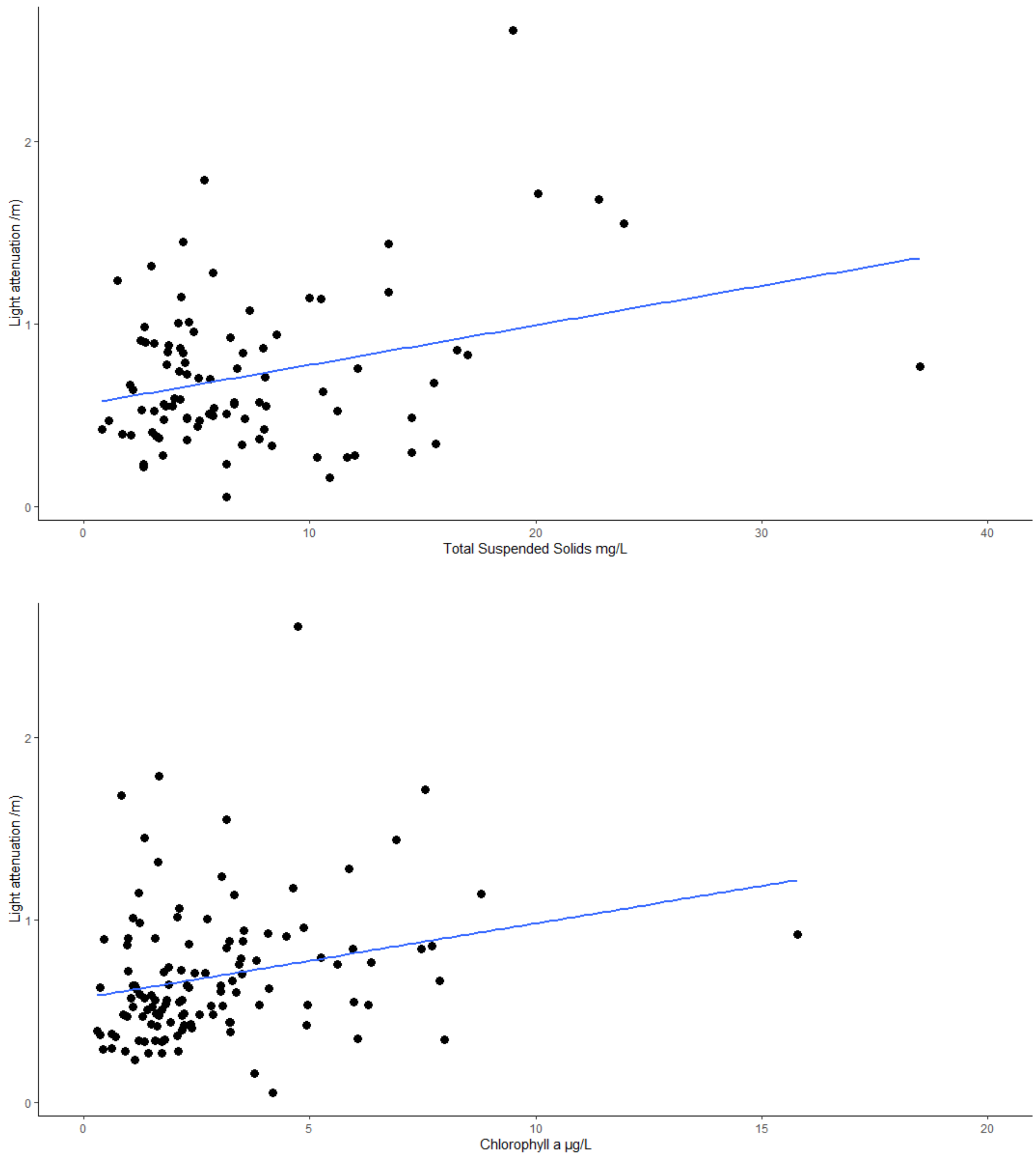

Figure 15 - Total Suspended Solids versus light attenuation (top panel) and chlorophyll a versus light attenuation (bottom panel). Best fit linear regression line shown in blue.

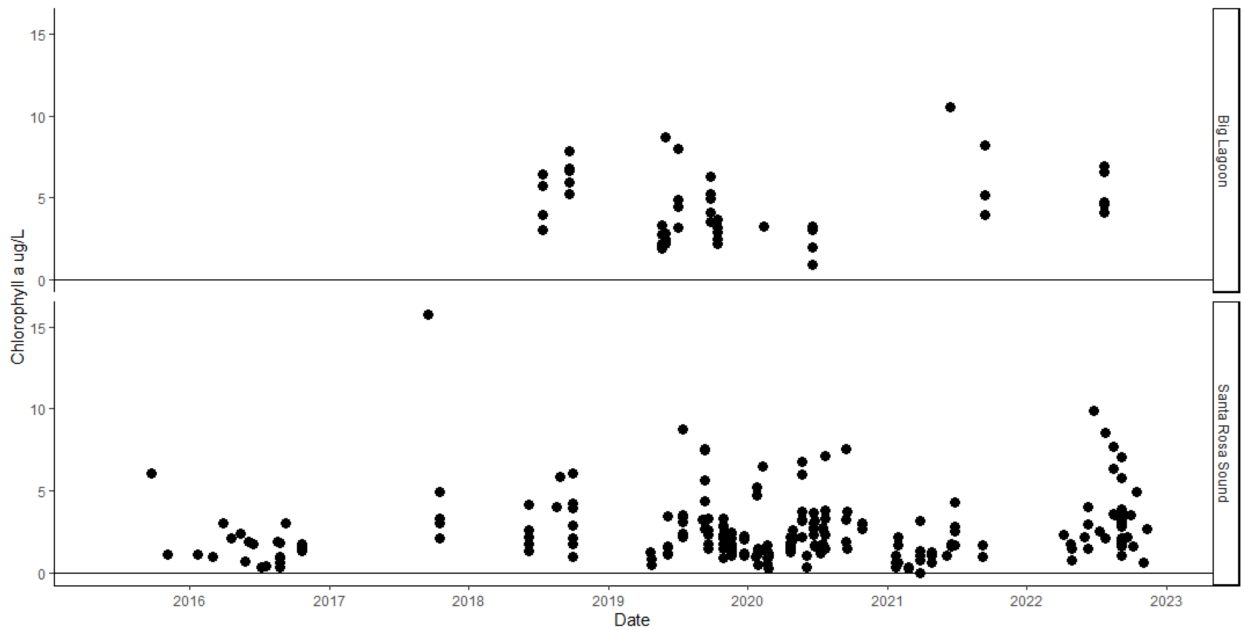

Figure 16 - Chlorophyll a concentrations in Big Lagoon and Santa Rosa Sound between 2015 and 2022

Chlorophyll a concentrations are a measure of phytoplankton biomass. In Big Lagoon and Santa Rosa Sound values were usually less than 10 µg/L (Fig. 16). The higher the phytoplankton biomass is, the less light is available for seagrasses. Phytoplankton biomass in these lagoon systems is much lower than levels found in the urban bayous such as Bayous Texar and Chico, where chlorophyll a concentrations can reach 100 µg/L (Sommerville 2018).

Nutrient levels were usually low in both Big Lagoon and Santa Rosa Sound (Table 3, Appendix Fig. 1). Dissolved inorganic nitrogen is primarily in the form of ammonium. Nitrite concentrations are almost always below detection as are nitrate concentrations. Occasional high values of DIN occur in Santa Rosa Sound. Dissolved inorganic phosphate is generally less than 1 µM except for a few higher values in 2020 (Table 3, Appendix Fig. 2).

In contrast to these two lagoonal systems, the creeks feeding into Santa Rosa Sound can have very high nutrient levels, particularly Williams Creek and the ditches draining Villa Venyce and Maplewood Dr (Table 3). Nitrate+nitrite concentrations were often above 8 µM with ammonium concentrations in the same range (Appendix Fig. 3). Dissolved inorganic phosphate averaged 5 µM in Williams Creek and the Maplewood Dr. ditch (Appendix Fig. 4). Creeks with more natural drainage areas such as those near Lands End Dr and in Shoreline Park generally had nitrate+nitrite levels less than 2 μM, ammonium levels less than 5 μM and dissolved inorganic phosphate concentrations less than 1 μM (Appendix Fig 3 & 4).

Table 3 - Dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) concentration between 2015 and 2022. Mean and range.

Location	DIN μM mean (range)	DIP μM mean (range)
Big Lagoon	0.9 (<0.05-4.6)	0.12 (<0.05-0.51)
Santa Rosa Sound	1.2 (<0.05-15.9)	0.11 (<0.05-1.46)
Santa Rosa Sound Creeks	11.6 (0.2 – 54)	3.0 (<0.05-14.8)

Identifying long term trends in seagrass cover with citizen science data due to changes in personnel (different citizens and students) and site locations over the years. It may also be difficult avoid bias in sampling if quadrats are always placed in the densest part of the bed. While randomly selected locations could be identified to minimize this bias, that would require that citizens have GPS capabilities either through a smartphone app or GPS unit. Despite these challenges, the cover data is generally consistent. It seems likely that any drastic declines in seagrass cover would be evident, particularly if citizens and students note obvious changes in environmental conditions or conditions within the beds.

Salinity, total suspended solid measurements, drift macroalgal cover and notes about conditions also provide key information about the environmental conditions within the beds. Freshwater into the beds may directly affect seagrass productivity. High concentrations of particulates (total suspended solids) or color often coincide with freshwater runoff which attenuated light within the grassbeds. Nutrient inputs promote the growth of phytoplankton (chlorophyll a) and drift macroalgae which can outcompete seagrasses.

An important goal of this program has been to encourage citizens and students to pay attention through regular observation. Citizens can serve as important sentinels in these critical habitats. Their volunteer efforts provide data to increase our understanding of factors impacting seagrasses in this rapidly growing region.

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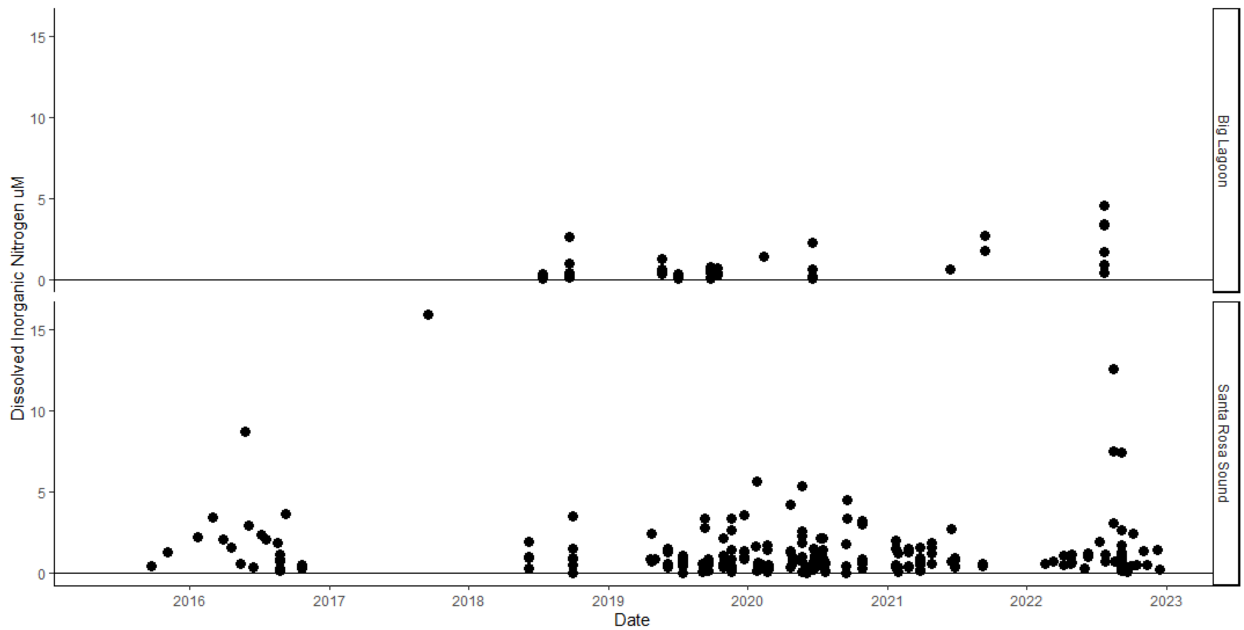
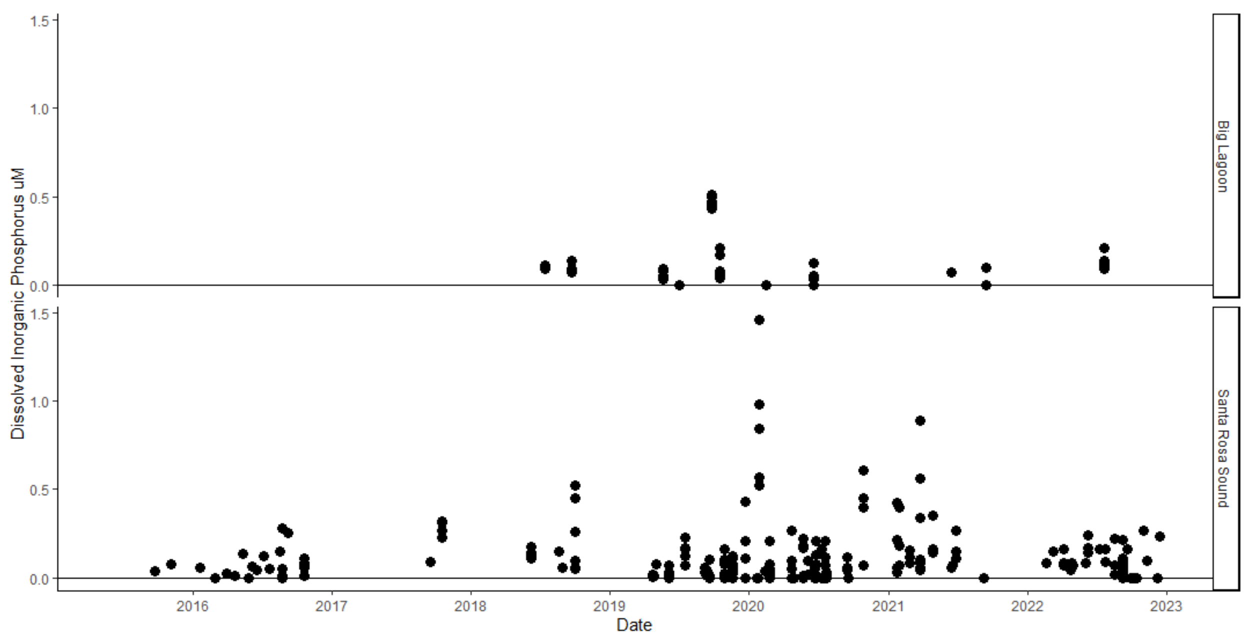
Appendix Table 1 – Sampling locations, start and end dates and total number of samples collected at each location.

Estuary	Site	Region	Start Date	End Date	# samples
Bayou Chico	Lexington Terrace	Bayou Chico	5/9/2021	7/25/2021	2
Bayou Grande	Blackwell	Bayou Grande	6/24/2018	8/23/2020	8
Bayou Grande	Navy Point SE	Bayou Grande	4/21/2021	9/30/2022	9
Bayou Texar	Scott	Bayou Texar	5/20/2022	9/13/2022	4
Big Lagoon	BLSP Burns	BLSP	6/19/2017	8/25/2019	15
Big Lagoon	BLSP NW Obs Tower	BLSP	4/14/2021	8/25/2021	2
Big Lagoon	BLSP Park West	BLSP	5/24/2019	9/30/2021	7
Big Lagoon	BLSP Smith	BLSP	7/26/2017	8/16/2020	17
Big Lagoon	BLSP W of obs Tower	BLSP	6/17/2020		1
Big Lagoon	Grid #2	BLSP	6/24/2021	9/28/2022	5
Big Lagoon	Observation Tower	BLSP	5/23/2021	9/25/2022	9
Big Lagoon	Fort McRee	East	5/12/2022	9/13/2022	4
Big Lagoon	NAS Grid #11	East	5/14/2021	8/11/2021	6
Big Lagoon	Tebay	East	8/24/2017	7/22/2022	16
Big Lagoon	GUIS Johnson Beach	GUIS	5/21/2019	7/14/2021	6
Big Lagoon	Albano	mid	5/21/2018	6/3/2018	2
Big Lagoon	Barker	mid	7/25/2017	8/23/2017	2
Big Lagoon	Seaglades	mid	5/21/2018	7/22/2022	7
Big Lagoon	Stanton	mid	5/17/2018	6/20/2018	2
Old River	Galvez_Sunset Island	Old River	6/24/2018	9/22/2018	4
Old River	Krupnick	Old River	5/26/2018	8/14/2019	11
Pensacola Bay	Project Greenshores	Pensacola Bay	5/16/2022	9/27/2022	5

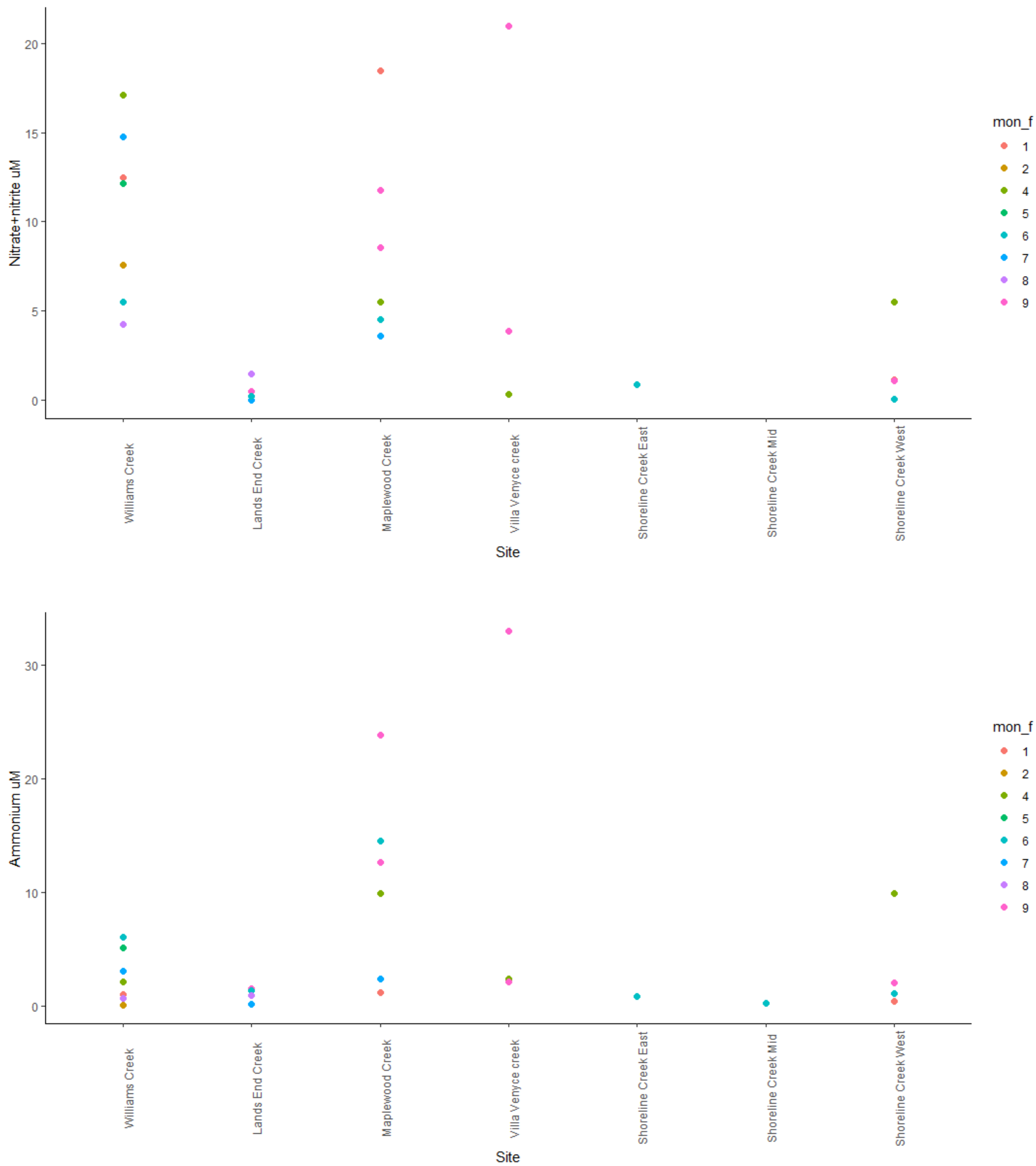
Estuary	Site	Region	Start Date	End Date	# samples
Perdido Bay	Arnica Bay	Perdido Bay	5/8/2021	7/1/2021	3
Santa Rosa Sound	Blue Tip	East	6/4/2019	7/16/2019	2
Santa Rosa Sound	Danger Beach	East	5/28/2019	7/27/2019	4
Santa Rosa Sound	Navarre CofC	East	6/24/2018	8/17/2022	6
Santa Rosa Sound	SR Island	East	6/23/2018		1
Santa Rosa Sound	Liza Jackson Park	far East	7/28/2022		1
Santa Rosa Sound	#25	Mid	5/16/2021	9/25/2022	10
Santa Rosa Sound	Big Sabine Point	Mid	6/4/2019		1
Santa Rosa Sound	Big Sabine Site #27	Mid	5/24/2021	9/30/2022	5
Santa Rosa Sound	BSP	Mid	6/27/2022	12/5/2022	2
Santa Rosa Sound	Oriole Beach	Mid	4/24/2019	11/16/2022	5
Santa Rosa Sound	Soundside	Mid	6/21/2019		1
Santa Rosa Sound	Soundside - Mead's	Mid	6/30/2019		1
Santa Rosa Sound	Soundside Dimick	Mid	6/21/2019	9/20/2022	5
Santa Rosa Sound	Soundside Preserve	Mid	5/3/2021	7/8/2021	2
Santa Rosa Sound	Woodlawn Beach	Mid	7/6/2018	5/2/2019	3
Santa Rosa Sound	#3	West	4/7/2021	9/27/2022	11
Santa Rosa Sound	Malaga	West	7/28/2017	9/3/2020	6
Santa Rosa Sound	Naval Live Oaks	West	6/15/2021	11/18/2022	12
Santa Rosa Sound	Shoreline Park	West	7/28/2017	7/26/2022	16



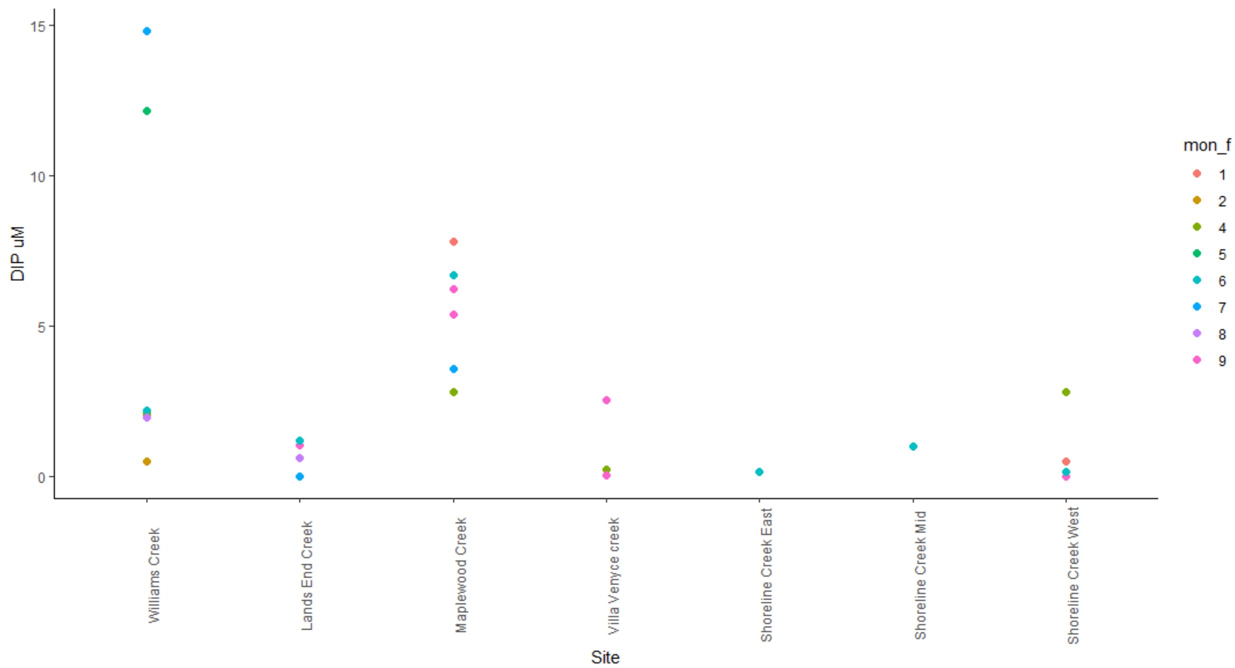
Appendix Figure 1- Dissolved inorganic nitrogen in Big Lagoon and Santa Rosa sound between 2015-2022



Appendix Figure 2- Dissolved inorganic phosphorus in Big Lagoon and Santa Rosa Sound between 2015-2022



Appendix Figure 3 - Nitrate+nitrite concentrations (top panel) and ammonium concentration (bottom panel) in Santa Rosa Sound tidal creeks



Appendix Figure 4 - Dissolved inorganic phosphate (DIP) in Santa Rosa Sound tidal creeks