Statewide Seagrass Monitoring Protocol Development – Phase 2 Final Report

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Acronyms

Acronym	**Definition**
% SI	percent surface irradiance
°C	degrees Centigrade
ANOVA	analysis of variance
CW	coastwide
DO	dissolved oxygen
EX	existing (Phase 1)
GIS	geographical information system
GLO	General Land Office
Halodule	*Halodule wrightii*
Halophila	*Halophila engelmanii*
ICWW	Intracoastal Waterway
K_d	light attenuation coefficient
m	meters
MANERR	Mission Aransas National Estuarine Research Reserve
NELAC	National Environmental Laboratory Accreditation Conference
PAR	photosynthetically-active radiation
PPT	parts per thousand
QAPP	quality assurance project plan
r^2	determination coefficient (square of correlation coefficient r)
RF	Redfish Bay
RMS	root-mean-square
RSR	root:shoot ratio
Ruppia	*Ruppia maritima*
µS/cm	microsiemens per centimeter
SA	San Antonio Bay
SD	standard deviation
SE	standard error of the mean
SI	surface irradiance
su	standard units
SWQM	surface water quality monitoring
SWQMIS	Surface Water Quality Monitoring Information System
Syringodium	*Syringodium filiforme*
T	transect
T1, T2, T3	transect 1, 2, or 3, respectively
TCEQ	Texas Commission on Environmental Quality
Thalassia	*Thalassia testudinum*

Acronym	**Definition**
TOC	total organic carbon
TPWD	Texas Park and Wildlife Department
TSS	total suspended solids
VSS	volatile suspended solids

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Executive Summary

The Texas Commission on Environmental Quality funded Texas Parks and Wildlife Department to conduct a statewide seagrass monitoring project in Texas estuaries. Monitoring followed a tiered approach used by seagrass monitors in other parts of the United States (Fourqurean *et al.* 2002; Neckles *et al.* 2012) and recommended by Dunton *et al*. (2007, 2011) for Texas. The purpose of the project was to implement Tiers 2 and 3 of a tiered sampling approach that will enable the state to monitor changes in seagrass condition over large areas and to infer cause-effect relationships that may explain those changes. Tier 2 seagrass monitoring was implemented at coastwide and bay scales, and Tier 3 monitoring at bay-scale. In Tier 2 monitoring, seagrass percent coverage and canopy height were measured at 53 probabilistically-selected sites and 14 fixed sites coastwide from Galveston Bay to Lower Laguna Madre, and at 50 probabilistically-selected sites in both Redfish Bay and San Antonio Bay. The 14 fixed sites were also sampled in the Phase 1 seagrass monitoring project conducted in 2010-2011. Tier 3 monitoring, which entailed measuring a number of seagrass condition and environmental indicators, was completed at five transects in Redfish Bay and three transects in San Antonio Bay. Methods and quality assurance protocols are detailed in the Quality Assurance Project Plan (QAPP) for the project. Results of this project included establishing permanent seagrass monitoring sites and recommendations for establishing a statewide seagrass monitoring program.

Establishing a statewide seagrass monitoring program is the foundation of seagrass management in Texas. Resource managers must have accurate information regarding the condition of seagrass beds along the Texas coast and it is vital for regulatory decisions to be science-based. To accomplish this, statewide seagrass monitoring must focus the state's limited resources on collecting seagrass information that best describes seagrass condition and environmental stressors affecting seagrass. An optimal seagrass monitoring program would include Tier 2 sampling coastwide and Tier 2 and Tier 3 sampling in eight bays during the period of peak seagrass biomass. This would give the greatest amount of information on statewide seagrass condition in the shortest period of time. With limited monitoring resources, annual Tier 2 sampling coastwide and Tier 2 and Tier 3 sampling in two bays, as was done in this project, would provide enough information to detect change coastwide annually and at bay-scale in a four-year cycle. A third option, requiring minimal resources, would implement a statewide seagrass monitoring program that included annual Tier 2 sampling coastwide, which would give the base level of information required for measuring changes in seagrass condition statewide, but would provide limited bay-scale information.

An "index period" of August 1 to October 31 worked well in capturing seagrass condition during peak biomass. Field work was conducted by numerous staff at dispersed locations who were not seagrass specialists. Training in seagrass monitoring methods ensured that staff collected consistent and repeatable seagrass condition information. Analysis of data collected during the training exercise showed an absence of observer effects in percent coverage and canopy height determinations. Similarly, analysis of visual and tactile estimates of seagrass coverage (tactile estimates are required in areas of reduced water clarity) showed no systematic difference in measurement types. Estimation of project operating expenses apportioned by field work type revealed that Tier 2 coastwide monitoring cost $44,399, Tier 2 bay-scale cost $17,914, and Tier 3 monitoring per bay cost $23,362. These estimates do not include one-time set-up costs.

Tier 2 coastwide sites documented all five seagrass species, with *Halodule wrightii* dominant. In Redfish Bay *Thalassia testudinum* was the dominant species, followed by *Halodule wrightii*. San Antonio Bay was dominated by *Halodule wrightii*. In general, *Halodule wrightii* coverage increased up the coast and *Thalassia testudinum* coverage increased down the coast. *Thalassia testudinum* and *Syringodium filiforme* had the tallest canopy height of the five seagrass species. Statistical analysis of percent coverage and canopy height data was able to detect spatial and temporal differences. Differences among Tier 2 coastwide, Redfish Bay and San Antonio Bay were distinguishable in the bare percent coverage, *Halodule wrightii* percent coverage and *Halodule wrightii* canopy height datasets. Combining data from the Phase 1 project and this project allowed temporal analysis of percent coverage and canopy height at the 14 fixed sites. At these sites, *Halodule wrightii* percent coverage in 2011 was different from 2010 and 2012. Bare percent coverage was different in 2012 from 2010 and 2011. *Halodule wrightii* canopy height was different in all three years. *Thalassia testudinum* canopy height in 2012 was different from 2010 and 2011. Tier 2 data from the 50 San Antonio Bay sites was compared with that from the seven coastwide sites located in San Antonio Bay. Results for bare percent coverage, *Halodule wrightii* percent coverage and *Halodule wrightii* canopy height were indistinguishable between the two datasets. This suggests that repeated monitoring at the probabilistically-selected coastwide sites will, over time, build a dataset comparable to that achieved by the more intensive bay-scale monitoring. *Halodule wrightii* canopy height and bare percent coverage were found to be the datasets that had the largest numbers of observations and the closest to normal distributions.

In Redfish and San Antonio Bays, Tier 3 characterization of seagrass condition indicators, biomass, shoot density, leaf morphometrics and percent coverage, varied between transects and sometimes within transects. Epiphyte loads for *Halodule wrightii* and *Thalassia testudinum* were similar and ranged from 0.15 to 0.96 mg/cm^2 for *Halodule wrightii* and 0.32 to 0.57 mg/cm^2 for *Thalassia testudinum*. The occurrence of macroalgae was sporadic, with macroalgae absent from 23 of 80 samples. Macroalgae biomass ranged from 0.0 to 116.2 g/m^2. Even with the limited dataset obtained at eight transects in 2012, there were some relationships between stressors (macroalgae and epiphyte biomass) and seagrass condition indicators such as shoot density, biomass, and leaf area index. One global seagrass monitoring program has detected declines in seagrass with as few as five years of monitoring data (Short *et al.* 2006). Along with results from this project, this lends confidence that relationships between environmental stress and seagrass response in Texas bays will be better defined and understood as data is collected over several years at permanent monitoring sites.

Introduction

Seagrass beds (submerged aquatic vegetation) serve as important habitat worldwide for estuarine fisheries and wildlife. Seagrasses provide food for fish, waterfowl and sea turtles, contribute organic material to estuarine and marine food webs, cycle nutrients, stabilize sediments, and act as global carbon sinks (Hemminga and Duarte 2000, Orth *et al.* 2006). They are economically important based on their function in maintaining Gulf fisheries by serving as nursery habitat for juvenile fish and invertebrates. In Texas, seagrass has been identified as a critical habitat under the Coastal Coordination Act. Globally, growing coastal populations and increasing coastal development threaten seagrass habitat (Waycott *et al.* 2009). Worldwide seagrass decline is most often linked with water quality decline (Orth *et al.* 2006). Only relatively recently, beginning in the 1970s, have seagrasses been singled out as a special conservation concern. As resource managers have become more aware of the ecosystem services provided by seagrasses, the need to evaluate the condition of seagrass beds and monitor seagrass health over time has come to the forefront.

Monitoring efforts generally fall under two approaches – mapping the extent of seagrasses on a large scale ("landscape monitoring") and biological monitoring at the scale of the seagrass bed. Some programs emphasize one or the other approach, but most programs attempt to integrate landscape analysis with biological monitoring. Landscape monitoring usually involves aerial imagery. The long-running seagrass monitoring program in Chesapeake Bay began in 1984 with annual aerial surveys (Koch and Orth 2003). In the Chesapeake program, aerial photography is analyzed to determine the areal extent of aquatic vegetation growth, including species commonly recognized as freshwater plants, in addition to eelgrass *Zostera marina* and other seagrass species. Ground surveys are used to verify presence and species of aquatic vegetation. Other programs that emphasize biological monitoring typically use a transect-based sampling design that includes estimation of species coverage with quadrats. Many programs go further by estimating shoot density and other plant health parameters, analyzing water and/or sediment quality, and making physical measurements such as water depth. An example is the seagrass monitoring program in southern Florida, which encompasses federal and state jurisdictions in Florida Bay, the Key Largo National Marine Sanctuary, and the Florida Keys region (Fourqurean *et al.* 2002). This multi-agency coordination effort has resulted in a long-term record of seagrass condition in this area. Two seagrass monitoring programs, Seagrass-Watch (McKenzie *et al.* 2003) and SeagrassNet (Short *et al.* 2006), have been developed to coordinate multi-national efforts to monitor seagrass beds in approximately 47 countries.

Some seagrass monitoring programs collect water quality data from seagrass areas being monitored. Others use water quality data that may be collected for broader purposes and integrate that data into seagrass monitoring efforts. For example, using almost a decade of monitoring data, Dennison *et al.* (1993) developed a model based on five water quality parameters (light attenuation coefficient, total suspended solids, chlorophyll-*a*, dissolved inorganic nitrogen and dissolved inorganic phosphorus) that predicts the distribution of submerged aquatic vegetation in Chesapeake Bay. Other common elements of most programs include focusing on monitoring during an index period (usually the time of the year when peak biomass occurs in the seagrass bed), and development of standardized protocols for monitoring. Monitoring during an index period is important due to the considerable temporal and spatial variability in most seagrass condition indicators (Neckles 1994). Using an index period facilitates analysis of change by reducing effects due to seasonal differences.

While Texas does not currently have a state seagrass monitoring program, in 1999 the three state agencies with primary responsibility for conserving coastal natural resources, Texas General Land Office (GLO), the Texas Commission on Environmental Quality (TCEQ), and the Texas Parks and Wildlife Department (TPWD), signed the Seagrass Conservation Plan for Texas (TPWD 1999). Currently, TPWD facilitates quarterly meetings of a Seagrass Monitoring Work Group comprised of experts from academics, government and non-governmental organizations. The group's primary focus is to facilitate implementation of a statewide seagrass monitoring plan. Some participants in the group researched and reviewed seagrass monitoring methods (Dunton *et al.* 2005, Dunton and Pulich 2007), resulting in recommendations for a Texas program incorporating landscape analysis and field-based indicators of environmental quality and seagrass condition in a three-tier system. Tier 1 is the landscape analysis component, calling for aerial imagery of the entire Texas coast to be obtained every five years (or more frequently) in order to determine seagrass bed areal extent. Tiers 2 and 3 are the biological and environmental components of the proposed program. Tier 2 is a rapid assessment at numerous fixed sites up and down the coast. Tier 3 is intensive site monitoring using a transect-based design. Tier 3 is for areas of special concern or areas that are experiencing seagrass declines. Tier 3 information is aimed not just at documenting changes in seagrass, but also identifying potential causes.

In 2010, the GLO Coastal Management Program funded TPWD, in conjunction with Dr. Kenneth Dunton of the University of Texas Marine Science Institute, to conduct a seagrass monitoring project in two Texas estuaries. The project was intended to explore the Tier 3 framework as a tool for evaluating seagrass condition (TPWD 2010). A suite of seagrass condition and water quality indicators were evaluated at each site, based on the recommendations of Dunton *et al.* (2007), which identified several potential indicators of stress on seagrasses that might work in Texas coastal waters. Water quality data collected included dissolved nutrients, chlorophyll-*a*, suspended solids, light attenuation, salinity, dissolved oxygen, and temperature. Sediment was analyzed for porewater ammonia-nitrogen, total organic carbon, and grain size. Seagrass condition indicators evaluated include total biomass, root:shoot biomass ratio, shoot density, leaf length and width, leaf area index, percent coverage, carbon and nitrogen isotope ratios (to measure human influence), and ratios of carbon-to-nitrogen in seagrass tissue. Seagrass stressors epiphyte biomass and macroalgae biomass were also measured. High-resolution aerial photographs were analyzed for extent of seagrass and macroalgae beds and patchiness of beds. Results from this project led to the recognition that several components would be important in establishing a statewide monitoring program for Texas: best time of year to conduct monitoring (index period), cost in money and staff time, and laboratory capability. Another important result coming out of this work was the demonstration that state staff can accurately and efficiently conduct monitoring and analyze seagrass samples.

TCEQ joined the seagrass monitoring effort with the Phase 1 Seagrass Monitoring Protocol Development project in 2010-2011 (TCEQ 2010, 2011). In Phase 1, several sites up and down the coast were monitored in fall 2010 and again in 2011 for a variety of environmental and biological parameters. Sites were selected based on best professional judgment from areas where seagrass beds might be experiencing stress from development activities and areas which were thought to be more pristine and least-impacted by development pressure. This project leveraged knowledge gained from the Coastal Management Program study in 2010, and expanded the same type of sampling to include all seagrass areas from West Bay in the Galveston Bay system to the Lower Laguna Madre.

In 2012, TCEQ funded a Phase 2 project, the subject of this report. Phase 2 expanded sampling to include many more sites under a tiered approach as used in other parts of the United States (Fourqurean *et al.* 2002; Neckles *et al.* 2012) and as recommended by Dunton and Pulich (2007) and Dunton *et al.* (2011). This approach included setting up a network of probabilistically-selected monitoring sites. These sites are intended to be permanent monitoring sites, which can be evaluated over time to detect changes in seagrass coverage, species composition, and canopy height. Phase 2 encompassed both a coastwide component and a bay-scale component, which was developed for San Antonio and Redfish bays. Each component consisted of about fifty permanent sites. In addition, Phase 2 included eight intensive sampling events (Tier 3) in San Antonio and Redfish Bays where many environmental and biological parameters were measured. These sites were chosen based on best professional judgment.

Project Area

The Texas coast covers 367 miles between the Louisiana and Mexico borders (TSHA 2013). Eight major bays are located along the coast. The upper coast is considered to be the four northernmost bays, Sabine Lake, Galveston Bay, Matagorda Bay and San Antonio Bay. The lower coast bays are Aransas Bay, Corpus Christi Bay, the Upper Laguna Madre and the Lower Laguna Madre. Seven primary barrier islands (Britton and Morton 1989) protect most of the bays and their seagrass from coastal surges and damaging waves from storms. The bays along the Texas coast vary in salinity, sediment types, freshwater inflows and other factors based on the diverse geology and hydrology across this large state. The northernmost bays have much lower salinity levels than the southernmost bays, due to reduced freshwater inflows in the southern parts of the state. Also, due to freshwater inflows, sediments in upper coast bays tend to have more silt, while lower coast bays are sandy (Britton and Morton 1989).

Texas Coastal bays provide habitat for seagrass and are home to five seagrass species. *Halodule wrightii* (also known as *Halodule beaudettei* or shoal grass, hereafter *Halodule*) (Figure 1) is fast growing and commonly inhabits areas of recent disturbance. The blades are flat with a blunt tip and are a staple food for Redhead Ducks. In comparison, *Thalassia testudinum* (turtle grass, hereafter *Thalassia*) (Figure 2) is relatively slow growing, a climax species and indicative of stable environments. Wide, flat blades simplify species identification. As its common name suggests, sea turtles graze on *Thalassia*. Manatee grass, *Syringodium filiforme* or *Cymodocea filiformis* (hereafter *Syringodium*) (Figure 3), is grazed on by sea turtles and manatees. This is the only Texas seagrass species with a cylindrical leaf cross-section. *Syringodium* grows in deep, stable environments and is thought of as a climax species. *Halophila engelmanii* (star grass, hereafter *Halophila*) (Figure 4) is unique in that the ovate leaves fan out creating a clover shape. *Halophila* is a short species that grows in the understory of *Halodule*, *Syringodium* and *Thalassia*. *Ruppia maritima* (hereafter *Ruppia*) (Figure 5), or widgeon grass, is found along the entire Texas coast and is grazed on by ducks. *Ruppia* is similar in appearance to *Halodule*, but leaves have pointed tips and it can grow in freshwater environments.

Figure 1. ***Halodule wrightii (Halodule beaudettei*) obtained from Port Bay, Jul 2010.**

Figure 2. ***Thalassia testudinum* obtained from Christmas Bay (Galveston Bay complex), Sep 2011.**

Figure 3. ***Syringodium filiforme*** **(*Cymodocea filiformis)*** **obtained from the Upper Laguna Madre, Aug 2012.**

Figure 4. ***Halophila engelmanii*** **obtained from San Antonio Bay, Aug 2012.**

Figure 5. *Ruppia maritima* obtained from Port Bay, Jul 2010.

Project Design

This report includes data from the Phase 1 and Phase 2 seagrass monitoring projects that spanned 2010-2012. The design is different in each of the three years of the seagrass monitoring project (Table 1). To avoid confusion, the three years are referenced differently. Sampling in 2010 is referred to as Phase 1 Year 1. Phase 1 Year 1 site locations are referred to in the dataset as "Phase 1," "EX," or existing sites. The second year of Phase 1, 2011, is called Phase 1 Year 2. The third year of monitoring is Phase 2. Phase 2 incorporates Tiers 2 and 3 of the recommended seagrass monitoring protocols (Dunton *et al.* 2007, 2011). Tier 2 coastwide sites are noted in the text and dataset as "CW" and Tier 2 bay-scale sites are noted as either "RF" for Redfish Bay or "SA" for San Antonio Bay. Phase 2 transect-based data were collected for Redfish Bay and San Antonio Bay to compliment the Tier 2 bay-scale data. Transect-based data is noted in the text and datasets as Tier 3.

The 14 "EX" sites were selected by seagrass biologists in 2010 using best professional judgment (Figure 6). Eleven of the 14 EX sites were sampled in Phase 1 Year 1, when time and weather precluded all sites from being sampled (Table 2). In Phase 1 Year 2 all 14 EX sites were sampled. In Phase 2 we transitioned from monitoring seagrass at a few select sites to implementing both probabilistic sampling and transect-based monitoring as recommended by Dunton *et al.* (2007, 2011), as well as continuing monitoring at the 14 EX sites (Figure 7, Figure 8, Figure 9). The type of samples, method of collection and the changes between the phases and years are described below.

Historically, Sabine Lake has not had significant seagrass coverage (except perhaps for *Ruppia*) and no historical seagrass coverage information is available. As such, Sabine Lake was omitted from both the Phase 1 and Phase 2 projects. Galveston Bay, Matagorda Bay, San Antonio Bay, Aransas Bay, Corpus Christi Bay, the Upper Laguna Madre and the Lower Laguna Madre were included in both phases. Given the large distance spanned by Matagorda Bay, in the Phase 2 project it was divided into East Matagorda Bay and West Matagorda Bay.

Table 1. Phase 1 and Phase 2 project design.

	EX sites sampled	Tier 2 sites sampled	Tier 3 transects sampled
Phase 1 Year 1 (2010)	11	---	---
Phase 1 Year 2 (2011)	14	---	---
Phase 2 (2012)	14	CW (53), RF (50), SA (50)	RF (5), SA (3)

Site Selection

Phase 1

Site selection in Phase 1 was based on best professional judgment. A group of seagrass professionals provided input about sites located within Texas bays that could be considered "least impacted" and "potentially impacted" by development. The suggested sites were sorted into upper, middle and lower coast regions. For each region, except Corpus Christi Bay, which has been extensively studied by Dunton, at least one potentially impacted site and one least impacted site was identified. From the original 23 proposed locations, 14 areas were chosen (Table 2).

Desktop research, followed by field reconnaissance, was used to determine specific Phase 1 sampling locations (Figure 6). The general areas previously identified were viewed on Google Earth and reviewed with staff knowledgeable of each area, which narrowed options for potential sampling locations. Once in the field, in each area the crew selected a specific location and surveyed a 10 m area around the boat to verify at least 50% coverage of seagrass. Latitude and longitude were recorded to ensure the site could be revisited.

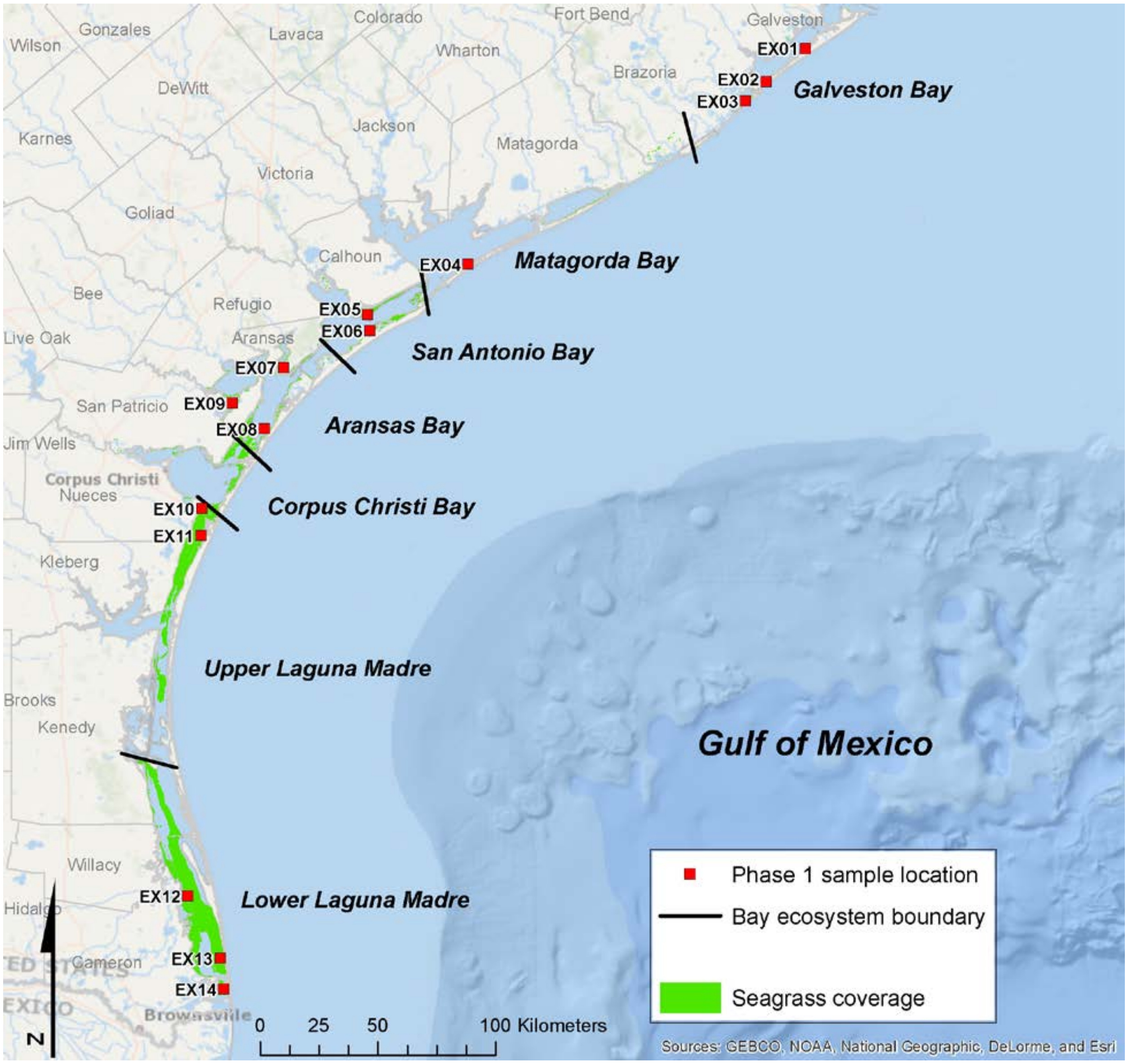

Figure 6. Phase 1 (EX) seagrass monitoring sites.

Fourteen sites are distributed among seven major bay systems. In addition to Phase 1 seagrass monitoring at these existing sites in fall 2010 and 2011, Phase 2 Tier 2 seagrass monitoring was completed at these sites in 2012. The seagrass coverage layer is derived from photointerpretation of imagery from 1988 to 2005, available online through the TPWD seagrass viewer (TPWD 2012b).

Table 2. Phase 1 (EX) site location descriptions.

Region[a]	Ecosystem	Coastal Region	Site ID	Site Area	Rationale
1	Galveston Bay	Upper	EX01	West Bay in Dana Cove approximately 400 m NW of RV parking circle at Galveston Island State Park	Recent seagrass expansion
			EX02	West Bay approximately 250 m from shore of Pointe West resort on Galveston Island west end	Potentially impacted
			EX03	Christmas Bay approximately 60 m from bay shore of Follets Island and 1.7 km ENE of Arcadia Reef	Coastal preserve - least impacted
2	Matagorda Bay	Upper	EX04	West Matagorda Bay approximately 500 m from bay shore of Matagorda Peninsula and 6.3 km ENE of Pierce Field	Least impacted
3	San Antonio Bay	Middle	EX05	Shoalwater Bay approximately 450 m east of Grass Island and 1.25 km SE of ICWW near Welder Flats Wildlife Management Area	Coastal preserve - least impacted
			EX06	Lower San Antonio Bay in Corey Cove approximately 35 m from bay shore of Matagorda Island State Park	Least impacted
4	Mission-Aransas (MANERR)	Middle	EX07	St. Charles Bay 2.1 km NE of Bird Point on east side of Aransas National Wildlife Refuge Complex	Least impacted
			EX08	Aransas Bay near south shore of Mud Island, 3.5 km W of San Jose Island airstrip	Least impacted
			EX09	Port Bay approximately 500 m WSW of Port Bay Rd.	Potentially impacted
5	Corpus Christi Bay	Middle	---	Not assigned	Area already extensively researched
6	Upper Laguna Madre	Middle	EX10	Upper Laguna Madre near islands 1.0 km ESE of Skipper Lane in Flour Bluff area of Corpus Christi	Recent seagrass loss
			EX11	Nighthawk Bay behind dredge spoil island 1.7 km SW of Coquina Bay subdivision	Recent seagrass expansion
7	Lower Laguna Madre	Lower	EX12	Lower Laguna Madre near mouth of Arroyo Colorado	Potentially impacted
			EX13	Bay shore of South Padre Island	Least impacted
			EX14	South Bay	Coastal preserve - least impacted

[a] Adapted from Dunton *et al.* (2007)

Phase 2 Tier 2

Tier 2 sites were selected probabilistically from a list of potential sampling sites generated using the TPWD Coastal Fisheries sampling grid system (TPWD 2012a) and historic seagrass coverage available as geographic information system (GIS) polygon shapefiles derived from imagery photointerpretation (M. Fisher, TPWD, pers. comm., TPWD 2012b) (Figure 7). TPWD grids cover each bay and the Texas Territorial Sea and are one minute latitude by one minute longitude in size. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Coordinate sets were obtained for each gridlet which center fell within a seagrass polygon. Separate sets of coordinates (gridlet center points) were generated for the coast (170), Redfish Bay (147), and San Antonio Bay (150). More than 50 coordinate sets were generated for each area to account for unsuitable sites and limitations of the seagrass coverage polygons. Coordinate sets were numbered using a random number generator.

Prior to sampling, a table top exercise was conducted with staff knowledgeable of each area to prioritize coordinate sets based on the presence of seagrass, accessibility by boat and safety. Ratings 1 and 2 suggested a coordinate set was suitable for sampling, while 3 and 4 indicated it was not. The coordinate sets rated 1 or 2 for each area were sorted according to the assigned random numbers and the first 50 were designated as “priority” sites. The remaining coordinate sets were designated as “alternative” and used to replace priority coordinate sets unsuitable for sampling. For example, of the 149 San Antonio Bay coordinate sets (one site was removed from the dataset), 95 were rated 1 or 2, resulting in 50 priority sites and 45 alternative sites (Table 43).

Each priority coordinate set was validated before establishing a permanent sampling site. Seagrass monitoring teams navigated to within 10 m of a selected priority coordinate set using a handheld GPS and maps with coordinate locations. A priority coordinate set was validated and became a permanent site if visual observation indicated it had relatively uniform seagrass coverage of 50% or more within a 10 m radius and the area was free of navigation and safety hazards. If a priority coordinate set did not meet the validation criteria, an alternative coordinate set was investigated for validation. Alternative coordinate sets meeting the validation criteria replaced invalid priority coordinate sets as permanent sites. A total of 53 coastwide sites, 50 in San Antonio Bay and 50 in Redfish Bay were validated (Figure 7, Table 42).

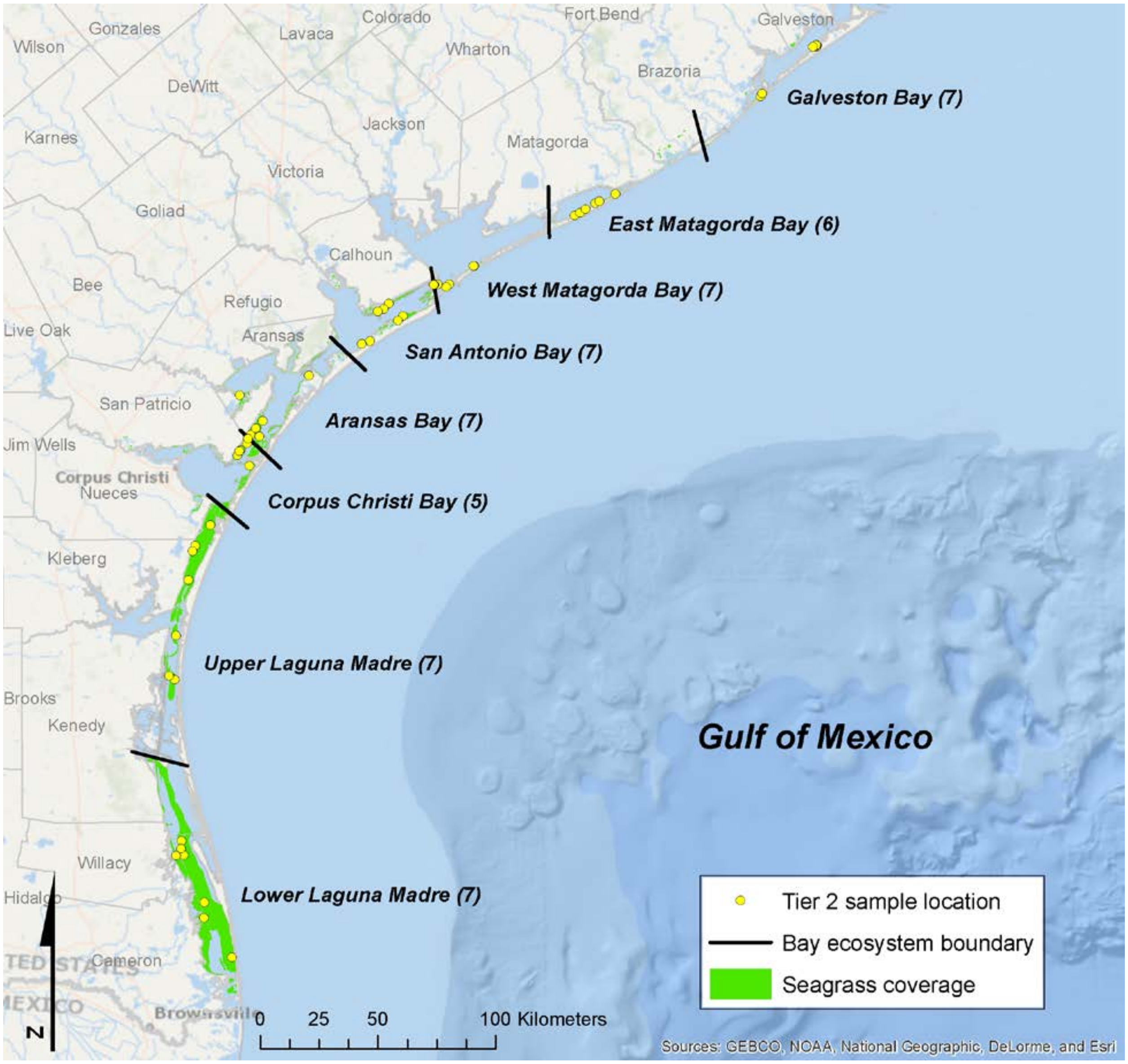

Figure 7. Phase 2 coastwide Tier 2 sites, 2012 (number of sites).
Fifty-three sites are distributed among the major Texas bays. The seagrass coverage layer is derived from photointerpretation of imagery from 1988 to 2005, available online through the TPWD seagrass viewer (TPWD 2012b).

Phase 2 Tier 3

Three 50 m transects were sampled in San Antonio Bay (Figure 8) and five transects in Redfish Bay (Figure 9). Tier 3 transect site selection was based on best professional judgment of experienced staff and included the deep edge of the seagrass bed. Beds of *Thalassia* and *Halodule* were targeted since these are the two most common seagrass species along the Texas coast.

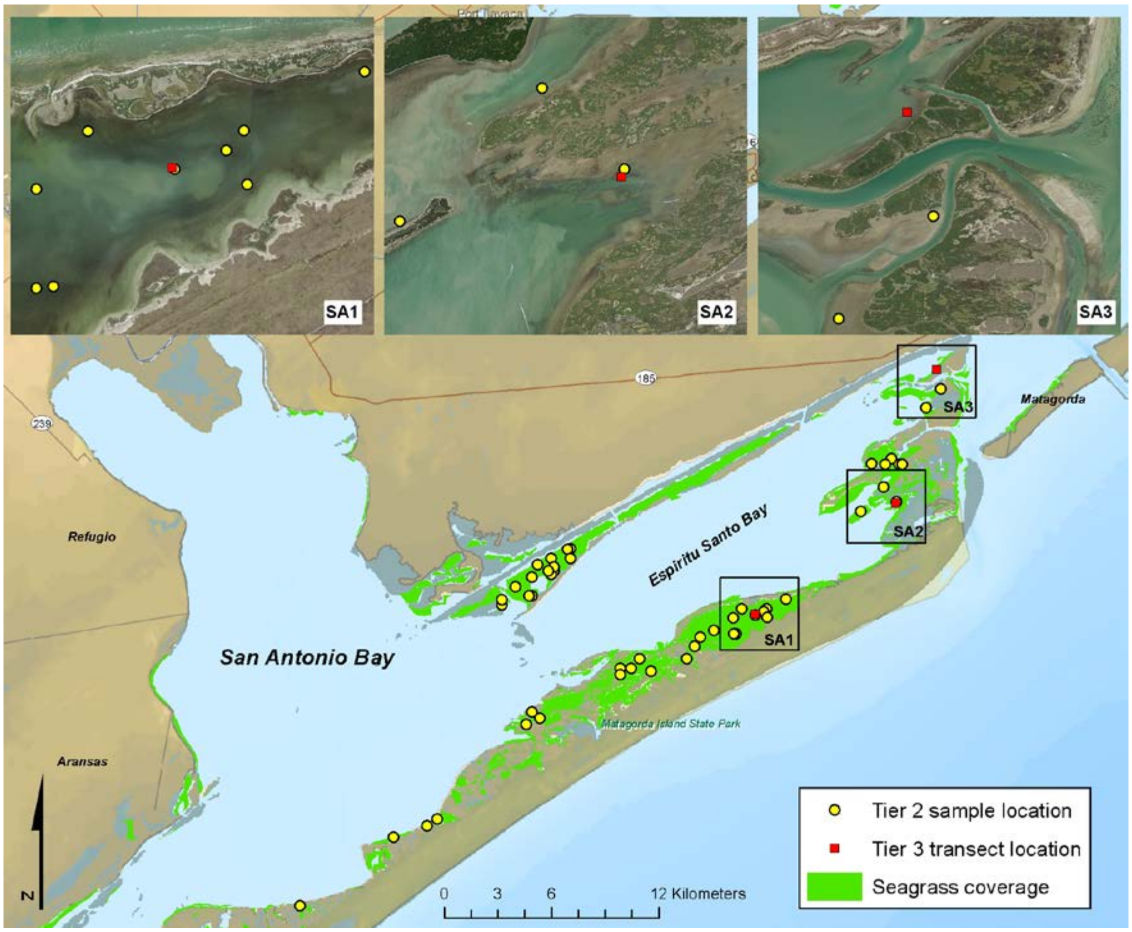

Figure 8. Phase 2 San Antonio Bay Tier 2 sites and Tier 3 transect locations, 2012.
There are 50 Tier 2 sites. Tier 3 transects are located in Pringle Lake (SA1), Big Pocket (SA2), and Barroom Bay (SA3). The seagrass coverage layer is derived from photointerpretation of imagery from 1988 to 2005, available online through the TPWD seagrass viewer (TPWD 2012b).

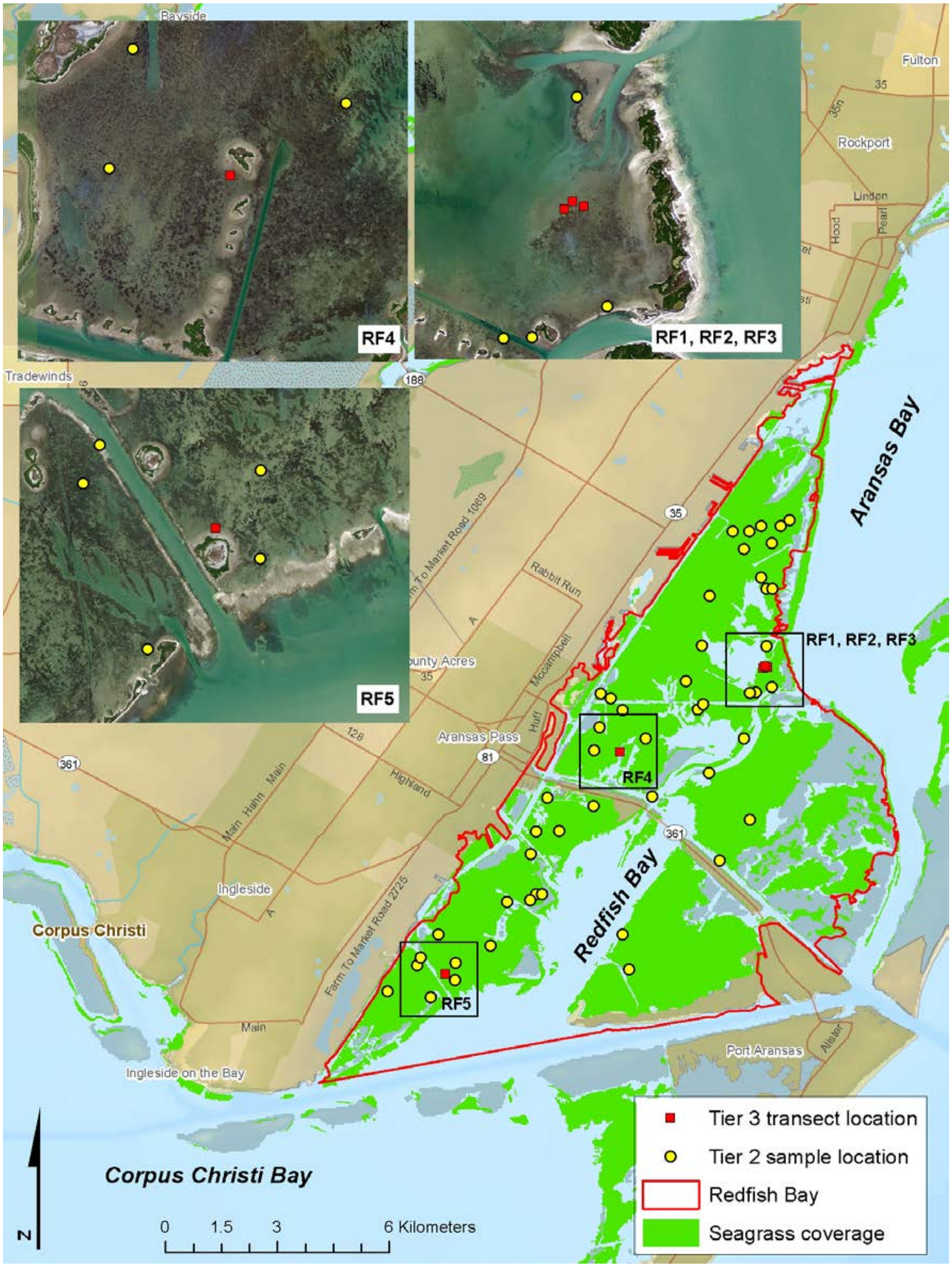

Figure 9. Phase 2 Redfish Bay Tier 2 sites and Tier 3 transect locations, 2012.
There are 50 Tier 2 sites. Tier 3 transects RF1, RF2, RF3, RF4 are located in the Aransas Bay portion of Redfish Bay. Transect RF5 is located in the Corpus Christi Bay portion of Redfish Bay. The seagrass coverage layer is derived from photointerpretation of imagery from 1988 to 2005, available online through the TPWD seagrass viewer (TPWD 2012b).

Methods

Detailed descriptions of sampling methods and quality assurance protocols used in this project are provided in several documents. The TCEQ Surface Water Quality Monitoring Procedures (SWQM) Manual Volumes 1 and 2 (TCEQ 2008 and 2007, respectively) include information about field measurements, water and sediment chemistry and calibration protocols. Seagrass condition indicators, seagrass protocol training and other project specific information can be found in TCEQ SWQM Program Quality Assurance Plan (QAP) 2010 and 2011 (TCEQ 2010 and 2011) as well as this project's Quality Assurance Project Plan (QAPP) (TPWD 2012c).

During the Phase 2 project, staffing and field conditions varied, enabling us to get a sense of the work load and staff-hours required to complete Tier 2 sampling in various situations. Tier 2 field crew sizes varied from two to five. A crew of three proved most efficient. This allowed two crew members in the water with one on deck to record data and make canopy height measurements. Navigating between sites was the slowest step of the Tier 2 field work and was the limiting factor in determining how many sites could be sampled each day. When Tier 2 sites were closely spaced, as in the Redfish and San Antonio Bay sampling, crews averaged 14 sites per day. When sites were spaced further apart, they averaged 8 sites per day. Shallow draft boats were required in the shallower bays in order to access all seagrass areas. Having a hydraulic anchoring system, such as a Power Pole, and a push pole provided a safe way to anchor the boat and then keep the boat from rotating in the wind. Carrying four quadrats for use in seagrass percent coverage determinations improved efficiency. Two crew members in the water could each quickly establish and clean one quadrat and then let the disturbed sediment settle while cleaning another quadrat. Tier 3 field and lab crews typically consisted of three or four staff. Three transects would typically require 1-1/2 field days followed by two to three days in the lab.

Field Measurements

Basic information, such as weather, latitude, longitude and human use was collected at each site.

Physicochemical and Secchi Depth Measurements

Phase 1

Dissolved oxygen, temperature, pH, specific conductivity and salinity were measured using a multiprobe instrument (YSI 600XLM or equivalent). Secchi depth and total water depth were also measured (Figure 10, Figure 11). These measurements were made before staff entered the water, to prevent disturbing the sediments and influencing water and sediment chemistry measurements (TCEQ 2010, 2011).

Phase 2 Tier 2

Total water depth was measured at each site (TPWD 2012c).

Phase 2 Tier 3

Tier 3 physicochemical, Secchi depth and total water depth measurements followed Phase 1 protocols (Figure 12, TPWD 2012c).

Photosynthetically Active Radiation (PAR)

Phase 1

In Year 1, measurements of percent surface irradiance (% SI) and the diffuse light attenuation coefficient (*k*) were made from replicate measurements of surface (ambient) and underwater irradiance. Measurements of photosynthetically active radiation (PAR = ca. 400 to 700 nm wavelength) were collected on the surface using an LI-190SA quantum-sensor that provides input to a Licor datalogger (LI-COR Inc., Lincoln, Nebraska, USA) at each site (Figure 10). Underwater measurements were made using a LI-192SA or LI-193SA sensor. Measurements of % SI and *k* were based on three or more determinations of instantaneous PAR collected by surface and underwater sensors and recorded by the datalogger. Care was taken to reduce extraneous sources of reflected light (from boats or clothing) (TCEQ 2010). Light attenuation was calculated using the transformed Beer Lambert equation:

$$K_d = -[\ln(I_z/I_0)]/z$$

where k is the attenuation coefficient (m^{-1}) and I_z and I_0 are irradiance (µmol photons/m^2sec) at depth z (m) and at the surface, respectively. Percent surface irradiance available at the seagrass canopy is calculated as follows:

$$\% SI = (I_z/I_0) \times 100$$

where I_z and I_0 are irradiance (µmol photons/m^2sec) at depth z (m) and at the surface, respectively.

Changes were made for PAR measurements in Year 2 (TCEQ 2011). A LI-193SA spherical quantum sensor (LICOR Inc., Lincoln, Nebraska, USA) was used to measure PAR just above the water surface (in-air), just below the water surface, and at depth at the top of the seagrass canopy, respectively, to calculate % SI and *k* (Figure 11). Measurements were made sequentially, rather than replicated. Specific calibration constant multipliers were used for the values collected in air and for those collected underwater, to account for the immersion effect at both measurement depths. The use of the spherical sensor (LI-193SA) provided equal surface area for capturing PAR in the air and underwater in order to reduce conversions and calculations which can create errors. Calculations for %SI and *k* are the same as previously noted.

Phase 2 Tier 2 and Tier 3

Measurements were not made for PAR in Tier 2. Tier 3 PAR followed Phase 1 Year 2 protocols described above and were collected at each transect from the boat (TPWD 2012c).

Sample Collection

Water and Sediment Samples

Phase 1

In Year 1 and Year 2 water samples were collected from the boat at each site for each of the following parameters: ammonia-nitrogen, ortho-phosphate-phosphorus, nitrate-nitrogen plus nitrite-nitrogen, total suspended solids, volatile suspended solids, and chlorophyll-*a* (Figure 10, Figure 11) (TCEQ 2008, 2010, 2011).

Year 1 and Year 2 sediment samples were collected at each site for pore water ammonia-nitrogen, sediment grain size, and total organic carbon (Figure 10, Figure 11). Samples were collected separately using 60cc syringes and stored in sterile Whirlpak bags (TCEQ 2008, 2010, 2011).

Phase 2 Tier 2 and Tier 3

Water and sediment samples were not required for Tier 2.

Tier 3 water samples were collected from the boat at the deep end of the transect for each of the following parameters: ammonia-nitrogen, ortho-phosphate-phosphorus, nitrate-nitrogen plus nitrite-nitrogen, total suspended solids, volatile suspended solids, and chlorophyll-*a* (Figure 12) (TCEQ 2008, TPWD 2012c).

Tier 3 sediment sampling protocols included ten porewater ammonia-nitrogen samples collected adjacent to the quadrat locations. Sediment grain size and total organic carbon samples were collected near the middle of the transect (Figure 12) (TCEQ 2008, TPWD 2012c).

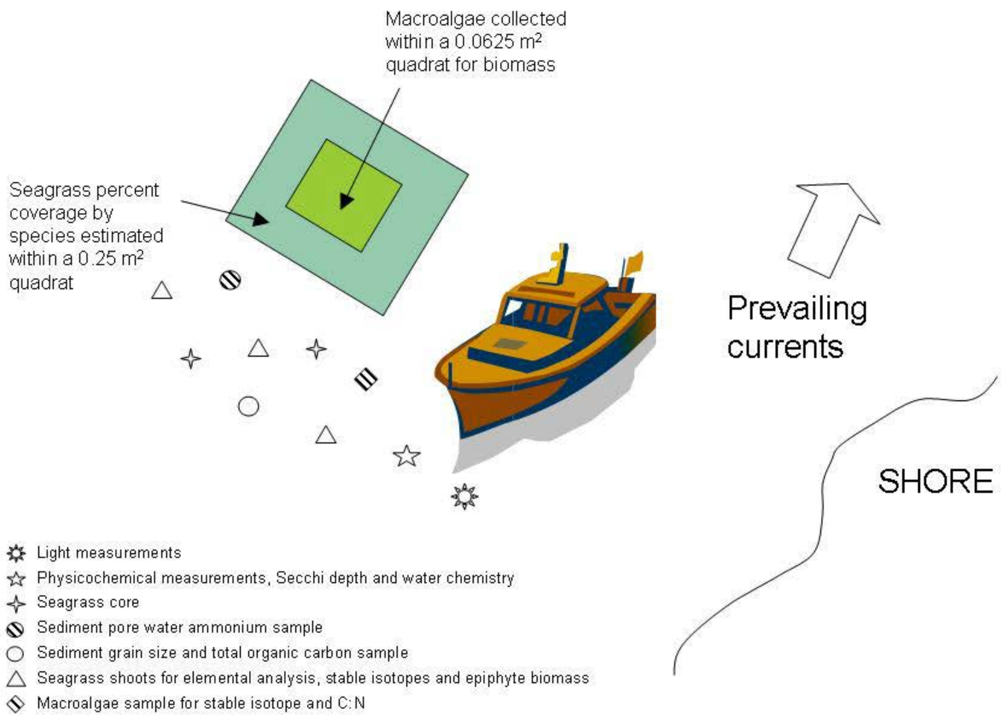

Figure 10. Phase 1 Year 1 field sampling design.

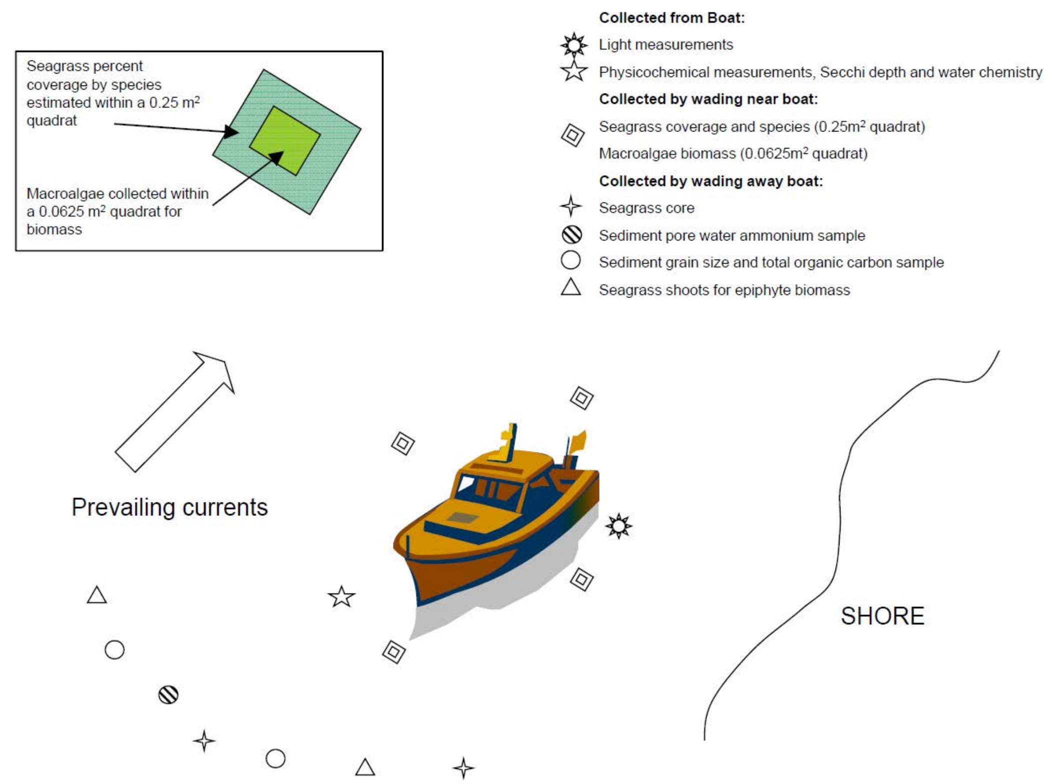

Figure 11. Phase 1 Year 2 field sampling design.

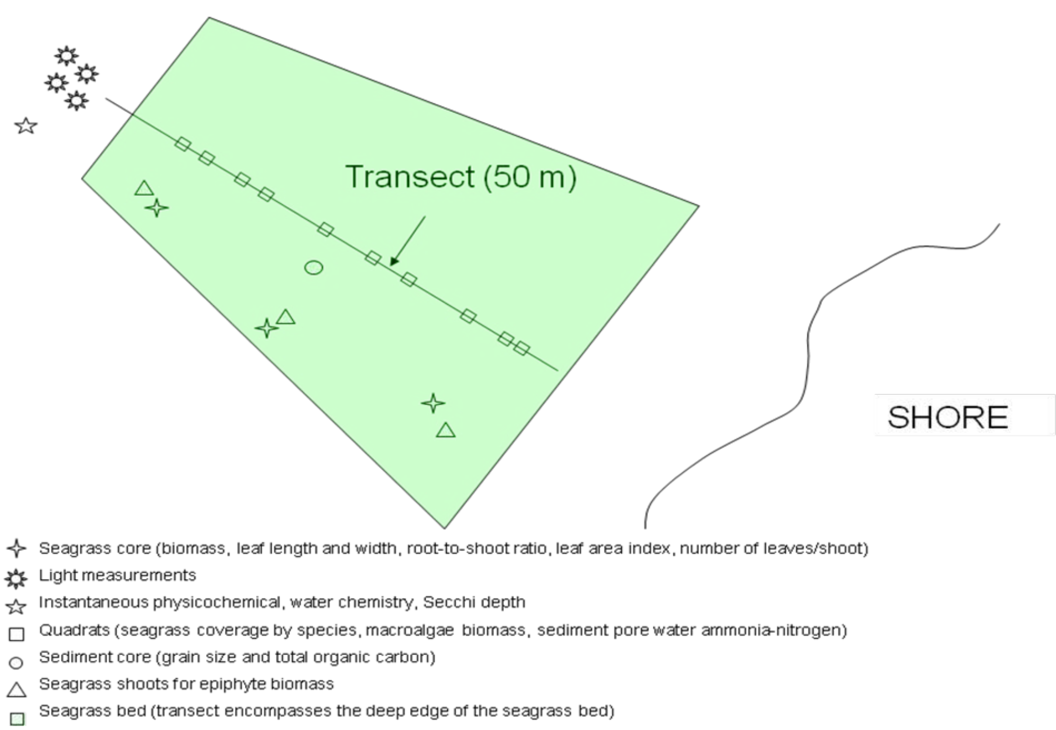

Figure 12. Phase 2 Tier 3 field sampling design.

Seagrass Condition Indicators

Seagrass percent coverage, canopy height, macroalgae biomass, seagrass core and epiphyte biomass samples were collected in both years of Phase 1 and in Phase 2 Tier 3. All biological samples were placed in pre-labeled plastic bags and stored on ice until the samples could be moved to a refrigerator. Seagrass percent coverage and canopy height were measured in Phase 2 Tier 2.

Phase 1

In Year 1, a 0.0625 m^2 quadrat was randomly placed on the bay bottom near the boat to collect one macroalgae sample at each location (Figure 10). Project staff carefully cleared the remaining macroalgae, dead seagrass and other material from the area surrounding the quadrat. After the macroalgae was cleared, a 0.25 m^2 quadrat (Figure 13) was positioned in the same area to determine seagrass percent coverage and species composition. Percent coverage is defined as the percent of the quadrat area that is obscured by seagrass when viewed from directly overhead. All species within the quadrat were recorded and the percent coverage per species was noted. Coverage was recorded such that the total of all species plus bare area equaled 100% (TCEQ 2010 and 2011). When water clarity prevented visual assessment of seagrass percent coverage, staff used touch to estimate seagrass percent coverage.

In Year 2, macroalgae collection and seagrass percent coverage protocols were the same as for Phase 1 Year 1 except that subsamples of both sample types were collected from each side of the boat (bow, starboard, stern and port) (Figure 11) (TPWD 2012c). Canopy height was not measured in the field in Phase 1.

Figure 13. Quadrat for determination of seagrass percent coverage by species. Quadrat is 0.50 m by 0.50 m (0.25 m^2) and constructed of white PVC.

In Year 1 and Year 2 project staff collected two seagrass cores near the boat (Figure 10, Figure 11). A 15 cm inner diameter corer with a hole and rubber stopper on top (Figure 14) was used to sample *Thalassia* and a 9 cm inner diameter cylindrical corer (Figure 15) was used to sample other Texas seagrass species: *Halodule, Syringodium, Ruppia,* and *Halophila*. Project staff typically collected only from the "up-current" side of the quadrant to prevent sample contamination (Figure 10, Figure 11). Seagrass cores were used for estimates of seagrass condition indicators (above- and below-ground biomass, root:shoot ratio, leaf area index, blade width and length, shoot density) as described in TCEQ (2010 and 2011).

Epiphyte biomass analysis required separate seagrass shoot collection to provide enough surface area to assess the biomass load. In Year 1 and Year 2, one bag of seagrass shoots was collected near the quadrat by gently uprooting the rhizomes from the sediment with minimal contact with the blades.

Figure 14. Seagrass corer (15 cm inner diameter) used for sampling *Thalassia*.

Figure 15. Seagrass corer (9 cm inner diameter) used for sampling *Halodule, Syringodium, Ruppia* and *Halophila.*

Phase 2 Tier 2

Tier 2 data collection for each site consisted of two measurements: seagrass percent coverage and canopy height. Seagrass percent coverage was determined as described above for Phase 1 Year 2 at four locations around the boat (bow, starboard, stern, port) (Figure 11, Figure 16). Also, data was noted as “V” or “T” on the datasheet to designate the percent coverage as being determined by sight or touch.

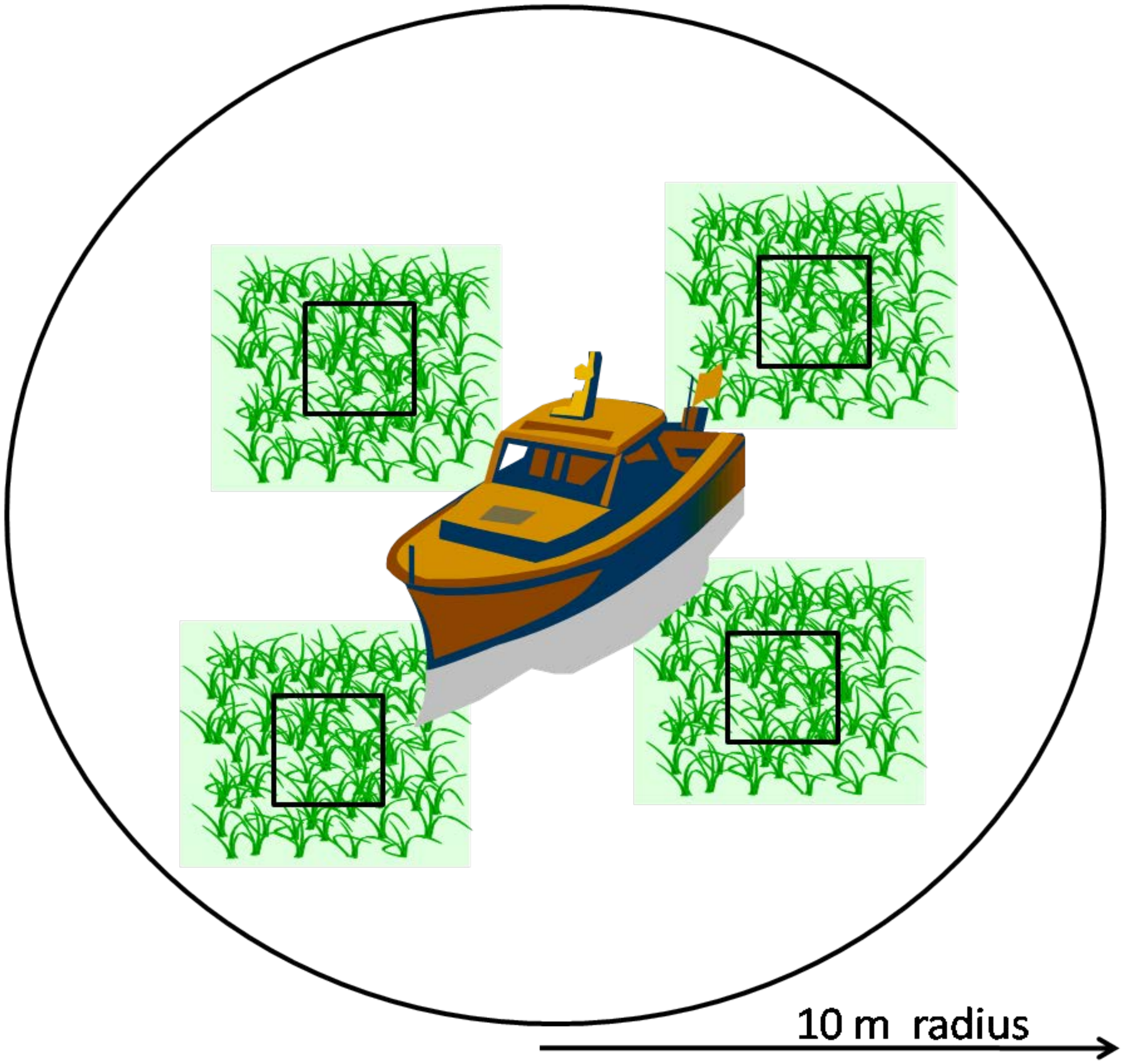

Figure 16. Phase 2 Tier 2 sampling site area and quadrat placement for estimating seagrass percent coverage and measuring canopy height.

Seagrass canopy height data was collected for all species within a quadrat having coverage of 20% or greater. For each species, five representative shoots were selected and leaf (blade) length was measured to the nearest 0.1 cm in the field (Figure 17). A seagrass leaf is defined as the portion of the seagrass shoot that is green and above the sediment line.

In both years of Phase 1 and Phase 2, leaf length was used as a surrogate for actual *in-situ* canopy height measurements. The growth patterns of *Halodule*, *Thalassia,* and *Syringodium* are similar and leaf length measurements of these species provide reliable estimates of canopy height (Figure 1, Figure 2 and Figure 3). However, *Ruppia,* and *Halophila* exhibit branching structures (Figure 4 and Figure 5). Hence measurements of leaf length for these species, while providing a measure of seagrass condition, do not accurately depict their canopy height.

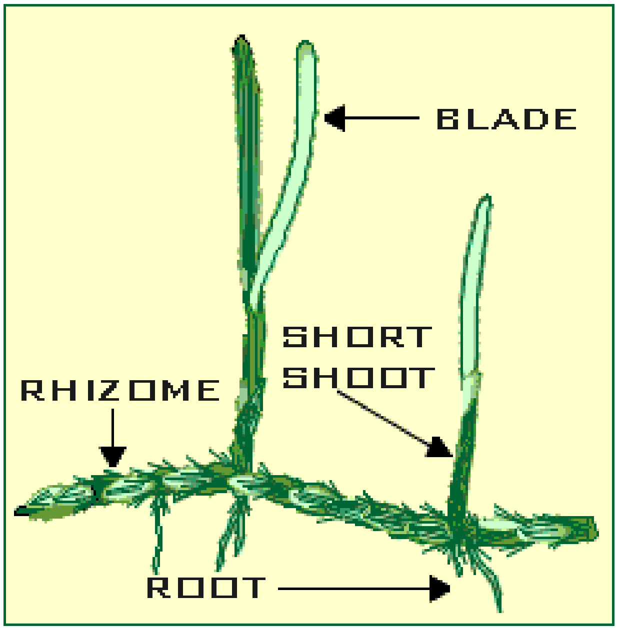

Figure 17. Typical seagrass morphology.
For purposes of this project, the area labeled "blade" on this illustration is referred to as the "leaf." Diagram found at website of the Florida Medical Entomology Laboratory, University of Florida, Gainesville. Accessed 27 Jan 2011 at http://fmel.ifas.ufl.edu/habitat/seagrass_parts.shtml.

Tier 3

Tier 3 protocols provided a more detailed look at local seagrass condition. Each site was sampled along a 50 m transect that encompassed the deep edge of the seagrass bed. Seagrass percent coverage, macroalgae biomass, seagrass core and epiphyte biomass samples were collected along each transect.

Tier 3 macroalgae biomass and seagrass percent coverage sampling protocols included ten samples collected at pre-selected random locations along a 50 m transect (Figure 12 and Figure 18) (TPWD 2012c). Canopy height was not measured in the field in Tier 3.

Seagrass core sample collection followed similar protocols to Phase 1 Year 2. Three cores were collected within 5 m of the transect line, representing shallow, middle and deep areas along the transect.

Shoot collection for epiphyte biomass also followed the Phase 1 Year 2 protocols with the exception that three samples were collected near the seagrass cores to represent shallow, middle and deep areas (TCEQ 2010, TCEQ 2011 and TPWD 2012c).

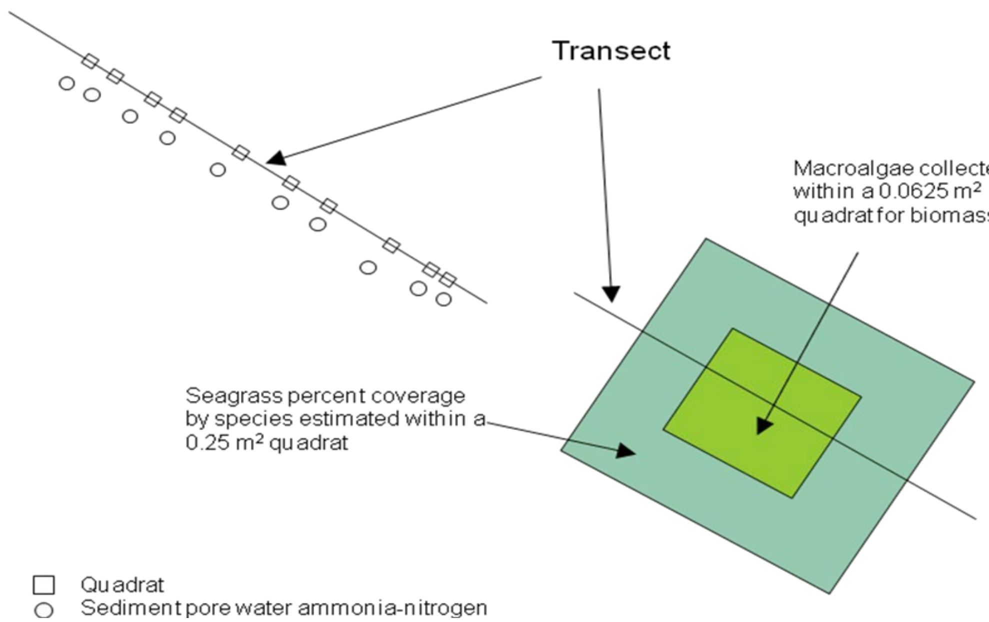

Figure 18. Phase 2 Tier 3 close-up of field sampling design.

Sample Analysis

Laboratory analysis procedures for each sample type are described in detail in the Phase 1 QAPs (TCEQ 2010 and TCEQ 2011) and the QAPP for Phase 2 (TPWD 2012c). The Lower Colorado River Authority Environmental Laboratory Services group analyzed all water and sediment samples (TCEQ 2010, TCEQ 2011, and TPWD 2012c). Analyses for biological samples were consistent throughout the studies and are summarized below.

Epiphyte Biomass

Seagrass shoots for epiphyte biomass determinations were processed within three days of collection. Epiphytes were separated from the leaf surface by scraping with a scalpel, forceps, or razor blade. For *Halodule, Syringodium, Ruppia* and *Halophila* at least twenty leaves of each sample (both sides/all surfaces of the leaf) were scraped. For *Thalassia,* a minimum of five leaves were scraped. The same length was scraped on each leaf (e.g., 10 cm or 15 cm of each leaf was scraped). The length and width and the total number of leaves scraped were recorded. Scraped material was collected on pre-weighed glass fiber filters. The collected epiphyte biomass samples and scraped seagrass leaves were then dried in separate pre-labeled aluminum foil envelopes in the oven at 60 °C. The top of the envelope was left open to allow water vapor to escape.

Seagrass

Seagrass core samples were processed within a week of collection. Samples were rinsed gently with tap water to remove sediment, then placed into white lab sorting trays and non-seagrass material and dead plant material were removed. Individual shoots were counted using tally counters. Five shoots selected at random were further examined for the calculation of leaf area index. (Leaf area index is the product of shoot density, leaf length and leaf width.) For each shoot, the number of leaves, the length (to the nearest 0.1 cm) and width (to the nearest 0.5 mm) of the longest leaf of each shoot were recorded. Leaf width was measured at the midpoint of the leaf (halfway between the base and the top). Shoots were then processed along with the rest of the sample. Above-ground tissue (leaves, sheaths, any floral parts) were separated from below-ground tissue (roots and rhizomes) by cutting the leaf at the point where the green color fades to white. Above-ground tissue was carefully cleaned of attached biota (such as epiphytes, hydrozoans, and polychaete worms) by scraping with a wet cloth, forceps, scalpel or razor blade. Above-ground tissue and below-ground tissue were then placed in separate pre-labeled and pre-weighed aluminum foil envelopes for drying in the oven at 60°C. The top of the envelope was left open to allow water vapor to escape.

In Phase 1 and Phase 2 Tier 3, canopy height was not measured in the field. Instead, leaf length was measured in the lab. In this report, Tier 2 field measurements of leaf length and Phase 1 and Tier 3 lab measurements of leaf length were considered equivalent and both were used in data analysis.

Macroalgae

Macroalgae samples were processed within a week of sample collection. In the lab, epiphytes were removed from the macroalgae by rinsing gently with tap water and then gently scraping off any non-macroalgal material (seagrass, shells, sediment, etc.). Samples were then placed into a device designed to spin excess water from salad greens (Salad Spinner) and spun to drive off as much water as possible from the material. Samples were examined and when necessary, additional non-macroalgal material was removed by hand. Following cleaning, samples were placed into pre-labeled aluminum foil envelopes for drying in the oven at 60°C. The top of the envelope was left open to allow water vapor to escape.

Seagrass Protocol Training

On 25-26 Jul 2012, twenty participants received Tier 2 seagrass protocol training in Rockport, TX. The training included four hours of classroom review and a practical exercise, and four hours of hands-on field training. The classroom portion covered the purpose of the project, how to validate sites, how to identify seagrass species, data to be collected, collection procedures, how to estimate coverage and how to measure leaf length as a surrogate for canopy height. The practical session covered how to navigate using GPS, identify seagrass species and measure leaf length on different seagrass species.

The field portion of the training allowed the participants to transfer classroom knowledge to real life experience. All the participants were paired with a trainer and a boat. The participants navigated to pre-selected training station locations using a GPS. Once each training station was validated and GPS data logged, each participant collected seagrass percent coverage and canopy height data. Participants within a group individually determined percent coverage and then compared their numbers. Trainers led discussion on how each number was determined to provide guidance on proper technique. This method allowed participants to calibrate their seagrass percent coverage estimation as a group. Next, seagrass canopy height measurements were recorded for each participant (Figure 19). Some groups had each participant measure the same blades (multiple measurements of the same data by different people) while other groups measured different blades (multiple measurements of different, but similar data by different people). The groups visited at least two stations to ensure protocols were well-understood and all were comfortable to collect the data on their own (without a trainer).

Figure 19. TPWD staff practicing leaf length measurements at a training exercise.

Measurement Precision

Confidence in sample results depends on measurement errors associated with individual samples and population errors associated with sample design. To ensure that measurement errors do not exceed population errors for a given sample design, estimates were made of the precision of individual measurements (measurement error) and smallest quantity that can be detected (sensitivity) for the biological parameters collected in this project (Table 3).

Seagrass condition and stressor indicator measurements are inherently less refined than water and sediment chemistry measurements. The precision for each biological parameter was estimated by identifying potential sources of measurement error and propagating errors using a root-mean-square formula (Equation 1). Percentage error was identified for equipment and instruments used in processing samples, for example, the uncertainty associated with weighing samples was estimated using the limit of quantitation of the analytical balance. Percentage error for other potential sources was estimated based on best professional judgment (TPWD 2012c).

$$RMS = \sqrt{(error1)^2 + (error2)^2 + (error3)^2 \ldots}$$

Equation 1. Root-mean-square (RMS) error.

Table 3. Seagrass condition and stressor indicator measurement performance specifications.

Analysis	Units	Parameter Code	Analytical method	Sensitivity (unit)	Precision	Expected range
Percent coverage by species	%	N/A	QAPP	1%[1]	10%	0-100%
Shoot density - 9 cm corer	shoots m^{-2}	N/A	QAPP	150	5%	150 - 22,000
Shoot density - 15 cm corer	shoots m^{-2}	N/A	QAPP	50	5%	50 - 6,000
Biomass (above-ground or below-ground) - 9 cm corer	g m^{-2}	N/A	QAPP	0.15	10%	0.5 - 400
Biomass (above-ground or below-ground) - 15 cm corer	g m^{-2}	N/A	QAPP	0.05	10%	0.5 - 400
Biomass - total - 9 cm corer	g m^{-2}	N/A	QAPP	0.3	10%	1 - 2,000
Biomass - total - 15 cm corer	g m^{-2}	N/A	QAPP	0.1	10%	1 - 2,000
RSR	N/A	N/A	QAPP	N/A	10%	0.5 - 25.0
Canopy height - *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 90
Canopy height - other than *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 60
Leaf length - *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 90
Leaf length - other than *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 60
Leaf width - *Thalassia*	mm	N/A	QAPP	0.5	25%	2 - 15
Leaf width - other than *Thalassia*	mm	N/A	QAPP	0.5	30%	1 - 3
LAI - *Thalassia*	m^2 m^{-2}	N/A	QAPP	0.001	25%	0.02 - 5
LAI - other than *Thalassia*	m^2 m^{-2}	N/A	QAPP	0.001	35%	0.02 - 5

[1] One shoot is the smallest quantity that can be detected by an observer, and was assigned a percent coverage of 1%

Analysis	Units	Parameter Code	Analytical method	Sensitivity (unit)	Precision	Expected range
Number of leaves per shoot	integer	N/A	QAPP	1	5%	1 - 4
Epiphyte load - other than *Thalassia*	mg cm^{-2}	N/A	QAPP	0.01	50%	0 - 5
Epiphyte load - *Thalassia*	mg cm^{-2}	N/A	QAPP	0.01	30%	0 - 7
Epiphyte load - other than *Thalassia*	mg g^{-1}	N/A	QAPP	3	30%	0 - 300
Epiphyte load - *Thalassia*	mg g^{-1}	N/A	QAPP	3	10%	N/A
Macroalgal biomass	g m^{-2}	N/A	QAPP	0.002	10%	0 - 225

Data Analysis

Data were transcribed from field sheets into a custom Microsoft Access (2007) database. Calculations were programmed into the database for summary statistics (mean, standard deviation, standard error) as well as calculated results including percent surface irradiance, light attenuation coefficient, leaf area index, above-ground and below-ground biomass, root:shoot ratio, shoot density, macroalgae biomass and epiphyte biomass. Data transcription was manually checked against field sheets (at least 10% of data). All calculations produced by Access were verified independently.

Data analysis tools included SAS 9.3 and SAS Enterprise Guide 4.3 (SAS Institute, Inc., Cary, NC), and PRIMER 6 (Clarke and Gorley 2006; Clarke and Warwick 2001).

Results

Project data collection began on 1 Aug 2012 and was completed on 2 Oct 2012. Tier 2 sampling was conducted under contract for the coastwide and Redfish Bay portions of the project and using TPWD resources (not under the contract) for San Antonio Bay. All results are presented here, as well as results from the Phase 1 seagrass monitoring project. In addition, seagrass percent coverage and canopy height data collected during the training exercise conducted 25-26 Jul 2012 were used in analysis of effects due to seagrass monitoring methods.

In 2012, a total of 153 probabilistically-selected Tier 2 sites were validated and sampled, with 53 sites in the coastwide portion of the project and 50 sites each in Redfish Bay and San Antonio Bay. Fifty additional sites were visited, but not validated because of lack of seagrass, safety issues, or other reasons which were documented on the field forms.

The 14 existing sites from the Phase 1 project were also sampled in 2012 under the Tier 2 protocol. For 11 of the 14 sites, this was the third consecutive year of monitoring. Data from the first and second years at these sites have not been previously published, and are reported here along with the 2012 data collected under this project.

Tier 3 sampling was conducted under contract at five transects in Redfish Bay and using TPWD resources (not under the contract) at three transects in San Antonio Bay.

Seagrass Condition and Stressor Indicators

Phase 1

In the first year of the Phase 1 project, 11 of the 14 sites were visited from 17 Nov through 2 Dec 2010. In the second year of the project, all 14 sites were visited from 7 Sep through 5 Oct 2011. On each visit a range of physicochemical parameters, water and sediment chemistry, and biological parameters were sampled. In this Phase 2 project, Tier 2 sampling was conducted at all 14 sites during the period from 1 Aug through 5 Sep 2012.

Percent coverage and canopy height data are available for three years for 11 of the Phase 1 sites and for two years for the three sites located in the Lower Laguna Madre (Table 4, Table 5).

Percent coverage by species showed dramatic changes between years at some sites. For example, over three years, *Halodule* percent coverage at site EX08 in Aransas Bay ranged from 0 to 99% and from 3 to 99% at EX09. However, these dramatic differences were not consistent, even at sites within the same bay system. At EX08 the highest value was seen in 2010 and at EX07 and EX09 it was seen in 2011. There was no consistent pattern over time at these 14 sites; some showed a decline over time, others stayed more or less the same, some showed a peak in 2011 with lower values in 2010 and 2012, and one site in Galveston Bay showed the lowest value in 2011, with higher values in 2010 and 2012. *Thalassia* was observed all three years at two of the 11 sites sampled (EX03 in Galveston Bay and EX08 in Aransas Bay), and at two of the Lower Laguna Madre sites that were sampled in 2011 and 2012. At EX03, *Thalassia* coverage was a little higher in 2011; at EX08, *Thalassia* coverage was high in 2010 and 2012 but zero in 2011. For the two LLM sites, *Thalassia* coverage was consistently high both years at EX13 and consistently low both years at EX12 and EX14, where *Halodule* and *Syringodium* were also observed. *Syringodium* was documented at three of the Phase 1 sites, EX10, EX11 and EX14. At EX10 and EX11, which were sampled in 2010, *Syringodium* coverage was highest that year, and at EX14 it was about the same both years it was sampled. *Ruppia* was documented at three of the Phase 1 sites, and *Halophila* at two, both species at low coverages.

Percent coverage and canopy height data were analyzed using mixed model ANOVAs with site and year as the model effects. *Halodule* percent coverage values in 2011 were significantly different from the other two years. Variance between sites was 60% and variance within sites (among subsamples) was 40%. For *Halodule* canopy height, all three years were significantly different with canopy height increasing over time. Variance was about the same between and within sites. For bare percent coverage, 2012 was significantly different from the other two years. Variance was about the same between and within sites. For *Thalassia* percent coverage, there was no significant difference among years, as most sites had zero percent coverage throughout the time period. For *Thalassia* canopy height, 2012 was significantly different (higher) from the other two years. Variance between sites was 56% and variance within sites was 44%. The constraints on this analysis include that the sites were selected using best professional judgment, rather than randomly, and that the dataset is very small. Despite these hindrances, with this simple monitoring design it was possible to distinguish changes over time. Implementing this project's recommendations for a Phase 2 seagrass monitoring program (see below), which includes probabilistic design will result in a more robust dataset for detecting coastwide and bay-scale temporal changes.

Note that sampling in 2010 was conducted in November and December, later than what we have now determined to be the optimal sampling period for monitoring seagrass at its peak biomass, 1 Aug – 31 Oct. In 2010, some parts of the Texas coast had already experienced cold fronts and in some areas seagrass had begun to senesce. This is evident in generally higher root:shoot ratios and lower leaf area indices in 2010 than 2011 (Table 31-Table 38), as well as lower water temperatures (Table 26, Table 27). The record drought of 2011 was evident in the salinity and specific conductance measurements along the coast, as 2011 values were much higher than those observed in 2010. Most of the Secchi depth readings were clear to bottom, including the deepest site (0.85 m) in Galveston Bay.

Nutrient and chlorophyll-*a* concentrations were mostly near or below the laboratory limits of quantitation in 2010 and 2011 (Table 28, Table 29). Total suspended solids levels were higher in 2011 than 2010. Sediment porewater ammonia-nitrogen levels ranged from 0.09-7.87 mg/L (Table 28, Table 29). The majority of sites tended to have higher porewater ammonia-nitrogen concentrations in 2011. Sediment at the majority of sites consisted primarily of sand (Table 30). The three sites in Lower Laguna Madre had substrates that consisted primarily of silt, with significant percentages of clay and sand.

Table 4. Mean percent coverage (SE) for Phase 1 sites, 2010-2012.

Bay	Station	Date	N	*Halodule*		*Thalassia*		*Syringodium*		*Ruppia*		*Halophila*		Bare	
Galveston Bay	EX01	Nov 2010	1	70	-	0	-	0	-	0	-	0	-	30	-
		Sep 2011	4	99	(1)	0	-	0	-	0	-	0	-	1	(1)
		Aug 2012	4	79	(4)	0	-	0	-	0	-	0	(0)	21	(4)
Galveston Bay	EX02	Nov 2010	1	95	-	0	-	0	-	0	-	0	-	5	-
		Sep 2011	4	69	(7)	0	-	0	-	0	-	0	-	31	(7)
		Aug 2012	4	85	(5)	0	-	0	-	0	-	0	-	15	(5)
Galveston Bay	EX03	Nov 2010	1	1	-	25	-	0	-	0	-	0	-	74	-
		Sep 2011	4	38	(24)	60	(24)	0	-	0	-	0	-	3	(3)
		Aug 2012	4	45	(26)	39	(23)	0	-	0	-	1	(1)	15	(5)
West Matagorda Bay	EX04	Dec 2010	1	60	-	0	-	0	-	0	-	0	-	40	-
		Oct 2011	4	88	(3)	0	-	0	-	0	-	0	-	13	(3)
		Aug 2012	4	76	(13)	0	-	0	-	0	-	0	-	25	(13)
San Antonio Bay	EX05	Dec 2010	1	99	-	0	-	0	-	0	-	0	-	1	-
		Oct 2011	4	83	(4)	0	-	0	-	0	-	0	-	18	(4)
		Sep 2012	4	86	(6)	0	-	0	-	0	-	0	-	14	(6)
San Antonio Bay	EX06	Dec 2010	1	65	-	0	-	0	-	1	-	0	-	34	-
		Oct 2011	4	100	-	0	-	0	-	0	-	0	-	0	(0)
		Aug 2012	4	78	(8)	0	-	0	-	0	-	0	-	23	(8)
Aransas Bay	EX07	Dec 2010	1	40	-	0	-	0	-	0	-	0	-	60	-
		Oct 2011	4	33	(6)	0	-	0	-	0	-	0	-	68	(6)
		Aug 2012	4	2	(1)	0	-	0	-	0	(0)	0	-	98	(1)
Aransas Bay	EX08	Dec 2010	1	0	-	80	-	0	-	0	-	0	-	20	-
		Oct 2011	4	99	(1)	0	-	0	-	0	-	0	-	1	(1)
		Aug 2012	4	2	(1)	79	(7)	0	-	0	-	0	-	19	(6)
Aransas Bay	EX09	Nov 2010	1	99	-	0	-	0	-	0	-	0	-	1	-
		Oct 2011	4	51	(16)	0	-	0	-	5	(5)	0	-	44	(13)
		Aug 2012	4	3	(1)	0	-	0	-	0	-	0	-	97	(1)
Upper Laguna Madre	EX10	Dec 2010	1	0	-	0	-	100	-	0	-	0	-	0	-

Bay	Station	Date	N	*Halodule*		*Thalassia*		*Syringodium*		*Ruppia*		*Halophila*		Bare	
		Sep 2011	4	0	-	0	-	46	(20)	0	-	0	-	54	(20)
		Aug 2012	4	20	(20)	0	-	14	(4)	0	-	0	-	66	(19)
Upper Laguna Madre	EX11	Dec 2010	1	1	-	0	-	99	-	0	-	0	-	0	-
		Sep 2011	4	71	(9)	0	-	13	(13)	0	-	0	-	16	(7)
		Aug 2012	4	49	(17)	0	-	0	-	4	(4)	0	-	48	(18)
Lower Laguna Madre	EX12	Sep 2011	4	75	(13)	0	-	0	-	0	-	0	-	25	(13)
		Aug 2012	4	54	(10)	0	-	0	-	0	-	0	-	46	(10)
Lower Laguna Madre	EX13	Sep 2011	4	0	-	99	(1)	0	-	0	-	0	-	1	(1)
		Aug 2012	4	0	-	96	(4)	0	-	0	-	0	-	4	(4)
Lower Laguna Madre	EX14	Sep 2011	4	0	-	15	(9)	68	(9)	0	-	0	-	17	(8)
		Aug 2012	4	0	-	0	-	64	(6)	0	-	0	-	36	(6)

Table 5. Weighted mean canopy height (cm) (weighted SE) for Phase 1 sites, 2010-2012.

Bay	Station	Date	N	*Halodule*		*Thalassia*		*Syringodium*		*Ruppia*	
Galveston Bay	EX01	Nov 2010	10	12.6	(0.6)	-	-	-	-	-	-
		Sep 2011	10	20.8	(1.6)	-	-	-	-	-	-
		Aug 2012	20	27.1	(1.3)	-	-	-	-	-	-
Galveston Bay	EX02	Nov 2010	10	11.6	(0.7)	-	-	-	-	-	-
		Sep 2011	10	12.3	(1.4)	-	-	-	-	-	-
		Aug 2012	20	10.6	(0.9)	-	-	-	-	-	-
Galveston Bay	EX03	Nov 2010	10	9.1	(0.6)	18.1	(2.3)	-	-	-	-
		Sep 2011	5	-	-	26.8	(2.5)	-	-	-	-
		Aug 2012	20	18.0	(1.1)	51.4	(2.8)	-	-	-	-
West Matagorda Bay	EX04	Dec 2010	10	17.5	(0.3)	-	-	-	-	3.7	(0.1)
		Oct 2011	10	12.8	(0.9)	-	-	-	-	-	-
		Aug 2012	20	17.5	(1.1)	-	-	-	-	-	-
San Antonio Bay	EX05	Dec 2010	10	12.1	(1.0)	-	-	-	-	-	-
		Oct 2011	15	20.2	(1.0)	-	-	-	-	-	-
		Sep 2012	20	27.1	(0.7)	-	-	-	-	-	-
San Antonio Bay	EX06	Dec 2010	10	15.7	(0.9)	-	-	-	-	-	-

Bay	Station	Date	N	*Halodule*		*Thalassia*		*Syringodium*		*Ruppia*	
		Oct 2011	15	15.9	(0.6)	-	-	-	-	-	-
		Aug 2012	20	20.9	(0.8)	-	-	-	-	-	-
Aransas Bay	EX07	Dec 2010	10	7.0	(0.8)	-	-	-	-	-	-
		Oct 2011	10	12.4	(1.8)	-	-	-	-	-	-
		Aug 2012	-	-	-	-	-	-	-	-	-
Aransas Bay	EX08	Dec 2010	10	6.9	(0.8)	10.2	(1.4)	-	-	-	-
		Oct 2011	10	-	-	-	-	-	-	12.7	(0.7)
		Aug 2012	20	-	-	22.8	(1.7)	-	-	-	-
Aransas Bay	EX09	Nov 2010	10	13.2	(0.9)	-	-	-	-	8.6	(1.8)
		Oct 2011	10	24.1	(2.3)	-	-	-	-	-	-
		Aug 2012	-	-	-	-	-	-	-	-	-
Upper Laguna Madre	EX10	Dec 2010	10	-	-	-	-	23.4	(2.6)	-	-
		Sep 2011	10	-	-	-	-	17.8	(2.1)	-	-
		Aug 2012	20	22.9	(2.7)	-	-	26.0	(2.3)	-	-
Upper Laguna Madre	EX11	Dec 2010	10	-	-	-	-	17.8	(1.8)	-	-
		Sep 2011	5	12.2	(0.9)	-	-	-	-	-	-
		Aug 2012	20	13.5	(1.0)	-	-	-	-	-	-
Lower Laguna Madre	EX12	Dec 2010	-	-	-	-	-	-	-	-	-
		Sept 2011[a]	-	-	-	-	-	-	-	-	-
		Aug 2012	20	27.1	(1.6)	-	-	-	-	-	-
Lower Laguna Madre	EX13	Dec 2010	-	-	-	-	-	-	-	-	-
		Sep 2011	10	-	-	25.3	(1.3)	-	-	-	-
		Aug 2012	20	-	-	24.2	(1.0)	-	-	-	-
Lower Laguna Madre	EX14	Dec 2010	-	-	-	-	-	-	-	-	-
		Sep 2011	5	-	-	-	-	18.0	(1.9)	-	-
		Aug 2012	20	-	-	-	-	31.1	(1.9)	-	-

[a] Leaves were not measured in the lab for this station in 2011.

Phase 2

Tier 2

Tier 2 percent coverage and canopy height results are presented for each of the three datasets: coastwide (CW), Redfish Bay (RF), and San Antonio Bay (SA). Note that the CW dataset includes a handful of sites in Redfish and San Antonio Bays that are distinct from the RF and SA datasets. Each of the three datasets was analyzed independently for the three areas of interest. Results are presented separately here; for example, data from the seven coastwide sites located in San Antonio Bay are reported as part of the coastwide dataset (CW). Those data are not included in analysis or reported again with the 50 sites comprising the SA dataset.

The Tier 2 percent coverage and canopy height datasets were not normally distributed. The *Halodule* and *Thalassia* canopy height datasets had the closest to normal distributions. *Halodule* and *Thalassia* percent coverage datasets were typically bimodal, dominated by values near zero and 100. Bare percent coverage datasets were typically one-sided, dominated by values near zero. We typically preferred to use *Halodule* canopy height and bare percent coverage in statistical analyses, as these had the greatest number of observations and were the closest to being normally distributed. Analysis of *Thalassia* data sometimes provides unusual results. Since *Thalassia* was not found extensively along the coast, there were a lot of zeroes in the *Thalassia* percent coverage dataset and relatively few observations in the canopy height dataset.

Coastwide sites (CW) were dominated by *Halodule* with an overall average 56% coverage (Table 6, Figure 20). *Thalassia* averaged 9%. All five seagrass species found along the Texas coast were documented, with overall average 70% seagrass coverage. In Redfish Bay (RF), *Thalassia* was the dominant species, followed by *Halodule* (Figure 21), with overall seagrass coverage averaging 67%. The other three seagrass species were also documented in the RF dataset, although at low levels (numbers in the table have been rounded to the nearest percent). In San Antonio Bay (SA), *Halodule* was the major seagrass species present, with *Ruppia* and *Halophila* also documented (Figure 22). Total seagrass coverage averaged 80%, higher than the CW or RF averages. No *Thalassia* or *Syringodium* was documented in San Antonio Bay.

Analysis of the coastwide (CW) dataset by bay system shows that *Halodule* was the dominant species in every bay except Corpus Christi Bay, while *Thalassia* becomes more abundant in the lower coast (Figure 20). *Thalassia* was measured in Aransas Bay, Corpus Christi Bay, Upper Laguna Madre, and Lower Laguna Madre. *Thalassia* was not documented in the CW dataset in Galveston Bay, even though the species had been observed in parts of Galveston Bay during the Phase 1 seagrass monitoring and measured at one EX site visited in 2012 under this project. *Halophila* is a small, understory plant that is easily overlooked; small amounts were found in Galveston Bay, West Matagorda Bay, and Upper Laguna Madre. Small amounts of *Syringodium* were measured in Corpus Christi Bay and Upper Laguna Madre. *Ruppia* was measured in small quantities in each bay except Corpus Christi Bay. Forty-two percent of Tier 2 sites in the coastwide dataset (CW) had more than one seagrass species (Table 7).

Table 6. Percent coverage for Tier 2 monitoring for coastwide and bay-scale datasets. (CW = coastwide, SA = San Antonio Bay, RF = Redfish Bay). Mean (SE) and N.

		Halodule		*Thalassia*		*Syringodium*		*Ruppia*		*Halophila*		Bare	
	N	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)
CW	53	56	(5)	9	(3)	2	(1)	3	(1)	1	(0)	30	(3)
RF	50	22	(4)	42	(4)	3	(1)	1	(0)	0	(0)	33	(3)
SA	50	77	(3)	-	-	-	-	2	(2)	1	(1)	20	(3)

Table 7. Number of seagrass species observed at Tier 2 sites for coastwide and bay-scale datasets. (CW = coastwide, SA = San Antonio Bay, RF = Redfish Bay).

	Total	One species	Two species	Three species	Four species
All Tier 2 sites	153	89	51	11	2
CW	53	31	20	2	0
RF	50	23	19	6	2
SA	50	35	12	3	0

Mean canopy heights were calculated as weighted averages since unequal numbers of leaves were measured at each site depending on the species present in the quadrats (Table 8, Figure 23). Standard errors were also weighted. San Antonio Bay had the longest *Halodule* leaves (Figure 24), followed by Redfish Bay (Figure 25), with the shortest leaves in the coastwide dataset. *Halophila* leaves were much longer in San Antonio Bay than the coastwide dataset. *Thalassia* and *Syringodium* leaves were longer in Redfish Bay than in the coastwide dataset (Figure 23, Figure 26, and Table 8).

Table 8. Canopy height (cm) by seagrass species for Tier 2 monitoring for coastwide and bay-scale datasets. (CW = coastwide, SA = San Antonio Bay, RF = Redfish Bay). Weighted means (weighted SE) and N.

		Halodule			*Thalassia*			*Syringodium*			*Ruppia*			*Halophila*		
	Sites	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N
CW	53	17.9	(0.8)	45	30.6	(3.0)	8	35.4	(3.0)	3	6.6	(0.5)	6	2.3	(0.4)	2
RF	50	20.7	(1.2)	24	32.6	(1.2)	38	37.7	(3.1)	9	6.1	(0.9)	2	-	-	0
SA	50	23.1	(0.8)	49	-	-	0	-	-	0	6.7	(0.0)	1	6.8	(0.0)	1

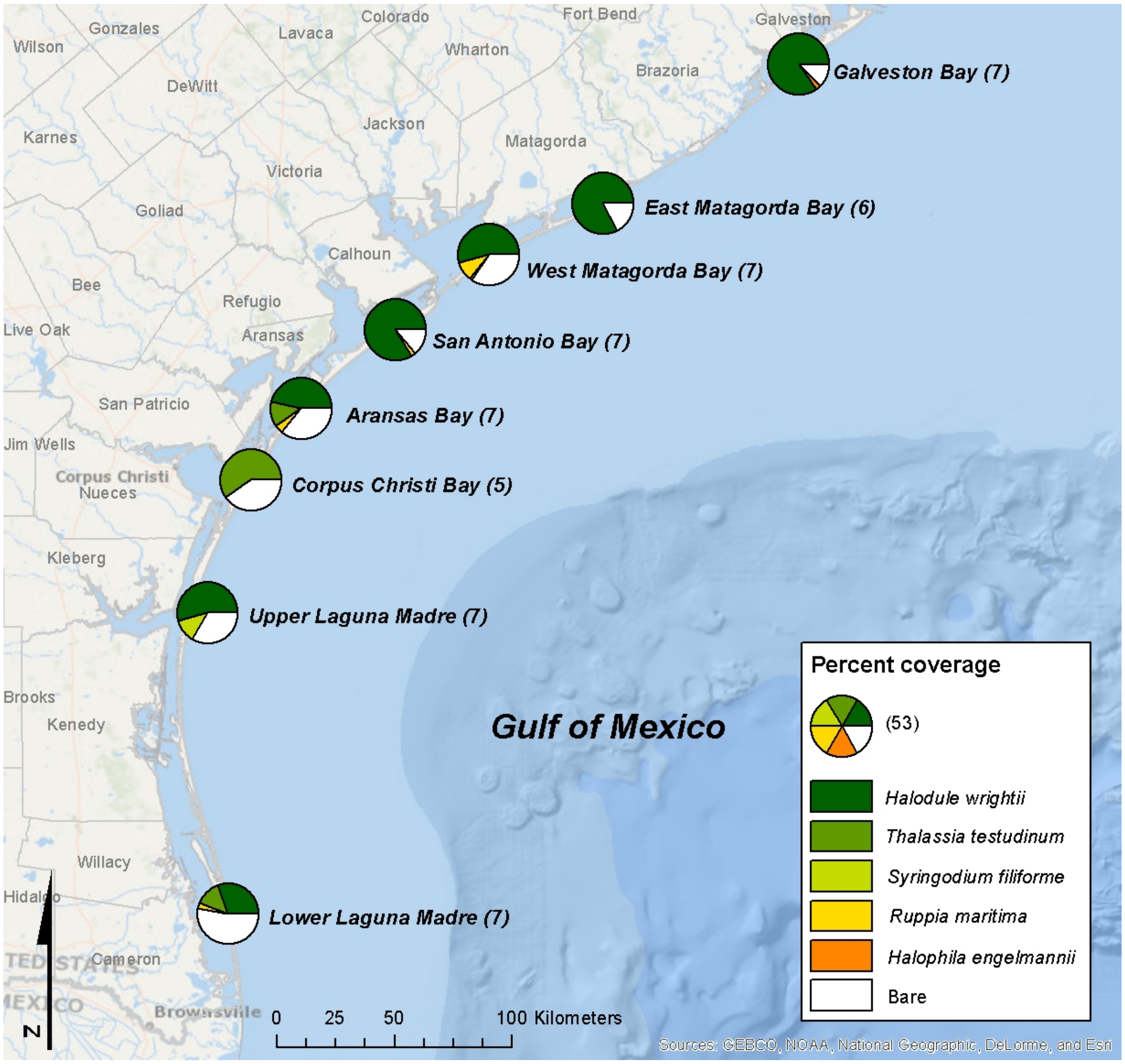

Figure 20. Coastwide Tier 2 mean percent coverage by bay (number of sites).

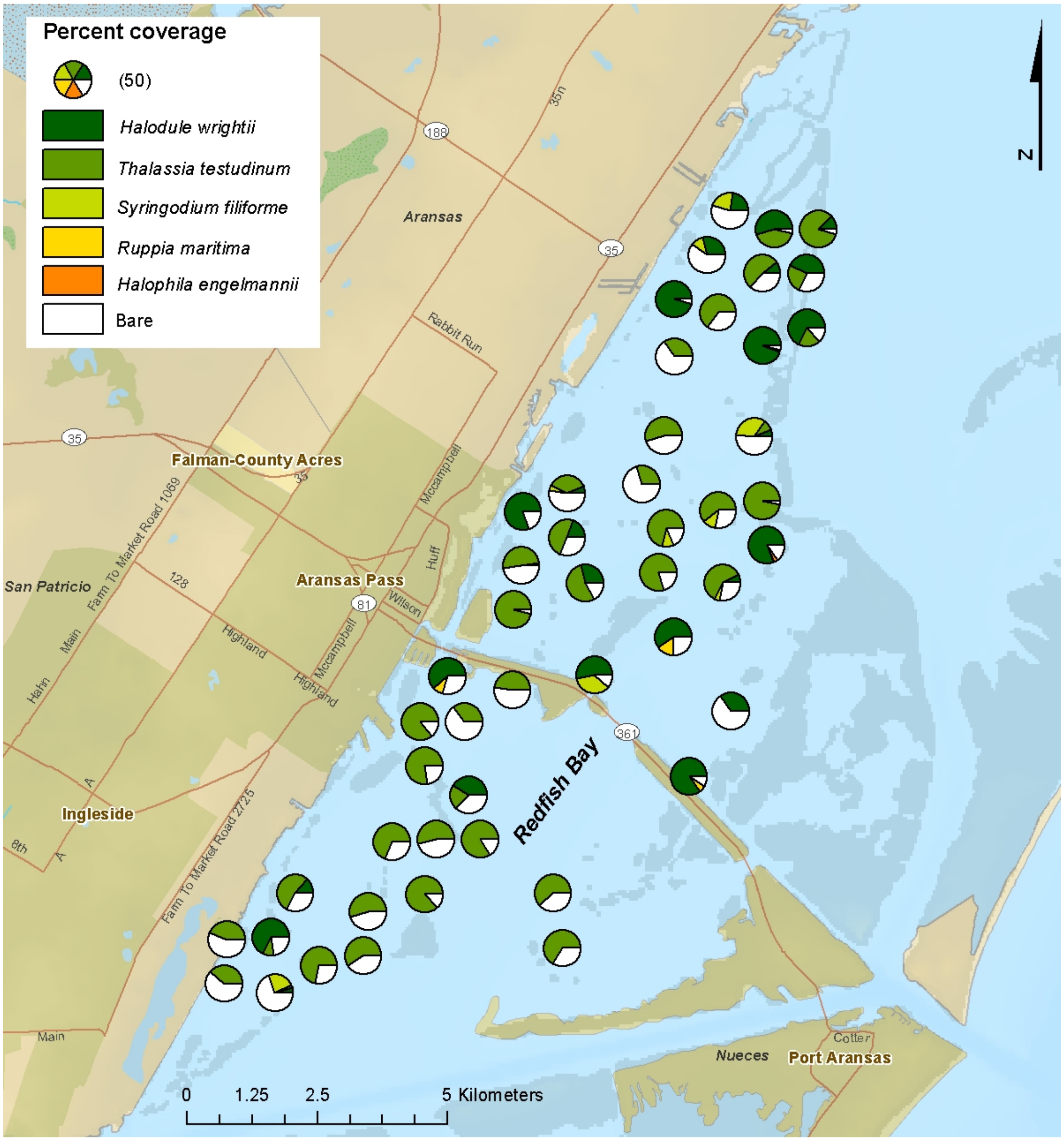

Figure 21. Bay-scale Tier 2 Redfish Bay mean percent coverage by site (N=4).

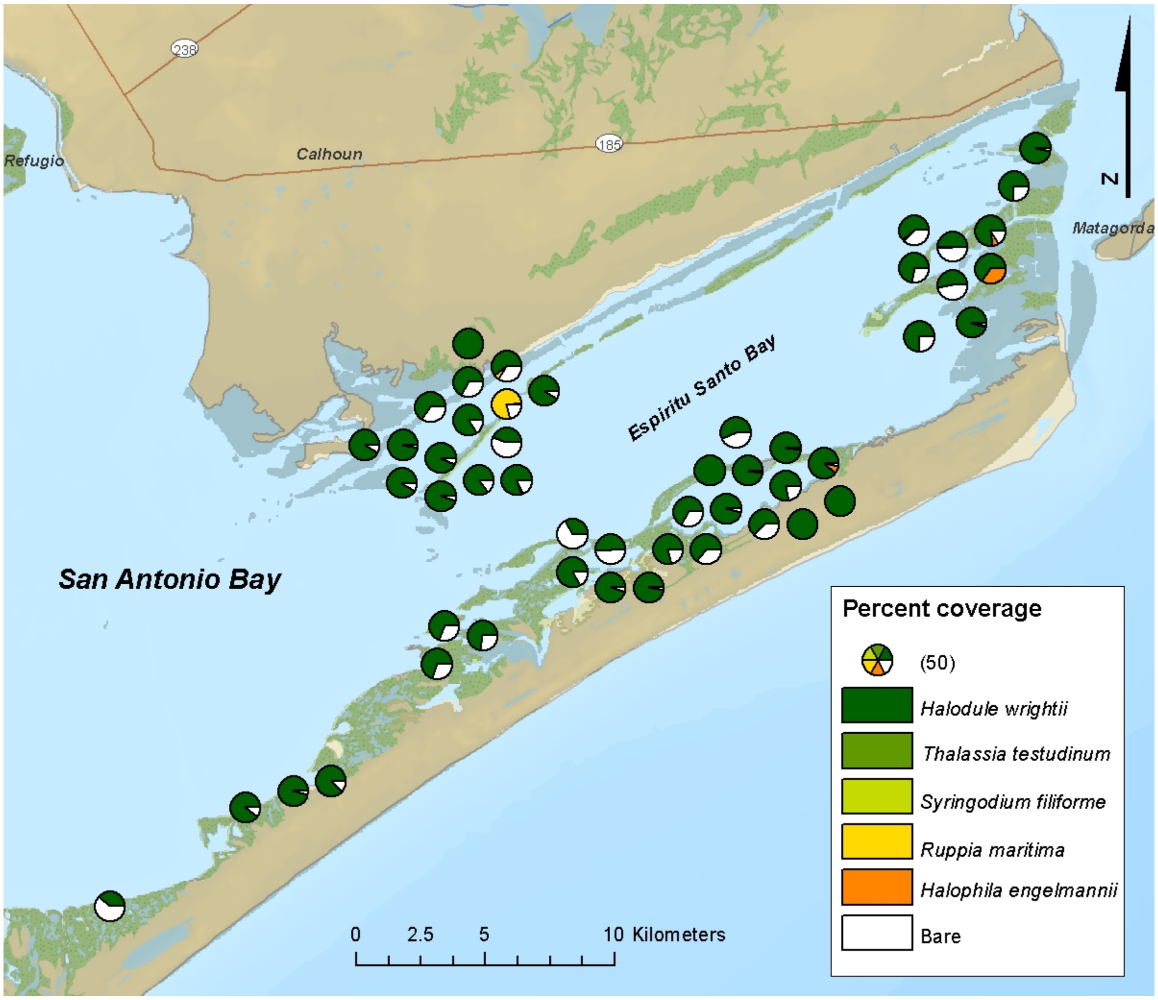

Figure 22. Bay-scale Tier 2 San Antonio Bay mean percent coverage by site (N=4).

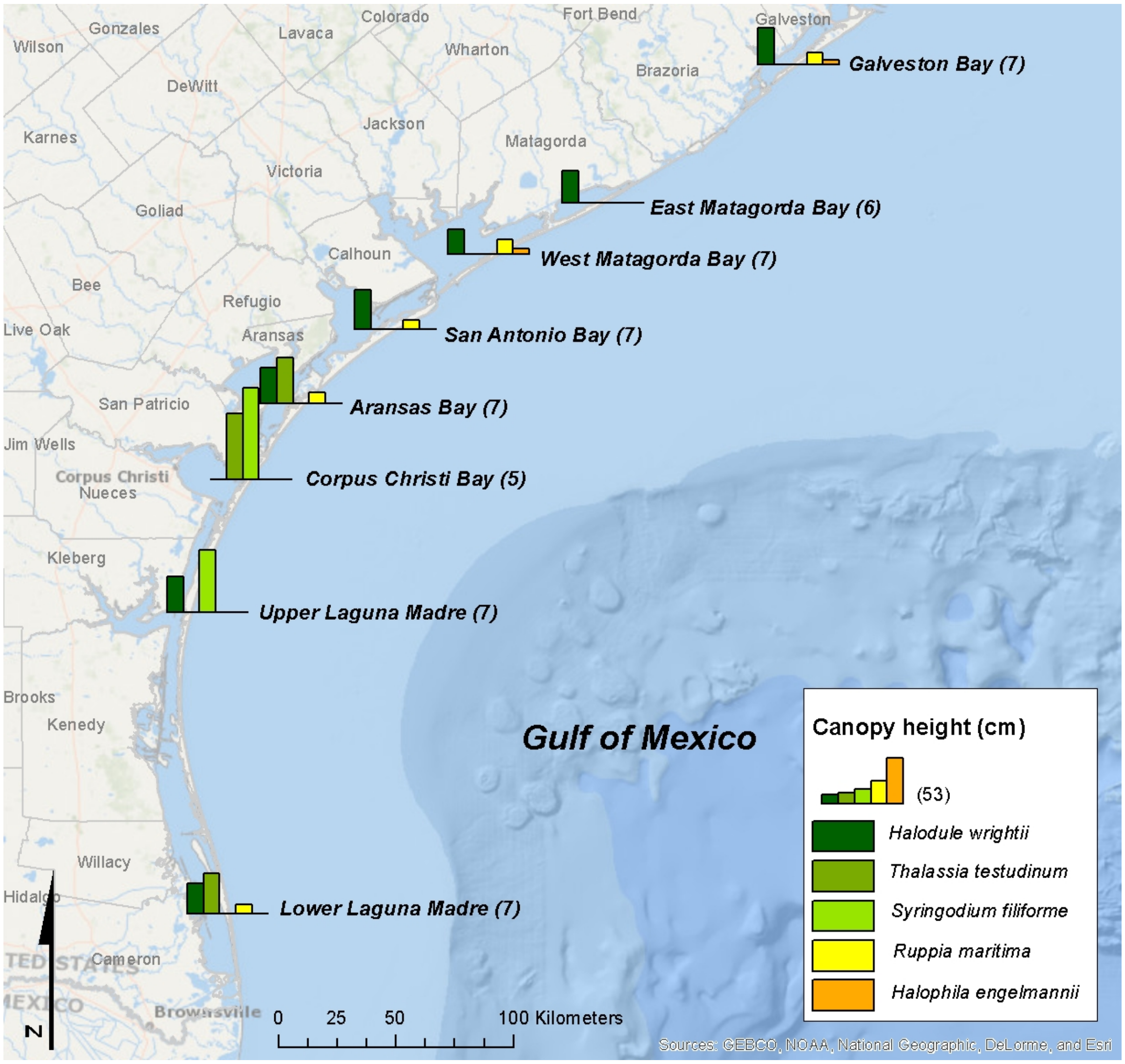

Figure 23. Coastwide Tier 2 mean canopy height by bay (number of sites).

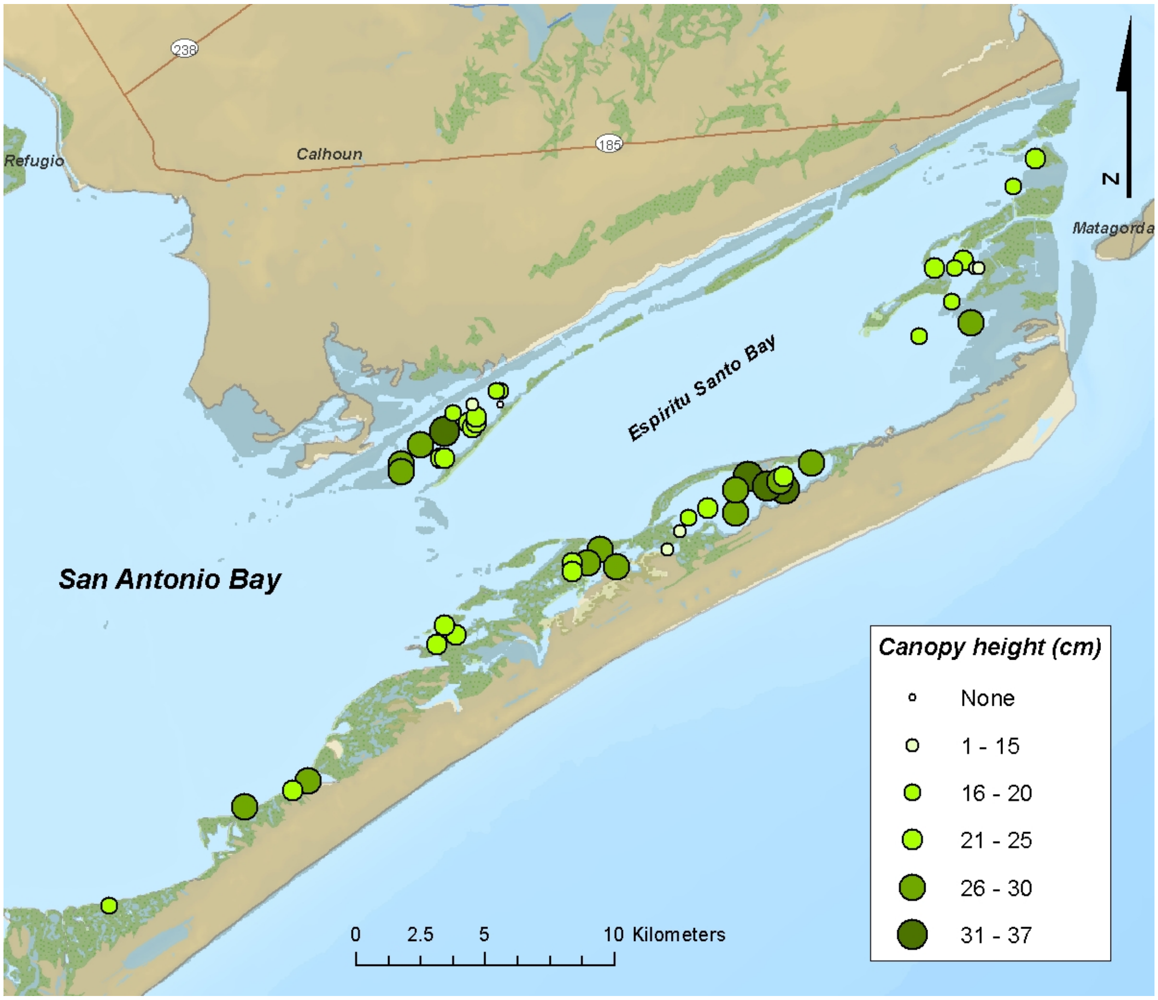

Figure 24. Bay-scale Tier 2 San Antonio Bay mean *Halodule* canopy height by site (N varies from 0-4).

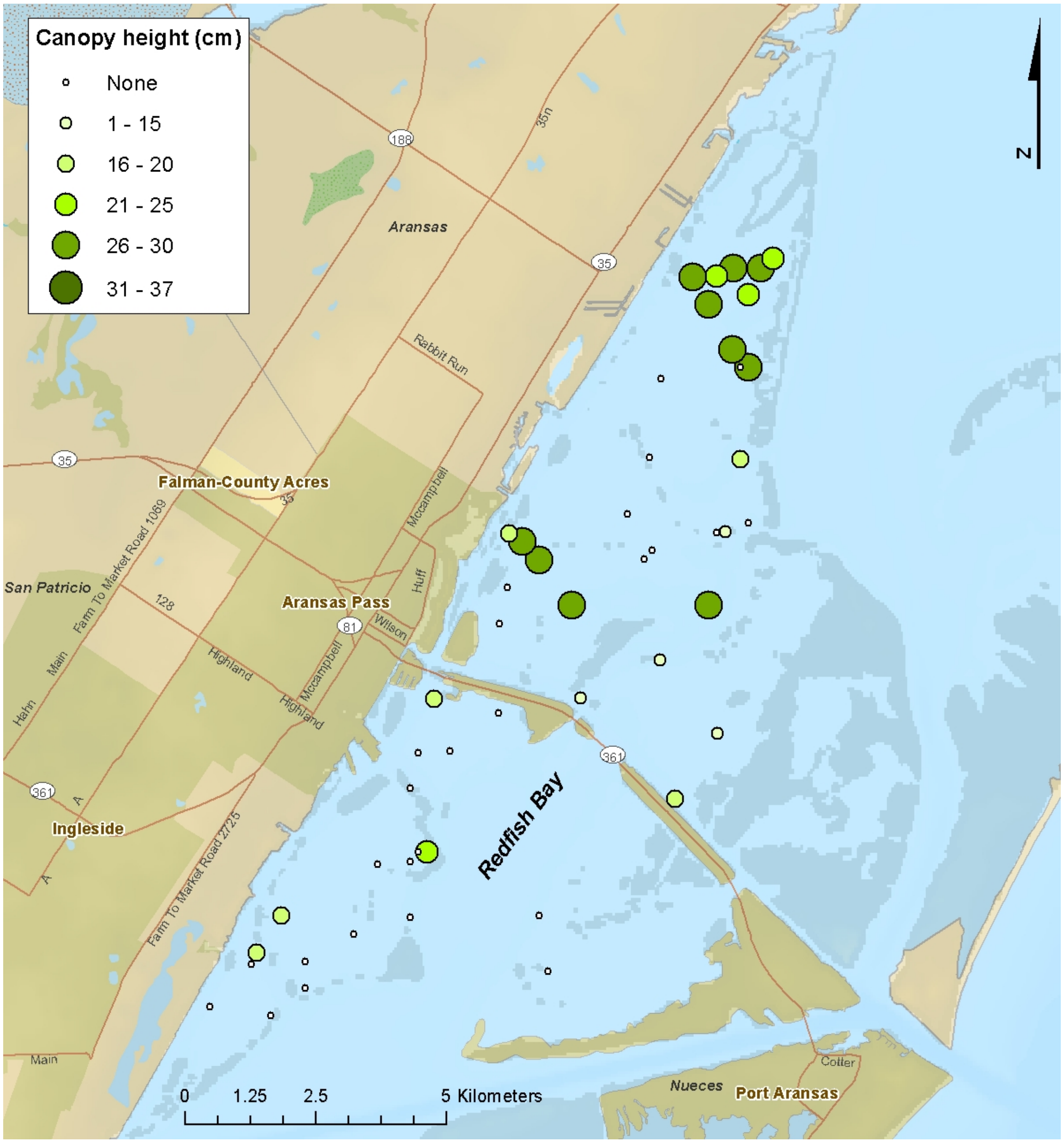

Figure 25. Bay-scale Tier 2 Redfish Bay mean *Halodule* canopy height by site (N varies from 0-4).

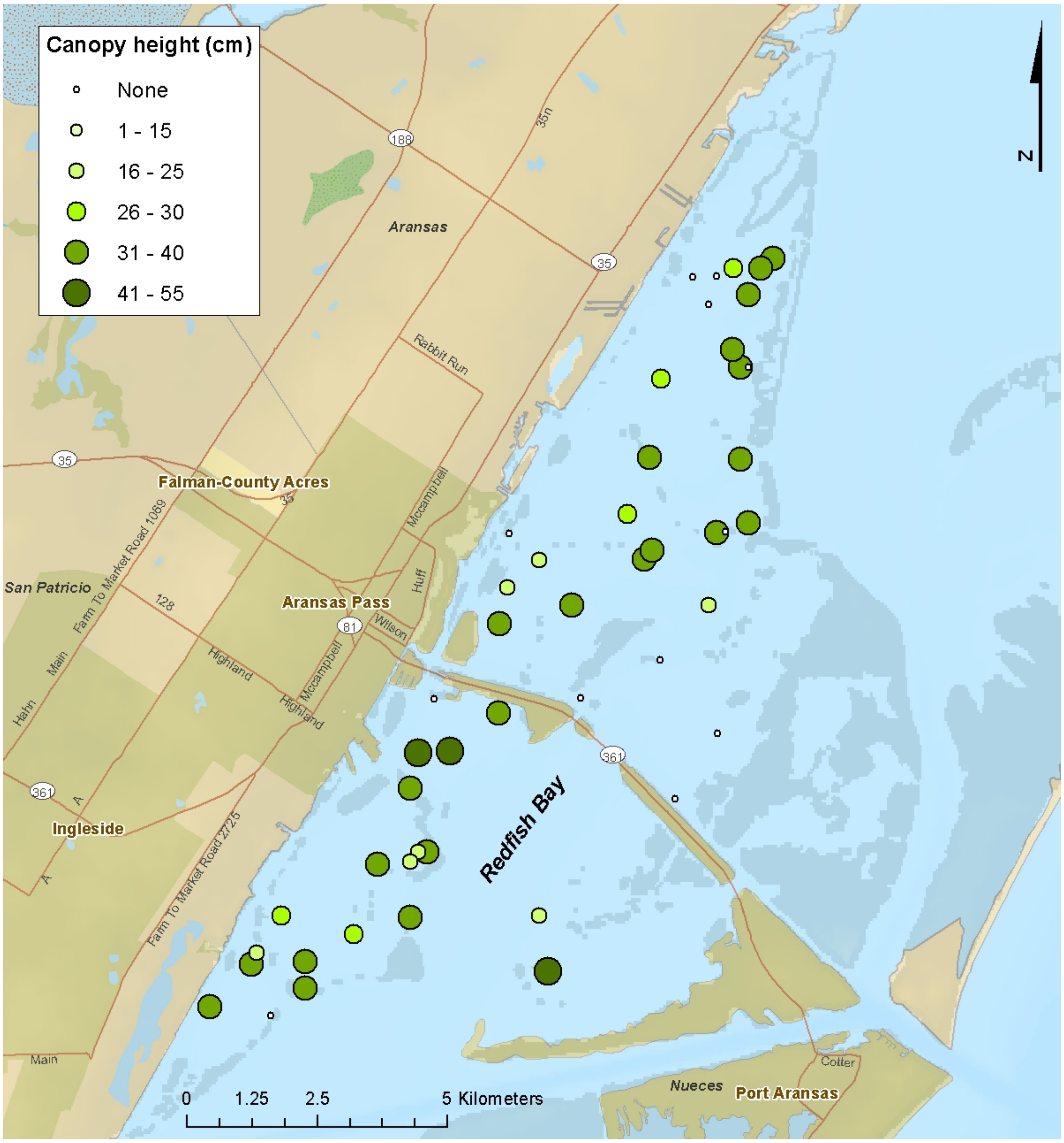

Figure 26. Bay-scale Tier 2 Redfish Bay mean *Thalassia* canopy height by site (N varies from 0-4).

Spearman rank correlations were run on individual quadrat data for Tier 2 parameters for the coastwide (CW), Redfish Bay (RF) and San Antonio Bay (SA) combined datasets. A significant correlation was observed for *Halodule* percent coverage and *Halodule* canopy height ($p<0.05$, $rho=0.42$), implying that seagrass beds with higher percent coverage also have longer leaves. This must be interpreted with caution, however, as a "comb-over" effect is a potential contributing factor. At sites with very long leaves, staff observed that leaves often lay across the quadrat. Based on protocols for determining percent coverage, this could result in the perception of higher percent coverage than if the seagrass leaves remained vertical. *Thalassia* percent coverage was also correlated with *Thalassia* canopy height, but more weakly ($p<0.05$, $rho=0.22$).

This project was capable of discerning differences in seagrass species and canopy height between the bays. Since this work encompassed a collection of independent datasets for coastwide (CW) and Redfish Bay and San Antonio Bay bay-scale (SA, RF) monitoring, we were able to compare results among different spatial components. Bare percent coverage, *Halodule* percent coverage and *Halodule* canopy height were analyzed using ANOVA; significant differences were found among the coastwide, Redfish Bay and San Antonio Bay datasets ($p<0.05$). The Bonferroni test identified *Halodule* canopy height in the CW dataset as different ($p<0.05$) from the other two (shorter leaves; see Table 8). The analyses of bare percent coverage and *Halodule* percent coverage were done using a nonparametric ANOVA test, and there was no nonparametric equivalent to the Bonferroni test available to distinguish which of the three data sets (CW, SA, RF) were different from each other. We conclude that the monitoring design is capable of distinguishing differences among the spatial components of the project. Collection of more data through implementation of an ongoing seagrass monitoring program will improve ability to detect differences.

Equally important is demonstration that independent datasets provide similar results when results are expected to be equivalent. To test this, we compared the San Antonio Bay (SA) dataset, which consisted of sampling at 50 sites, with the San Antonio Bay component of the coastwide dataset (CW-SA), which consisted of sampling at 7 sites only. *Halodule* canopy height was analyzed with an ANOVA, and bare percent coverage and *Halodule* percent coverage were analyzed using a nonparametric ANOVA. Analysis showed no difference in bare percent coverage, *Halodule* percent coverage and *Halodule* canopy height between the two datasets ($p>0.05$). This implies that the probabilistically-selected datasets produced similar results, irrespective of sample size. This analysis suggests that repeated monitoring at the probabilistically-selected coastwide (CW) sites will, over time, build a dataset comparable to that achieved by the more intensive bay-scale monitoring and provide meaningful information about not just the coast as a whole, but about each of the eight bay systems.

Finally, we compared results obtained for the 14 fixed sites, chosen using best professional judgment (EX), with the 53 coastwide sites that were selected probabilistically (CW). We wondered whether the results from the existing sites would betray some type of bias since the sites were not selected probabilistically. We compared the coastwide dataset (CW) with the 2012 existing site (EX) dataset. Again, *Halodule* canopy height was analyzed with an ANOVA, and bare percent coverage and *Halodule* percent coverage using a nonparametric ANOVA. Analysis showed no difference between the two datasets for bare percent coverage, *Halodule* percent coverage and *Halodule* canopy height ($p>0.05$). This implies that even though we selected the EX sites using best professional judgment, and the EX dataset is small (14 sites), measurements were consistent with those from the CW dataset. Since the EX sites have already been sampled for three years, they should continue to be sampled to expand the time-series of data.

Tier 3

Five transects were sampled in Redfish Bay and three in San Antonio Bay in Aug and Sep 2012. Additional transects were sampled in Redfish Bay in order to capture information about both *Halodule* and *Thalassia.* Instantaneous physicochemical data, water and sediment chemistry samples and biological samples for seagrass percent coverage, macroalgae biomass, seagrass core and epiphyte biomass were collected along each transect.

Physicochemical Measurements

Surface water temperature ranged from 26.5 to 31.5°C (Table 9). Salinity ranged from 34.4 to 39.9 ppt. Dissolved oxygen was usually above 5.0 mg/L; however, on three occasions (RF1, RF4, and SA1) values were lower than expected. In all three cases, the readings were measured at the first transect that was visited that day, before 0900 hours, and the low values probably reflect typical pre-dawn lows caused by plant and animal respiration. At all but two transects, the Secchi disk was visible all the way to the bottom. Instantaneous surface irradiance ranged from 56.3 to 98.6%, and light attenuation ranged from 0.16 to 1.02. Physicochemical measurements made near the bottom were nearly identical to those made near the surface, demonstrating that the water column was well-mixed at the time of sampling.

Table 9. Instantaneous physicochemical measurements from Tier 3 transects.

	Redfish Bay					San Antonio Bay		
	RF1	RF2	RF3	RF4	RF5	SA1	SA2	SA3
	8/21/2012	8/21/2012	8/21/2012	9/12/2012	9/12/2012	9/11/2012	9/11/2012	9/11/2012
Near surface (depth 0.3 m)								
Water temperature (°C)	29.1	30.1	31.5	27.3	29.1	26.6	26.5	28.6
Salinity (ppt)	38.4	38.5	38.5	39.9	39.1	34.4	38.7	36.3
Specific conductance (µS cm^{-1})	57,800	57,900	58,100	59,600	58,700	52,500	58,100	54,900
pH (standard units)	8.0	8.1	8.3	8.0	8.1	8.5	8.5	8.2
DO (mg L^{-1})	2.0	5.3	7.7	4.0	7.5	4.9	7.0	9.3
DO (%)	32.4	86.2	129.6	62.1	121.2	72.2	108.5	146.0
Secchi visibility (m)	>0.70	>0.60	>0.60	>0.88	>0.83	0.78	>0.86	0.63
Total water depth (m)	0.70	0.60	0.60	0.88	0.83	1.17	0.86	1.06
% surface irradiance	70.8	98.6	98.0	56.3	82.0	55.4	72.0	90.3
Light attenuation coefficient (K_d)	1.02	- [a]	- [a]	0.88	0.35	0.87	0.59	0.16
Near bottom (0.3 m from bottom)								
Water temperature (°C)	29.1	30.1	31.6	27.4	29.1	26.9	26.5	28.5
Salinity (ppt)	38.4	38.5	38.5	39.9	39.1	35.5	38.7	36.3
Specific conductance (µS cm^{-1})	57,800	57,900	58,000	59,600	58,700	53,800	58,200	54,900
pH (standard units)	8.0	8.1	8.3	8.1	8.2	8.5	8.5	8.2
DO (mg L^{-1})	1.9	5.3	7.7	3.8	7.5	4.8	7.3	9.0
DO (%)	30.9	87.1	129.6	60.0	121.2	73.1	113.8	142.0

[a] Variability in measured PAR values made calculation of light attenuation coefficient unreliable

Water and Sediment Chemistry

Water column nutrients, chlorophyll-*a* and total suspended solids were measured at the deep end of each transect (Table 10, Table 11). Nutrient and chlorophyll-*a* concentrations were low, typically near laboratory limits of quantitation. This is consistent with Phase 1 sampling in 2010 and 2011 (Table 28, Table 29). Total suspended solids were highest at transect SA3. Of the five sites, SA3 may be the most prone to disturbance due to nearby navigation channels that can increase the suspension of sediments in the water column.

Sediment porewater ammonia-nitrogen was sampled at ten randomly selected locations along each transect (Table 10, Table 11). Available nitrogen in the substrate of seagrass beds, measured as porewater ammonia-nitrogen, is known to be a factor influencing seagrass growth (Lee and Dunton 1999). In an experimental sediment fertilization study in Corpus Christi Bay and the Lower Laguna Madre, Lee and Dunton (1999) found that *Thalassia* above-ground biomass increased at sites with nitrogen fertilization, whereas sites without fertilization had an increase in below-ground biomass at the expense of above-ground biomass. Mean sediment porewater ammonia-nitrogen concentrations in Redfish Bay were similar, while concentrations in San Antonio Bay varied between transects. Mean concentrations were highest (9.12 mg/L) at SA2 and higher than what were measured during Phase 1 in 2010 and 2011 (Table 28, Table 29).

Sediment total organic carbon ranged from 2,070 to 9,790 mg/kg (0.21-0.98%). Sediment total organic carbon in seagrass beds can range widely but typically less than 5% (Short and Coles 2006). Total organic carbon in seagrass bed sediments can reflect organic input from the surrounding area as well as detritus from the seagrass plants themselves. Organic content of seagrass sediments may relate to seagrass health in a number of ways associated mainly with nutrient availability. Higher organic content may result in increased nutrient availability to the seagrass plant, and provides for opportunity to trap more particulate matter (which sometimes contains nutrients) from the water column (Short and Coles 2006).

Table 10. Redfish Bay Tier 3 sediment and water chemistry, Aug and Sep 2012.
All values reported as greater than the method detection limit were included in the averages. Values reported as non-detect were included at half the reported value.

	RF1			RF2			RF3			RF4			RF5		
	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N
Sediment															
Porewater ammonia-N (mg L^{-1})	3.31	(0.99)	10	3.39	(2.30)	10	3.82	(1.31)	10	3.58	(2.91)	10	4.05	(2.96)	10
Total organic carbon (mg kg^{-1})	2070	-	1	2500	-	1	2910	-	1	5590	-	1	3780	-	1
Water															
Ammonia-N (mg L^{-1})	0.034	-	1	0.057	-	1	0.046	0.010	2	-	-	-	-	-	-
Chlorophyll-*a* (µg L^{-1})	0.7	-	1	1.1	-	1	1.4	0.0	2	-	-	-	-	-	-
Pheophytin-*a* (µg L^{-1})	0.7	-	1	0.9	-	1	0.9	0.0	2	-	-	-	-	-	-
Nitrate-N + nitrite-N (mg L^{-1})	0.016	-	1	0.036	-	1	0.064	0.004	2	-	-	-	-	-	-
Ortho-phosphate-P (mg L^{-1})	0.020	-	1	0.016	-	1	0.020	0.012	2	-	-	-	-	-	-
Total suspended solids (mg L^{-1})	10.1	-	1	11.2	-	1	13.9	(4.1)	2	-	-	-	-	-	-

Table 11. San Antonio Bay Tier 3 sediment and water chemistry, Sep 2012.
All values reported as greater than the method detection limit were included in the averages. Values reported as non-detect were included at half the reported value.

	SA1			SA2			SA3		
	mean	(SE)	N	mean	(SE)	N	mean	(SE)	N
Sediment									
Porewater ammonia-N (mg L^{-1})	1.62	(1.27)	10	9.12	(8.52)	10	3.18	(2.08)	10
Total organic carbon (mg kg^{-1})	9790	-	1	3540	-	1	2370	1	1
Water									
Ammonia-N (mg L^{-1})	0.024	-	1	0.078	-	1	0.027	0.001	2
Chlorophyll-*a* (µg L^{-1})	3.3	-	1	0.7	-	1	1.4	0.1	2
Pheophytin-*a* (µg L^{-1})	1.4	-	1	0.5	-	1	0.7	0.1	2
Nitrate-N + nitrite-N (mg L^{-1})	0.024	-	1	0.016	-	1	0.016	0.000	2
Ortho-phosphate-P (mg L^{-1})	0.008	-	1	0.008	-	1	0.014	0.006	2
Total suspended solids (mg L^{-1})	9.8	-	1	7.9	-	1	37.0	(0.8)	2

Sediment Grain Size

Sediment grain size was determined from one sediment sample at the middle of each transect. Statewide, little is known about sediment characteristics in seagrass beds. Sand was the dominant sediment type found at all transects in Redfish and San Antonio Bays, followed by clay and silt, with very little gravel (Figure 27). San Antonio Bay Transect 1 had the greatest mixture of sand, silt, and clay (46.8%, 26.2%, and 26.3%). Sediment characteristics from Phase 1 sites were also primarily sand (Table 30). However, the three Phase 1 Lower Laguna Madre sites were dominated by silt.

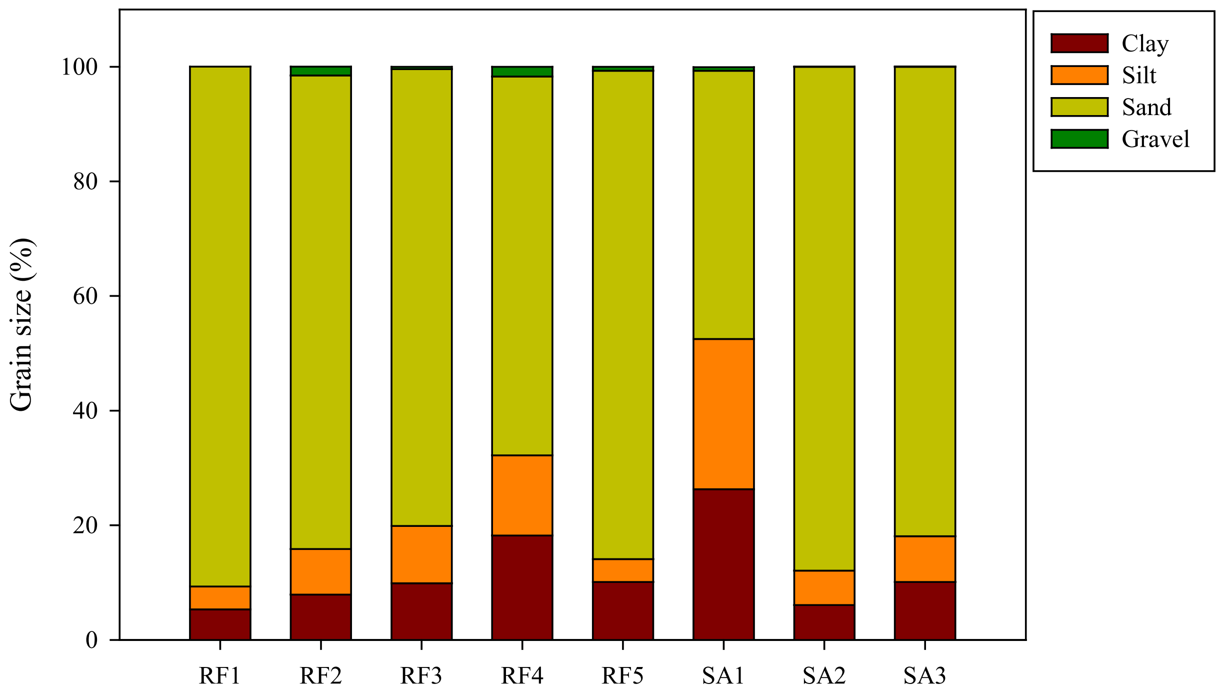

Figure 27. Sediment texture for Redfish Bay and San Antonio Bay Tier 3 transects, Aug and Sep 2012. Grain size classes: Clay <0.002 mm, Silt 0.002-0.05 mm, Sand 0.05-2.0 mm, Gravel >2.0 mm. Sample size is one per transect.

Biological Parameters

Seagrass condition indicators varied between transects, and sometimes within transects (Table 12, Table 13). At least one core from every transect contained *Halodule,* although not always as the dominant species. Across all eight transects, root:shoot ratio for *Halodule* ranged from 1.0 to 4.1. Values above 1 are generally thought to represent healthy plants (Ken Dunton, pers. comm.). *Halodule* shoot density ranged widely, from 510 to over 10,000 shoots/m^2. The lowest values were found in RF1, RF2, and RF3, where *Thalassia* dominated. Shoot density was higher for *Halodule* in the other five transects, which were located in beds dominated by *Halodule.* Below-ground biomass ranged from 17 to 242 g/m^2, and above-ground biomass from 10 to 204 g/m^2.

Thalassia condition indicators were measured only at RF1, RF2, and RF3. These three transects were located close together, about 50 m apart, and *Thalassia* seagrass condition indicators were fairly consistent among the transects. Root:shoot ratio ranged from 3.1 to 5.6. Shoot density ranged from 1,280 to 1,450 shoots/m^2. Below-ground biomass ranged from 484 to 607 g/m^2, and above-ground biomass ranged from 98 to 193 g/m^2.

Mean leaf length and width were also measured from shoots collected in seagrass cores (Table 14, Table 15). For *Halodule*, the mean number of leaves per shoot ranged from 2.2 to 3.2. Mean leaf length ranged from 11.9 to 36.4 cm, and mean leaf width was consistently 1 mm. Leaf Area Index (LAI), calculated as the product of mean leaf width, mean leaf length, and shoot density for each core and then averaged for each transect, was quite variable, ranging from 0.10 to 2.79, and was lowest for the *Thalassia* dominated transects. For *Thalassia*, there were 2.8 to 3.1 leaves per shoot and mean leaf length ranged from 24.0 to 33.3 cm. Mean leaf width ranged from 5.6 to 6.4 mm and LAI ranged from 1.88 to 2.68.

Only three cores contained any *Halophila,* and only two cores contained *Ruppia*. These cores were dominated by *Halodule*.

Epiphyte biomass load on seagrass leaves is reported separately by seagrass species (Table 16, Table 17). Epiphyte load is expressed both as weight of epiphytes by area of seagrass leaf scraped (mg/cm^2), and as weight of epiphytes by weight of seagrass leaf scraped (mg/g). Expressing epiphyte load as weight of epiphytes divided by weight of seagrass leaf scraped may be more appropriate for seagrass species whose leaves are not flat, e.g., *Syringodium*, (Contreras *et al.* 2011). However, we found that the two measures of epiphyte load were strongly correlated for both *Halodule* and *Thalassia* ($p<0.05$, $rho>0.9$) and we recommend in the future measuring only epiphyte load by area, since it requires less laboratory effort. For *Halodule*, epiphyte load ranged from 0.15 to 0.96 mg/cm^2 (84 to 779 mg/g). In San Antonio Bay, epiphyte load on *Halodule* was three times as high at Transect 3 (SA3) than at the other two transects in San Antonio Bay. For Redfish Bay, *Thalassia* epiphyte load ranged from 0.32 to 0.57 mg/cm^2 (161 to 247 mg/g). Epiphyte load for both *Halodule* and *Thalassia* was about twice as high at Transect 2 (RF2) than at the other two transects.

Higher epiphyte loads on *Halodule* were correlated with lower above- and below-ground biomass, shoot density and leaf length, which supports that epiphyte growth is a stressor ($p<0.05$, $|rho|>0.5$). *Thalassia* leaf width was negatively correlated with epiphyte load ($p<0.05$, $|rho|=.89$). For each seagrass species, some of the biomass and leaf morphometric measures appear to be correlated. If these relationships remain valid as more data is collected and analyzed, it may be possible to reduce the number of seagrass parameters collected, potentially replacing the time-consuming biomass measures, where leaves need to be sorted, separated, scraped, dried, and weighed with easier-to-measure leaf morphometrics and shoot density.

Halodule was present at each transect with mean percent coverage ranging from 1 to 97% (Table 18). San Antonio Bay Transect 1 (SA1) had the highest *Halodule* percent coverage with no other seagrass species present; Redfish Bay Transects 1, 2 and 3 (RF1, RF2, and RF3) had very little *Halodule* (1–7%). *Thalassia* was only observed in Redfish Bay and was the dominant species at RF1, RF2, and RF3, where percent coverage ranged from 22 to 69%. Where they were observed, *Halophila* and *Ruppia* were present at low coverages; no *Syringodium* was observed at any of the transects.

Mean macroalgae biomass ranged from 0.0 to 116.2 g/m^2 (Table 19, Figure 28). No macroalgae was collected at San Antonio Bay Transect 1 (SA1), and macroalgae was collected in only one of ten quadrats at Redfish Bay Transect 5 (RF5). Even though Redfish Bay Transects 1, 2 and 3 (RF1, RF2 and RF3) were located close together and sampled on the same day, macroalgae biomass ranged over two orders of magnitude. Floating mats of macroalgae can shade seagrass, or die and settle on top of the seagrass canopy. In the field, macroalgal accumulations were often noted in bare spots in the seagrass bed.

Spearman rank correlations were analyzed for percent coverage, macroalgae biomass and porewater ammonia-nitrogen results from the transects (N=80). *Halodule* percent coverage was negatively correlated with macroalgae biomass ($p<0.05$). The negative correlation between *Halodule* and macroalgae suggests that they may compete for the same resources. However, *Thalassia* percent coverage was positively correlated with macroalgae biomass ($p<0.05$). This is another example of unusual results for *Thalassia*, which may stem from a dataset dominated by zeroes. (*Thalassia* was observed at only 33 of the 80 quadrats analyzed.) Porewater ammonia-nitrogen was collected near each quadrat location. A positive correlation was observed between porewater ammonia-nitrogen and macroalgae ($p<0.0.5$). As was the case with *Thalassia*, this may be an artifact of a dataset with a significant number of zeroes (macroalgae was observed at only 57 of 80 quadrats) or it may reflect nutrient cycling between water and sediment.

Numerous factors, many related to depth, may limit seagrass growth (de Boer 2007). Tier 3 seagrass monitoring occurred along 50 m transects, with one end of the transect encompassing the deep edge of the seagrass bed. Identifying the deep edge of the seagrass bed is important because change may occur there first. We analyzed Tier 3 data for depth effects on seagrass condition using one-way ANOVA and linear regression. The analysis did not yield any significant results. This is likely due to the small dataset ($N\leq80$) and the very small depth change at each transect, which over 50 m ranged from 0.04 - 0.28 m.

Transect-averaged data were reviewed using Spearman rank correlations as a way to examine relationships between the seagrass condition measures from the quadrats and cores. The sample size was low (N=8), but there are several potential relationships between *Halodule* condition indicators and sediment characteristics. *Halodule* shoot density increases with porewater ammonia load ($p<0.05$, rho=.69), which may indicate that *Halodule* could be nitrogen limited. *Halodule* above- and below-ground biomass and shoot density are positively correlated with sediment TOC ($p<0.05$, rho>0.76). Several *Halodule* condition indicators are also correlated with sediment characteristics, suggesting overall that *Halodule* does better in sediment with high percentages of sand, more clay than silt, higher TOC and higher porewater ammonia loads.

Table 12. Redfish Bay Tier 3 seagrass condition indicators: root:shoot ratio, shoot density, and biomass from seagrass cores, by species. Mean values (SE) and number of cores (N), by transect.

	RF1			RF2			RF3			RF4			RF5		
	8/21/2012	(SE)	N	8/21/2012	(SE)	N	8/21/2012	(SE)	N	9/12/2012	(SE)	N	9/12/2012	(SE)	N
							Halodule								
Root:shoot ratio	4.1	(1.8)	2	2.6	-	1	1.5	-	1	2.2	(0.5)	3	3.1	(0.7)	3
Shoot density (number m^{-2})	510	(400)	2	2,207	-	1	622	-	1	9,065	(1,470)	3	10,794	(4,051)	3
Below-ground biomass (g m^{-2})	24	(20)	2	51	-	1	17	-	1	242	(14)	3	196	(16)	3
Above-ground biomass (g m^{-2})	10	(09)	2	20	-	1	11	-	1	119	(18)	3	68	(12)	3
Total biomass (g m^{-2})	33	(29)	2	72	-	1	28	-	1	361	(05)	3	263	(15)	3
							Thalassia								
Root:shoot ratio	3.2	(0.6)	3	5.6	(1.4)	3	3.1	(0.3)	3	-	-	-	-	-	-
Shoot density (number m^{-2})	1,450	(220)	3	1,280	(360)	3	1,340	(240)	3	-	-	-	-	-	-
Below-ground biomass (g m^{-2})	607	(70)	3	484	(90)	3	523	(44)	3	-	-	-	-	-	-
Above-ground biomass (g m^{-2})	193	(14)	3	98	(30)	3	175	(27)	3	-	-	-	-	-	-
Total biomass (g m^{-2})	800	(58)	3	582	(100)	3	698	(64)	3	-	-	-	-	-	-
							Ruppia								
Root:shoot ratio	-	-		-	-	-	-	-	-	5.9	-	1	-	-	-
Shoot density (number m^{-2})	-	-		-	-	-	-	-	-	629	-	1	-	-	-
Below-ground biomass (g m^{-2})	-	-		-	-	-	-	-	-	9	-	1	-	-	-
Above-ground biomass (g m^{-2})	-	-		-	-	-	-	-	-	1	-	1	-	-	-
Total biomass (g m^{-2})	-	-		-	-	-	-	-	-	10	-	1	-	-	-
							Halophila								
Root:shoot ratio	-	-	-	1.6	-	1	-	-	-	-	-	-	1.2	-	1
Shoot density (number m^{-2})	-	-	-	680	-	1	-	-	-	-	-	-	310	-	1
Below-ground biomass (g m^{-2})	-	-	-	25	-	1	-	-	-	-	-	-	1	-	1
Above-ground biomass (g m^{-2})	-	-	-	15	-	1	-	-	-	-	-	-	1	-	1
Total biomass (g m^{-2})	-	-	-	40	-	1	-	-	-	-	-	-	1	-	1

Table 13. San Antonio Bay Tier 3 seagrass condition indicators: root:shoot ratio, shoot density, and biomass from seagrass cores, by species. Mean values (SE) and number of cores (N), by transect.

	SA1			SA2			SA3		
	9/11/2012	(SE)	N	9/11/2012	(SE)	N	9/11/2012	(SE)	N
				Halodule					
Root:shoot ratio	1.0	(0.2)	3	2.7	(1.1)	3	3.8	(2.3)	3
Shoot density (number m^{-2})	7,910	(1,270)	3	7,340	(2,420)	3	2,720	(1,030)	3
Below-ground biomass (g m^{-2})	193	(24)	3	175	(36)	3	77	(17)	3
Above-ground biomass (g m^{-2})	204	(28)	3	92	(35)	3	34	(14)	3
Total biomass (g m^{-2})	397	(34)	3	267	(69)	3	111	(20)	3
				Ruppia					
Root:shoot ratio	-	-	-	-	-	-	0.0	-	1
Shoot density (number m^{-2})	-	-	-	-	-	-	470	-	1
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	0	-	1
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	5	-	1
Total biomass (g m^{-2})	-	-	-	-	-	-	5	-	1
				Halophila					
Root:shoot ratio	-	-	-	-	-	-	0.9	-	1
Shoot density (number m^{-2})	-	-	-	-	-	-	940	-	1
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	4	-	1
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	4	-	1
Total biomass (g m^{-2})	-	-	-	-	-	-	8	-	1

Table 14. Redfish Bay Tier 3 seagrass condition indicators: leaf morphometrics, by species.
Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N), by transect.

	RF1			RF2			RF3			RF4			RF5		
	8/21/2012	(SE)	N	8/21/2012	(SE)	N	8/21/2012	(SE)	N	9/12/2012	(SE)	N	9/12/2012	(SE)	N
							Halodule								
Leaves (number per shoot)	3.0	(0.5)	2	2.2	-	1	3.2	-	1	2.9	(0.1)	3	2.7	(0.1)	3
Leaf length (cm)	18.7	(3.1)	2	19.5	-	1	22.2	-	1	21.7	(2.4)	3	11.9	(1.0)	3
Leaf width (mm)	1.0	(0.0)	2	1.0	-	1	1.0	-	1	0.9	(0.0)	3	1.0	(0.0)	3
LAI	0.10	(0.09)	2	0.43	-	1	0.14	-	1	1.84	(0.49)	3	1.19	(0.37)	3
							Thalassia								
Leaves (number per shoot)	2.9	(0.1)	3	3.1	(0.1)	3	2.8	(0.2)	3	-	-	-	-	-	-
Leaf length (cm)	31.2	(1.3)	3	24.0	(2.7)	3	33.3	(0.9)	3	-	-	-	-	-	-
Leaf width (mm)	5.9	(0.4)	3	6.4	(0.6)	3	5.6	(0.3)	3	-	-	-	-	-	-
LAI	2.68	(0.47)	3	1.88	(0.52)	3	2.42	(0.17)	3	-	-	-	-	-	-
							Ruppia								
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	1.8	-	1	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	5.6	-	1	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	0.5	-	1	-	-	-
LAI	-	-	-	-	-	-	-	-	-	0.02	-	1	-	-	-
							Halophila								
Leaves (number per shoot)	-	-	-	5.8	-	1	-	-	-	-	-	-	1.5	-	1
Leaf length (cm)	-	-	-	2.7	-	1	-	-	-	-	-	-	1.8	-	1
Leaf width (mm)	-	-	-	5.7	-	1	-	-	-	-	-	-	2.5	-	1
LAI	-	-	-	0.10	-	1	-	-	-	-	-	-	0.01	-	1

Table 15. San Antonio Bay Tier 3 seagrass condition indicators: leaf morphometrics, by species.
Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N), by transect.

	SA1			SA2			SA3		
	9/11/2012	(SE)	N	9/11/2012	(SE)	N	9/11/2012	(SE)	N
				Halodule					
Leaves (number per shoot)	2.9	(0.2)	3	2.7	(0.1)	3	2.7	(0.1)	3
Leaf length (cm)	36.4	(3.6)	3	23.0	(3.0)	3	17.9	(1.6)	3
Leaf width (mm)	1.0	(0.0)	3	1.0	(0.0)	3	0.9	(0.1)	3
LAI	2.79	(0.29)	3	1.70	(0.56)	3	0.47	(0.21)	3
				Ruppia					
Leaves (number per shoot)	-	-	-	-	-	-	2.0	-	1
Leaf length (cm)	-	-	-	-	-	-	3.4	-	1
Leaf width (mm)	-	-	-	-	-	-	1.0	-	1
LAI	-	-	-	-	-	-	0.02	-	1
				Halophila					
Leaves (number per shoot)	-	-	-	-	-	-	5.2	-	1
Leaf length (cm)	-	-	-	-	-	-	1.4	-	1
Leaf width (mm)	-	-	-	-	-	-	3.0	-	1
LAI	-	-	-	-	-	-	0.04	-	1

Table 16. Redfish Bay Tier 3 seagrass condition indicators: epiphyte biomass, by species. Mean values (SE) and number of cores (N), by transect.

	RF1			RF2			RF3			RF4			RF5		
	8/21/2012	(SE)	N	8/21/2012	(SE)	N	8/21/2012	(SE)	N	9/12/2012	(SE)	N	9/12/2012	(SE)	N
							Halodule								
Epiphyte load (mg cm^{-2})	0.33	-	1	0.58	-	1	0.19	(0.10)	2	0.15	(0.06)	3	0.32	(0.04)	3
Epiphyte load (mg g^{-1})	252	-	1	348	-	1	114	(56)	2	84	(38)	3	244	(58)	3
							Thalassia								
Epiphyte load (mg cm^{-2})	0.32	(0.17)	3	0.57	(0.27)	3	0.33	(0.13)	3	-	-	-	-	-	-
Epiphyte load (mg g^{-1})	161	(97)	3	247	(106)	3	167	(69)	3	-	-	-	-	-	-

Table 17. San Antonio Bay Tier 3 seagrass condition indicators: epiphyte biomass, by species. Mean values (SE) and number of cores (N), by transect.

	SA1			SA2			SA3		
	9/11/2012	(SE)	N	9/11/2012	(SE)	N	9/11/2012	(SE)	N
				Halodule					
Epiphyte load (mg cm^{-2})	0.26	(0.06)	3	0.26	(0.08)	3	0.96	(0.23)	3
Epiphyte load (mg g^{-1})	163	(38)	3	185	(69)	3	779	(194)	3

Table 18. Redfish Bay and San Antonio Bay Tier 3 seagrass condition indicators: seagrass percent coverage. Mean values (SE), by transect (N=10).

	Transect	Date	*Halodule*	(SE)	*Thalassia*	(SE)	*Syringodium*	(SE)	*Ruppia*	(SE)	*Halophila*	(SE)	Bare	(SE)
Redfish Bay	RF1	8/21/2012	1	(1)	69	(3)	0	-	0	-	0	-	30	(4)
	RF2	8/21/2012	7	(4)	55	(7)	0	-	0	-	0	-	39	(6)
	RF3	8/21/2012	1	(1)	68	(4)	0	-	0	-	0	-	31	(3)
	RF4	9/12/2012	41	(5)	0	-	0	-	1	(0)	1	(0)	58	(5)
	RF5	9/12/2012	54	(12)	22	(12)	0	-	0	(0)	0	-	25	(5)
San Antonio Bay	SA1	9/11/2012	97	(2)	0	-	0	-	0	-	0	-	3	(2)
	SA2	9/11/2012	67	(5)	0	-	0	-	2	(1)	0	-	31	(4)
	SA3	9/11/2012	53	(3)	0	-	0	-	0	-	0	-	47	(3)

Table 19. Redfish Bay and San Antonio Bay Tier 3 seagrass condition indicators: macroalgae biomass. Mean values (SE), by transect (N=10).

	RF1		RF2		RF3		RF4		RF5		SA1		SA2		SA3	
	8/21/2012	(SE)	8/21/2012	(SE)	8/21/2012	(SE)	9/12/2012	(SE)	9/12/2012	(SE)	9/11/2012	(SE)	9/11/2012	(SE)	9/11/2012	(SE)
Macroalgae (g m^{-2})	12.6	6.5	76.0	35.4	116.2	24.0	28.6	10.8	1.6	1.6	0.0	0.0	7.3	4.5	16.4	7.9

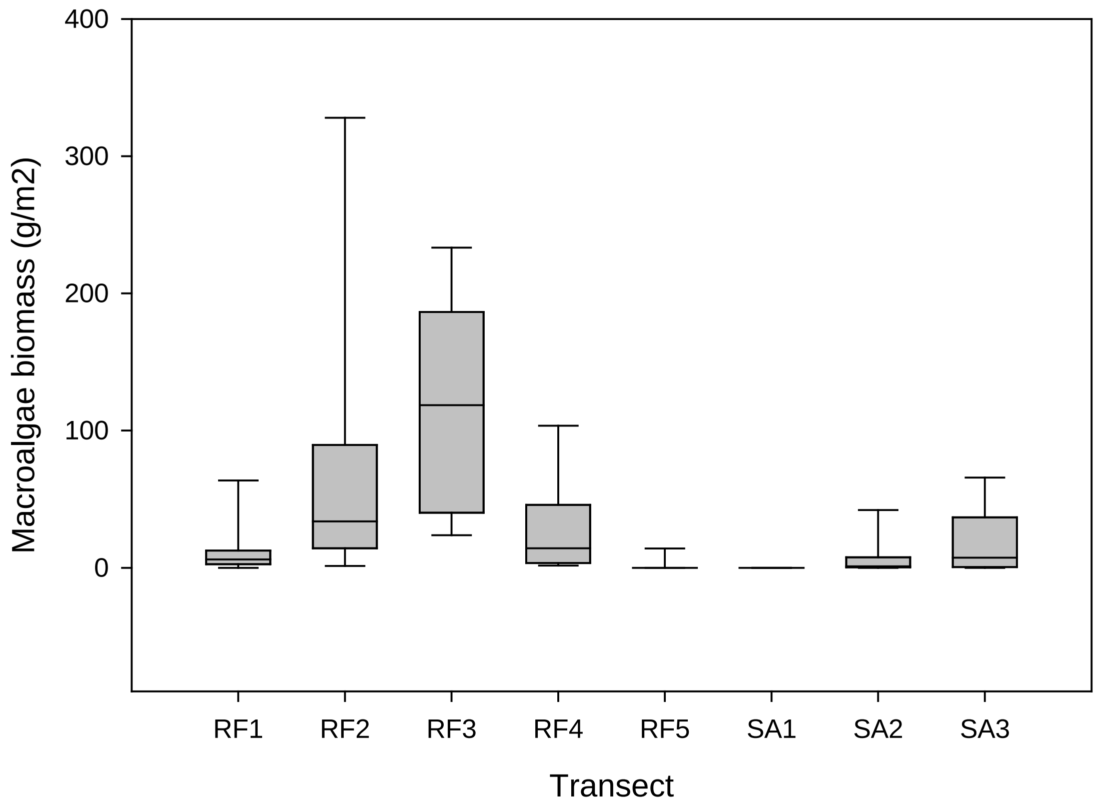

Figure 28. Macroalgae biomass for Redfish Bay and San Antonio Bay Tier 3 transects, Aug and Sep 2012. Boxes depict median and 25th and 75th percentiles. Error bars above and below the box indicate the 90th and 10th percentiles.

Integration of Data to Interpret Seagrass Condition

A tiered approach to seagrass monitoring has been recommended (Fourqurean *et al.* 2002; Neckles *et al.* 2012; Dunton *et al*. 2011). However, it is not yet clear how to use information learned in Tier 3 monitoring to interpret and assess seagrass condition health at a larger scale. We investigated whether Tier 3 *Halodule* and *Thalassia* quadrat percent coverage results were representative of the Tier 2 sites in the vicinity of the transects by analyzing Spearman rank correlations between Tier 2 vicinity-averages and Tier 3 transect-averaged data. No significant correlations were observed. This and previous work in Texas have shown no direct correlations between instantaneous water quality parameters and seagrass condition indicators (Dunton *et al*. 2005). It seems that a different approach is needed.

Long-term water quality data may be more meaningful for understanding how abiotic parameters can influence seagrass health. TCEQ and its partners have an established water quality monitoring program and data is collected quarterly from many Texas bays. It would be prudent to see if these data which are already being collected can be correlated with seagrass condition indicators. This could be done most simply by exploring annual or growing-season averages or with greater effort by determining nutrient and solids loadings. We attempted a simple analysis using quarterly monitoring data from TCEQ's SWQMIS database for Galveston Bay, East Matagorda Bay, West Matagorda

Bay, and San Antonio Bay. We calculated annual averages for temperature, Secchi depth, specific conductance, total suspended solids and total phosphorus in each bay system for 2010, 2011, and 2012. We compared these data with Phase 1 (2010 and 2011) and Tier 2 *Halodule* canopy height and bare percent coverage using one-way ANOVAs. The analysis did not show any significant results. Spearman rank order correlation was also analyzed and showed that bare percent coverage was negatively correlated with specific conductance ($p<0.05$, rho=-0.54). Given that the dataset was small (N=14), it is not surprising that there were no significant observations. Additional investigation of the use of long-term averages or loading data is warranted.

It may be helpful to explore development of metrics for use in interpretation of seagrass data. We used Tier 2 percent coverage data to develop a metric related to seagrass patchiness. Seagrass beds along the Texas coast are sometimes continuous and sometimes patchy. Patchiness can exist at many scales, from as small as a few square centimeters within a quadrat to a landscape-scale of several hundred square meters. During this project, at the small scale visible to field staff from boats or wading, staff noted that some areas were patchier than others. San Antonio Bay and Redfish Bay were very different in this respect. For example, Pringle Lake in San Antonio Bay, the location of transect SA1, was relatively continuous and consisted of mainly one seagrass species (*Halodule)*. On the other hand, many parts of Redfish Bay were patchy and resembled a mosaic of *Thalassia*, *Halodule*, and bare patches.

Dunton *et al.* (2010) have suggested that seagrass landscape feature indicators, such as bare patch frequency, number and shape, may be useful for characterizing seagrass beds. However, it is costly to acquire and interpret the aerial imagery needed for this type of analysis. It would be helpful if some measure of patchiness could be developed using data that were less expensive to acquire.

A potential measure of patchiness can be derived from Tier 2 data by considering bare percent coverage values at a given site. Recall that site validation criteria required that seagrass coverage, as determined by visual observation from the boat, be uniform and greater than 50% within a 10 m radius. Examination of the difference between the maximum and minimum bare percent coverage values at a given site could give a measure of the patchiness within that 20 m radius. A site with uniform seagrass coverage would have a Bare Percent Maximum less Bare Percent Minimum value of zero percent, while sites that were patchy would have values greater than zero, with 100% being the maximum possible value.

Bare Percent Maximum less Bare Percent Minimum was calculated for the 153 sites comprising the coastwide (CW) and bay-scale (RF, SA) datasets. Values for the coastwide dataset (CW) ranged from 1-95%, for Redfish Bay (RF) from 10-97% and for San Antonio Bay (SA) from 8-80% (Figure 29). A one-way ANOVA on the ranks for Bare Percent Maximum less Bare Percent Minimum found a significant difference ($p=0.004$). Dunn's method identified the San Antonio and Redfish Bay datasets as different, consistent with field observations in which staff observed Redfish Bay to be "patchier" than San Antonio Bay. The quantity Bare Percent Maximum less Bare Percent Minimum appears to be able to distinguish a seagrass characteristic among units of interest and it may be useful to explore this further in an effort to develop metrics capable of characterizing seagrass community health.

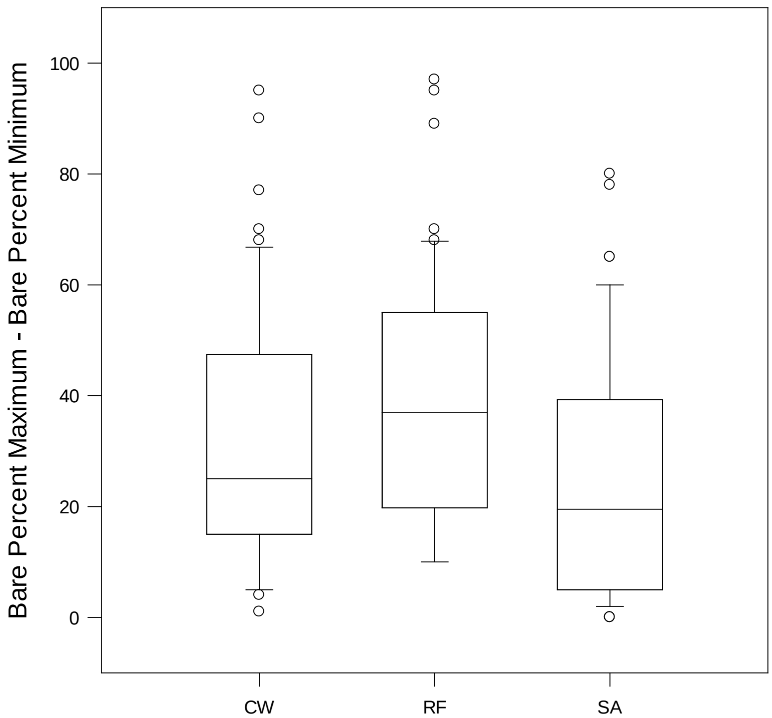

Figure 29. Bare Percent Maximum less Bare Percent Minimum by site for the Tier 2 coastwide (CW) and bay-scale datasets (RF and SA).
Boxes depict median and 25th and 75th percentiles. Error bars above and below the box indicate the 90th and 10th percentiles.

Seagrass Monitoring Methods

Effects of Using Different Observers

Coastwide seagrass monitoring relied upon use of multiple crews for the sake of efficiency and to reduce travel costs. As described above, training was planned and implemented to convey standard procedures to staff who would be participating in the field sampling. After receiving classroom instruction on standard procedures, staff practiced procedures in the field. After becoming comfortable practicing estimating percent coverage with an experienced team member, trainees were asked to privately document their estimates of percent coverage and canopy height in the field. These data were analyzed to determine if there was a detectable difference in the data collected among observers. Mixed model analyses of variance (ANOVAs) were conducted to determine whether an observer effect could be detected. Observer was a fixed effect and site a random effect in the test. The test was run on three dependent variables: *Halodule* percent coverage, *Halodule* canopy height, and bare percent coverage. *Halodule* was the dominant species observed during field training, and we wanted to use the largest dataset to increase the power of the statistical test to detect any observer effect. Tests indicated that it was unlikely that observers had an effect on the dependent variables ($p>0.05$). The training dataset was the best dataset for exploring observer effect because all the observers were training in a relatively small area of Redfish Bay, which would be expected to reduce differences in percent coverage or canopy height caused by different environmental conditions. This optimized detection of differences due to observer. Also, this scenario would represent a worst-case scenario for differences due to observer, since staff had just been trained earlier that day and many had not sampled seagrass beds before. Since, under these conditions, observer effects were not noted, we are confident that properly trained staff can conduct seagrass sampling without introducing bias.

Effects of Estimating Seagrass Coverage Using Tactile Means

For this project, percent coverage was defined as the percent of the quadrat area that was obscured by seagrass when viewed from directly overhead (TPWD 2012c). This methodology relies on visual observation. Past experience, however, shows that water clarity in Texas bays is not always adequate for visual observation of seagrass, even using a viewscope or dive mask. As observers become proficient in estimating seagrass percent coverage visually, they also must learn to estimate percent coverage by tactile means (feeling the quadrat area with the hands and fingers). When the QAPP for this project was reviewed by EPA, one of the questions raised was how frequently it is necessary to use tactile means to estimate percent coverage when working in Texas bays. Based on experience from previous work (Contreras *et al.* 2011), we estimated that tactile means were required around 50% of the time. However, because of excellent water clarity in late summer and fall 2012 (partly due to ideal weather conditions), we actually only needed to use tactile measurements around 16% of the time for this project.

Since it is clear that tactile means will be used to some extent in any seagrass monitoring program, we evaluated whether this method introduced a bias in project results. Percent coverage data from the coastwide (CW), Redfish Bay (RF), San Antonio Bay (SA) and existing site (EX, 2012 data only) datasets was analyzed using Student's t-tests between the data obtained visually and the data obtained using tactile methods. For *Halodule* percent coverage and bare percent coverage, there was no difference between visual and tactile methods ($p = 0.2042$ and $p = 0.8589$, respectively). The absence of an effect suggests that using tactile methods does not introduce bias. We note that for *Thalassia*, a significant difference was found ($p = 0.0017$). This may be due to actual differences in seagrass characteristics or it may be an artifact due to a small sample size. Of the 667 total percent coverage observations analyzed, only 183 were non-zero for *Thalassia* percent coverage. Of the 183, only 10 were collected using tactile means.

Costs

Costs associated with monitoring are an important consideration in program implementation. After the contract with TCEQ was signed 26 Apr 2012, expenditures and staff time were tracked using the TPWD financial accounting system. Time spent in project development prior to contract initiation was estimated based on information in the TPWD timekeeping system. Expenses incurred from Oct 2011 through Apr 2012 were divided into one-time set-up costs (Table 20) and costs associated with operating an ongoing seagrass monitoring program (Table 21). Operating expenses were incurred from Apr through Oct 2012. One-time expenses were incurred beginning Oct 2011 and will cease in Aug 2013 upon acceptance of the final report by TCEQ. Note that cost estimates assume that the monitoring team already has functioning boats for use on Texas' bays.

Table 20. One-time costs associated with setting up a statewide seagrass monitoring program and fulfilling contract requirements (Oct 2011 – Apr 2013).

Element	Task cost	Out of pocket cost	Personnel cost	Task hours[a]
Monitoring plan design and work plan preparation	$17,669	$0	$17,669	450
Coordination with field staff, reconnaissance	$17,366	$1,161	$16,205	413
QAPP and SOP development	$24,659	$0	$24,659	628
Contracting (contracting, billing)[b]	$0	$0	$0	0
Project staffing	$1,667	$0	$1,667	42
Equipment, supplies and services	$21,723	$21,723	$0	0
Database design	$4,617	$0	$4,617	118
Software and training	$5,508	$5,508	$0	0
Data analysis and report writing	$76,927	$2,441	$74,487	1897
Total set-up	$170,137	$30,833	$139,304	3,547

[a] Hours estimated as sum of personnel costs divided by (1.23*$31.93).
Hourly rate of $31.93 obtained as total personnel costs through Dec 2012 ($147,442.54) divided by total hours (3754), quantity divided by 1.23.
[b] Contracting expenses were minimal and were not tracked.

Table 21. Ongoing costs associated with operating a statewide seagrass monitoring program consisting of Tier 2 coastwide, Tier 2 bay-scale (2 bays) and Tier 3 (2 bays) field work (Apr – Oct 2012).

Element	Task cost	Out of pocket cost	Personnel cost	Task hours
Equipment and supplies	$16,957	$5,555	$11,402	290
Training (field exercise)	$22,402	$4,152	$18,250	465
Sampling	$71,313	$16,685	$54,628	1,391
Tier 2 sampling (probabilistic)				
Tier 3 sampling (transect-based, includes lab)				
Data entry	$10,505	$0	$10,505	267
Data QA	$5,774	$0	$5,774	147
Total operating	$126,951	$26,391	$100,559	2,560

* Hours estimated as sum of personnel costs divided by (1.23*$31.93).
Hourly rate of $31.93 obtained as total personnel costs through Dec 2012 ($147,442.54) divided by total hours (3754), quantity divided by 1.23.

Personnel costs dominate both set-up and operating expenses, comprising 82% of set-up and 79% of operating costs. Travel, including mileage, is the second highest operating cost, with $17,048 billed through Apr 2013 ($1,844 (1%) for set-up and $15,204 (12%) for operating). Supply, equipment and maintenance costs were about 5% of operating expenses and 13% of set-up costs. Contract laboratory costs for water and sediment chemistry analyses were $5,768 or about 5% of operating expenses. Staff time and travel costs could be reduced by staffing with local crews. For this project, Tier 2 crews were typically staffed with one local and two Austin crew members. Tier 3 crews were staffed primarily with Austin crew members.

To aid in implementation of a statewide monitoring program, it's also helpful to consider the costs associated with each field work type. Since TPWD expenditure reports do not provide the level of detail required to divide expenses by monitoring type, set-up and operating expenses were apportioned to each field work type using percentages developed from a budget estimate prepared in 2011. Field work types evaluated were Tier 2 coastwide, Tier 2 bay-scale and Tier 3, using average costs for Tier 2 bay-scale and Tier 3 sampling (Table 22).

Table 22. Seagrass monitoring project expenses apportioned by field work type (Oct 2011 – Dec 2012).

Expense type	Description	Operating costs	Operating hours	Set-up costs	Set-up hours	Total costs	Total hours
Tier 2							
Coastwide	50 widely-spaced sites and 14 fixed sites	$44,399	895	$59,502	1241	$103,901	2,136
Bay-scale (per bay)	50 closely-spaced sites	$17,914	361	$24,007	501	$41,921	862
Tier 3 (per bay)	Three transects with associated samples	$23,362	471	$31,310	653	$54,672	1,124

Tier 2 coastwide sampling, which gives information about the status of seagrass on the entire Texas coast, was the most expensive sample type. This is largely due to personnel and travel costs associated with launching crews at multiple locations along the coast. Tier 2 bay-scale sampling, which gives information about the status of seagrass only in the specified bay, affords economies associated with collection of samples from closely-spaced sites. Tier 3 sampling, which gives detailed information about seagrass condition in a localized area, has lower field work costs than either type of Tier 2 sampling (field work can typically be conducted in 1-1/2 days), but overall costs are increased due to the need to also staff a laboratory crew for 2 to 3 days.

Specific Sampling Protocol Recommendations

As Texas begins to implement statewide seagrass monitoring, knowledge gained from pilot seagrass projects will be useful in refining monitoring methods. Evaluation of Tier 2 and Tier 3 sampling protocols used in this project have resulted in specific recommendations to improve sampling efficiency and data quality. These include suggestions to limit redundancy and optimize ability to detect change in seagrass condition, as well as addressing limited state monitoring resources.

Sampling Period

Field work for this project was conducted between 1 Aug and 31 Oct. This sampling period worked well, allowing enough time to sample the entire coast during the peak biomass period for Texas seagrass. During Phase 1, some sampling occurred later in November and December. During these later months, the seagrasses had already begun to senesce or deteriorate. As with other seagrass monitoring programs (Fourqurean *et al.* 2002, Neckles *et al.* 2012), it is appropriate to monitor seagrass once annually during the peak growing period. Our recommendation is to monitor Texas seagrass annually during the period 1 Aug and 31 Oct.

Training

Training is essential to achieve consistent and accurate seagrass measurements. We recommend a minimum of one training day annually for Tier 2 seagrass monitors, with additional training for any staff participating in Tier 3 monitoring. Annual training would allow new participants to learn the protocols, serve as a refresher for veteran seagrass monitors and provide for lessons learned during previous sampling to be incorporated, improving sampling efficiency and quality.

Training should include classroom review of procedures and identification of seagrass species combined with a field exercise with experienced professionals. Hands-on practice during training with an established staffer provides consistency. A common source of confusion with inexperienced staff is estimating seagrass density rather than percent coverage. To provide on-the-job training and ensure consistency, we recommend that an experienced staff member accompany a new crew during sample collection.

Training must emphasize the need to remove all macroalgae and dead seagrass before estimating coverage. Macroalgae and dead plant matter often obscured seagrass quadrats. Clearing all the macroalgae and loose, dead seagrass from the quadrat before estimating coverage allowed for accurate and reproducible estimates. During training, we observed that estimates of seagrass coverage changed (usually decreasing) as more macroalgae and loose, dead seagrass were removed. The estimates became stable, with agreement among estimators, when all the macroalgae and loose, dead seagrass were removed.

Training should also cover the complications of estimating seagrass coverage along the Texas coast. In low visibility conditions it is necessary to use tactile methods to estimate bare percent coverage and to determine what species were in the quadrat. Recall that monitoring protocols define seagrass coverage as the percent of the quadrat area that is obscured by seagrass when viewed from directly overhead. Although there were no visual vs. touch effects observed during this project, there is the risk that touch estimates can be different than visual estimates due to individual perceptions of what is bare by touch vs. what is bare as seen from above. One way to minimize the difference between visual and touch estimates is to practice touch estimates at a monitoring location that can also be assessed visually. This will allow the estimator to calibrate what they feel to what they see. Another challenge of estimating coverage by touch is finding smaller seagrass species, such as *Halophila*, that cannot be detected visually from above. Care will need to be taken not to include seagrass species in tactile coverage estimates that would not be part of visual estimates. It is, however, important to make note of any species found in a quadrat regardless of whether it was part of the coverage estimate.

To reduce the misidentification of seagrasses in the field, training must include seagrass species identification. *Halodule* and *Ruppia* can look remarkably the same. Training will need to emphasize key morphological characteristics. New or short (< 10 cm) *Thalassia* can look similar to *Halophila*. It is easy to miss *Halophila* in a mixed *Thalassia*/*Halophila* bed, with the result that a greater percent coverage is assigned to *Thalassia* and *Halophila* in the quadrat is overlooked.

Leaf length, a surrogate for canopy height, was used to determine canopy height at each quadrat. To ensure leaf length measurements accurately estimate canopy height, participants can be trained to measure mature shoots, not the newest (shortest) nor the oldest (longest) shoot on each rhizome. *Halophila* and *Ruppia* leaf length measurements are not representative of canopy height as their morphology has branching leaves. Accurate canopy height measurements for both species need to start at the area that transition from white to green and include the rest of the plant.

Quality Assurance and Quality Control

Future statewide seagrass monitoring will need to maintain quality assurance and quality control measures to ensure consistent seagrass sampling along the coast. This will allow confidence in the seagrass information as multiple years of data are analyzed to detect changes in seagrass condition. This project adhered to a QAPP which included training staff, developing standard operating procedures (SOP) for Tier 2 sampling, and using a NELAC laboratory for water and sediment chemistry analyses. As more Texas seagrass monitors are involved in a statewide program, maintaining the integrity of the monitoring will be essential. This is similar as what is done for other biological assemblages monitored by TCEQ and their monitoring partners.

Collection of voucher specimens would provide assurance for species identification, especially in mixed seagrass beds that contain *Halodule* and *Ruppia*, as these two species can be hard to distinguish. *Thalassia* and *Halophila* are also hard to distinguish at various stages of their growth cycle, also supporting the need for a voucher collection program.

Tier 2

Tier 2 parameters were easy to sample and provided meaningful information. We recommend continuing Tier 2 sampling at the permanent sites established by this project. For any unit of interest, such as the Texas coast, an individual bay or an area within a bay, we recommend measuring percent coverage, canopy height and water depth at 50 sites (Table 23). Additional recommendations for Tier 2 sampling are specific to how each parameter is measured to maintain sampling efficiency and consistency between observers within a site, as well as across the coast.

Table 23. Recommended Tier 2 monitoring program design for coastwide, bay-scale or other unit of interest.

Parameter	Indicator	Sites	Subsamples	Samples
Seagrass percent coverage by species	Species identified and percent coverage estimated within a 0.25 m^2 quadrat	50	4	200
Seagrass canopy height by species	Average of the longest leaf measured from each of five representative shoots, by species. This is measured within each seagrass coverage quadrat for any seagrass species that has at least 20% coverage at that quadrat	50	4	200
Water depth	Representative water depth at a site	50	1	50

The way *Ruppia* and *Halophila* blades were measured (longest blade on a shoot) probably underestimated canopy height for these species. Unlike the other seagrass species, *Ruppia* can grow long runners of blades and have rhizomes that are suspended in the water column. *Halophila* has a shoot that extends into the water column that was not measured with the longest blade. The key for future leaf length measurements for all species is determining where on the shoot the color changes from white to green, which is indicative of what part of the seagrass is in the water column. For future leaf length measurements for all species, we recommend measuring from the white-green transition to the longest leaf on the shoot. In addition, staff should select shoots that are representative of the canopy within the quadrat and avoid shoots with leaves that are below the canopy or extend well above the canopy. If for some reason it is determined that measuring leaf length is not adequate for determining canopy height, an alternative method would be to make at least four canopy height measurements at each quadrat for each species present using a meter stick. For

Ruppia and long seagrass that tend to lie over, measuring canopy height with a meter stick in the water may yield more accurate canopy heights.

Sampling efficiency improved when there were at least two PVC quadrats on the boat and two staff in the water. At some sites four quadrats were deployed with two people responsible for two quadrats. Clearing one quadrat of macroalgae and dead seagrass before moving to the second quadrat provided time for suspended particulates to settle at the first location. This reduced the time spent per site.

Crew sizes ranged from two to five, and all sizes worked well. The minimum number of people required on a boat to complete Tier 2 sampling is two. Having three to five people on a boat allowed for more efficient sampling. Three is probably the ideal number for optimal efficiency, with two in the water, each estimating percent coverage at two quadrats and pulling shoots for canopy height, and one on the boat recording percent coverage estimates and measuring and recording leaf lengths. Once all staff were familiar with procedures, sampling became quite efficient, completing a site in 10 minutes.

For sampling 50 closely-spaced Tier 2 sites in a bay, plan for three days of field work. Monitoring 50 sites coastwide requires a different approach and typically only the six or seven located within a given bay could be sampled in one day. Most of the Tier 2 field work was spent traveling to sites and ensuring that sites met validation criteria. In an ongoing monitoring program, where sites have already been validated, sampling will be more efficient. If a single boat portage is required, travel distance between sites is minimal and the weather is conducive to sampling, we estimate that at least 15 - 20 established monitoring sites can be sampled in a day. For example, during the first two days of Tier 2 sampling in San Antonio Bay, 18 sites were visited on day one and 19 sites on day two. This example included site validation during both days.

At times we had two boats working the same bay concurrently. To ensure consistency of results, we found it important that the two teams work the first couple of sites together to "calibrate" the seagrass coverage estimates. Working together allowed us to ensure we were uniform in clearing the macroalgae and letting solids settle, in order to get consistent and stable coverage estimates between the two teams.

For monitoring sites that are expected to be shallow, it is vital to visit during high tide to ensure the sites are accessible by boat. An example is East Matagorda Bay where much of the seagrass is along the margins of the shoreline in water depths near 0.3 m. Even when attempting to access these sites at high tide, staff had to park the boat several meters away and walk.

To account for the possibility of field forms getting wet, we typically used "rite in the rain®" paper. When using this type of paper, regular pens fail. Only pencils and specialized pens marked the field data forms well when the forms were wet. Although pencils were used, staff refrained from using erasers.

Tier 3

Measures of seagrass condition obtained during Tier 3 monitoring provided detailed information about seagrass condition. We recommend continuing Tier 3 monitoring, with some small changes to the monitoring protocol. During the analysis of Tier 3 data, we found that some type of measurements did not appear to be helpful in understanding seagrass condition. As a consequence, we do not recommend that these types of measurements be continued in an ongoing monitoring program (Table 24).

Table 24. Recommended sample design for one Tier 3 site consisting of three transects. NR means "not recommended."

Parameter	Indicator	Transects	Replicates per transect	Total number of samples
Water and sediment quality indicators				
Instantaneous physicochemical monitoring	Dissolved oxygen, salinity, temperature, pH, specific conductance, Secchi depth	3	1	3
Light attenuation coefficient (*k*) and percent surface irradiance (% SI)	PAR at surface and top of seagrass canopy (4 replicates = 1 sample)	NR	NR	NR
Water chemistry	ammonia-nitrogen, chloride, chlorophyll-*a*, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, total phosphorus, total suspended solids, volatile suspended solids, ortho-phosphate-phosphorus, and pheophytin-*a*	NR	NR	NR
Sediment chemistry	Sediment pore water ammonia-nitrogen	3	10	30
Sediment chemistry	Grain size, total organic carbon	3	1	3
Seagrass condition indicators				
Seagrass percent coverage by species	Species identified and percent coverage estimated within a 0.25m^2 quadrat	3	10	30
Seagrass morphology	Core sample yielding above-ground biomass, below-ground biomass, root:shoot ratio, leaf area index, leaf width, leaf length, number of leaves per shoot, and shoot density	3	3	9
Seagrass stressor indicators				
Epiphyte biomass	Seagrass shoot sample yielding biomass of epiphytes scraped off seagrass leaves	3	3	9
Macroalgae biomass	Macroalgae sample yielding biomass collected from 0.0625 m^2 quadrat	3	10	30

Instantaneous measurements of physicochemical parameters help characterize the ambient conditions while monitoring Tier 3 transects. The data is easy to collect and can be used to interpret spatial and annual changes in seagrass condition.

Light availability is a major limiting factor for seagrass growth. Light penetration can be obtained directly with a meter measuring photosynthetically-active radiation (PAR), or indirectly by using a Secchi disk or by analyzing TSS from water samples. In the field, the measurement of PAR is easily affected by atmospheric conditions such as cloud cover and by other factors including movement of the probe, light reflection from waves, reflection from nearby surfaces such as the boat or clothing of the field personnel, reflections from underwater structures and floating particles or debris. Project protocols specified measures to collect consistent data; nevertheless it was difficult to obtain consistent readings from the meter when the water was very clear and the sampling site was very shallow. Time of day is another important factor in collecting PAR. Seagrass researchers recommend only using data collected near the sun's zenith (between 1000 and 1400 hours). This limits the time available to collect measurements when several sites are to be visited and monitored over a full day of field work. Finally, even under the best conditions, instantaneous PAR may not be representative of PAR at a site over long periods of time, i.e. the typical or average PAR to which the seagrass plants are exposed. For this reason, some seagrass researchers deploy PAR meters to collect long-term measurements that may be more representative of the conditions in the seagrass bed over time (Dunton, pers. comm.). These arrangements are expensive and must be regularly maintained to yield good data. For these reasons we recommend the use of Secchi depth as a surrogate for light availability. Secchi disks are used in both freshwater and marine environments for water quality monitoring. They are inexpensive, environmental scientists are familiar with their use, and quality assurance protocols are available (TCEQ 2008). While instantaneous Secchi depth shares the limitations of instantaneous PAR, additional Secchi depth data may be available from water quality monitoring programs.

Nutrient concentrations were consistently at or below laboratory limits of quantitation. Dunton *et al.* (2005) found that instantaneous measurements of water chemistry weren't useful in interpreting seagrass condition. We believe that a better use of resources would be to explore the use of existing SWQMIS and Texas Water Development Board data for correlations between longer-term averages and seagrass parameters. Another option would be to establish a permanent SWQMIS site at each Tier 3 monitoring site. A site could be monitored quarterly at a minimum, measuring physicochemical parameters and collecting water chemistry parameters. This approach would help build the data set of site-specific water quality information needed to interpret changes in seagrass condition. Either approach would allow Tier 3 monitoring to focus on sediment and biological parameters.

As discussed above, some of the biomass and leaf morphometric measures appear to be correlated. More data is needed to determine whether any measure can be omitted from Tier 3 monitoring to improve sampling efficiency without neglecting the interpretation of changes in seagrass condition. If these relationships remain valid as more data is collected and analyzed, it may be possible to reduce the number of seagrass parameters collected, potentially reducing the level of effort required.

This and other work has shown that epiphyte biomass is a promising indicator for seagrass condition. However, the scraping method used in this project for measuring epiphyte biomass does present some challenges. As mention above, it is a time-consuming process. It is also prone to measurement error, due to the difficulty in scraping *Halodule* blades, which tend to be thin and fragile. In this work, we measured epiphyte load as a function of seagrass mass and area scraped. Analysis showed that these two measures are highly correlated. We recommend eliminating the measure of epiphyte load by seagrass mass and measuring only epiphyte load by area, which will increase efficiency when processing seagrass in the lab, since this requires fewer weighings. Alternatively, Myers and Virnstein (2000) developed a field-based method for categorizing epiphyte growth on *Halodule* that may be useful for Texas. Their method is a rapid, visual, nondestructive technique that uses photography, which allowed them to develop an Epiphyte Photo-Index tool for a lagoon in Florida.

In interpreting Tier 3 data, it will be important to determine how large an area a set of Tier 3 transects represents. This will help in choosing the number of transects and their locations and understanding how they relate to nearby Tier 2 sites. Transect locations for this project were based on best professional judgment. The first three transects in Redfish Bay were grouped close together (approximately 50 m apart). Sampling a group of three closely-spaced transects, which primarily sampled *Thalassia*, had the advantages of more fully characterizing the immediate area as well as ease and efficiency of field work. The disadvantage of grouping transects closely was potentially characterizing only one species of seagrass and a small area of the bay. We chose to spread out transects in San Antonio Bay, which gave us better coverage of the bay, but fewer subsamples, and the field work was dispersed and consequently took longer. To complement the closely-spaced transects in a *Thalassia* bed in Redfish Bay, two additional transects in different *Halodule* beds were also sampled. This facilitated comparison with Tier 3 results from San Antonio Bay. It is not clear whether three closely-spaced transects provide any benefit over a single transect placed perpendicular to the shoreline that includes the deep edge. Neckles *et al.* (2012) found that one Tier 3 site with three closely-spaced transects (placed parallel to the shoreline in shallow, moderate, and deep depths) in Great South Bay, New York helped explain changes in percent coverage observed in the Tier 2 monitoring area closest to the transects. Consequently, they concluded that monitoring additional Tier 3 sites in a gradient of habitat characteristics found in Tier 2 monitoring would help explain larger-scale changes. However, they recognized that monitoring design is a compromise between information gain and monitoring feasibility. We believe that the variability in seagrass characteristics along the Texas coast and within each bay system warrants transects being spread apart to help interpret changes in seagrass in a wider area. Tier 2 seagrass species distribution, coverage, canopy height, water depth, as well as seagrass conservation priorities, can help determine where Tier 3 transects should be placed.

Discussion

Seagrass Monitoring Program Implementation

The purpose of this project was to implement a tiered sampling approach that will enable the state to monitor changes in seagrass condition over large areas and to infer cause-effect relationships that may explain those changes. We believe that this project has been successful and recommend that the state continue seagrass monitoring to expand these efforts and build a robust dataset that will allow us to adequately protect this resource. We offer three options, based on cost and level of effort.

The Optimal monitoring program (Table 25) would annually sample Tier 2 coastwide sites (50 probabilistically-selected sites and 14 existing sites, (Table 42, Figure 6, Figure 7) and all eight bay systems with 50 Tier 2 sites (Table 43 - Table 50) and three Tier 3 transects each. The second option, the Fundamental program, would annually sample the Tier 2 coastwide sites and two bay systems with 50 Tier 2 sites and three Tier 3 transects each. The Base program would annually monitor Tier 2 coastwide sites and no bay-scale sampling would occur.

Table 25. Seagrass monitoring program options.

Monitoring program components	Base	Fundamental	Optimal
Tier 2 coastwide	Yes	Yes	Yes
Tier 2 bay-scale	No	2 bays	8 bays
Tier 3 bay-scale	No	2 bays	8 bays
Estimated annual operating cost [a]	$45,000	$127,000	$375,000

[a] Based on data in Table 22.

We recommend that the state move forward with the Optimal monitoring program. The Optimal seagrass monitoring program would most quickly provide data at Tier 2 and Tier 3 scales. Coastwide and bay-scale Tier 2 data could be reviewed annually for changes and interpreted using Tier 3 information. While the Optimal Program is preferred, the other two options would also provide seagrass condition information and would be a significant step forward. The Fundamental program would allow annual review of coastwide Tier 2 data and, over twenty years, all eight bay systems would have Tier 2 bay-scale and Tier 3 sampling five times. The Base program would provide annual information about the status of seagrasses at a coastwide level. Over a seven-to-eight year period, implementation of the Base program would result in approximately 50 Tier 2 coastwide sampling events in each of bay systems, although it would lack the corresponding Tier 3 data to help interpret those results. The options provided allow implementation of an ongoing Texas seagrass monitoring program at several funding levels. Implementation of any option would enhance protection of Texas' estuarine ecosystems and advance the goals of the Seagrass Conservation Plan (TPWD 1999).

Implementation of a statewide seagrass monitoring program would allow Texas to be part of a global movement to conserve this critical estuarine habitat. We have learned that people who are not necessarily seagrass specialists can put into practice a seagrass monitoring program. Properly trained staff with appropriate quality assurance objectives can use the tiered seagrass monitoring approach in Texas to collect reliable and consistent seagrass information. This project allowed us to understand the costs associated with implementing a statewide seagrass monitoring program. With the flexible monitoring options and tiered approach, statewide seagrass monitoring can be implemented on a variety of budgets. Tier 1 seagrass monitoring or landscape analysis of aerial imagery, is not part of the recommendations above, as it is expensive. Until Tier 1 monitoring becomes more economical, implementing Tier 2 monitoring regularly can provide similar information with regards to seagrass species and coverage.

These recommendations are consistent with on-going seagrass monitoring programs in the United States and elsewhere. A tiered approach has been applied to ongoing U.S. seagrass monitoring programs in Little Pleasant Bay, MA, and Great South Bay/Moriches Bay, NY (Neckles, Kopp *et al.*

2011) and Florida Keys National Marine Sanctuary (Fourqurean *et al.* 2002). Tier 3 is modeled after the design used in a global seagrass monitoring program, SeagrassNet, coordinated by Frederick Short out of the University of New Hampshire (Short *et al.* 2006). In the Chesapeake Bay, seagrass beds are monitored by annual aerial surveys only (comparable to Tier 1), and ground-truthing efforts are conducted to verify presence and species (yielding Tier 2-type information) (Batiuk 1995).

Seagrass Condition and Stressor Indicators

Tier 2 monitoring is a scale-dependent rapid assessment of seagrass species coverage and canopy height. In 2012, permanent sampling sites were validated and monitored using Tier 2 protocols at coastwide scale and in two bays. We observed that *Halodule* was widespread along the coast. *Halodule* canopy height had a large number of observations and was the dataset that was the closest to normally distributed, allowing more confidence in statistical analysis. Bare percent coverage looks to be a promising way to compare areas with differing or multiple seagrass species. Ongoing Tier 2 monitoring will make it possible to identify whether seagrass percent coverage and canopy height are increasing, decreasing, or remaining the same in monitored areas. As additional years of data are collected, a clearer picture will develop of trends in seagrass condition, which will alert coastal resource managers to stressed areas.

We were able to detect differences among the three areas of Tier 2 seagrass monitoring. Analysis confirmed that coastwide, Redfish Bay and San Antonio Bay coverage and canopy height were different. Spatial variability will play an important part in understanding differences in seagrass species, coverage and canopy height as more monitoring is completed along the coast.

Understanding the difference between natural and anthropogenic temporal variability observed in Tier 2 will be the cornerstone to a successful monitoring program. Using the two years of Phase 1 data along with this project's data, we were able to detect changes in seagrass coverage and canopy height between years. We do not have enough information to determine what caused the change. As the state acquires more data, this will lead to a more robust, reliable dataset despite the high variability inherent in some of the environmental and biological parameters.

It is essential to collect Tier 3 data in order to get the information needed to understand causes of change detected from Tier 2 monitoring. Seagrasses may change due to natural or anthropogenic stresses. By providing information both about stressors and plant responses, Tier 3 data will help identify environmental causes that produce change. Over several years, Tier 3 sampling will yield a robust dataset that will enable Texas to more accurately evaluate the condition of seagrasses along the coast.

For coastal resource managers, it is not enough to know that change is occurring; they must know what is causing the change. Even with the limitations of only one season of data collection, some of the results from this project point to relationships between putative seagrass stressors and seagrass condition. For example, we saw correlations between stressors such as epiphyte load and macroalgae with seagrass parameters including *Halodule* shoot density and biomass. These results are consistent with another seagrass monitoring program, which was able to identify seagrass declines at five monitoring sites in North and South America after as few as five years of monitoring (Short *et al.* 2006).

Conclusion

Establishing a statewide seagrass monitoring program is the foundation of seagrass management in Texas. To ensure healthy coastal resources and coastal economy, resource managers must have accurate information regarding status and trends of seagrass beds along the Texas coast and regulatory decisions must be science-based. Recommendations for statewide seagrass monitoring focus the state's limited resources on collecting seagrass information that best describe seagrass condition and environmental stressors affecting seagrass. This project has provided a robust foundation to establish a statewide seagrass monitoring program in Texas. Options available at various levels of funding have been presented. As a high priority, we recommend implementation of statewide seagrass monitoring at some level as described in this report.

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Appendix A. Data Tables

Table 26. Physicochemical measurements for Phase 1 sites in Galveston, West Matagorda, and San Antonio Bays, fall 2010 and 2011.

	Galveston Bay						West Matagorda Bay		San Antonio Bay			
	EX01		EX02		EX03		EX04		EX05		EX06	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Temperature (C)	16.9	27.8	21.3	30.2	18.9	29.9	15.2	26.0	14.0	24.2	13.7	24.4
Salinity (ppt)	25.3	38.9	28.1	37.5	28.3	41.4	27.0	39.0	24.2	37.3	19.1	42.2
Specific conductance (uS cm^{-1})	39,600	58,200	43,500	56,500	44,000	61,500	41,900	58,300	38,100	56,100	30,700	62,700
pH	8.2	8.2	8.3	8.3	8.3	8.6	8.1	8.5	8.6	8.2	8.3	8.6
Dissolved oxygen (mg L^{-1})	9.4	5.6	10.4	8.8	10.6	10.3	9.7	10.0	8.6	5.9	9.2	5.2
Dissolved oxygen (%)	112.4	88.1	138.5	143.4	137.9	170.7	111.9	151.2	95.9	97.3	99.0	79.7
Secchi depth (m)	>0.35	>0.35	>0.25	>0.3	>0.85	0.44	>0.35	>0.48	>0.5	-	>0.6	-
Total water depth (m)	0.35	0.35	0.25	0.30	0.85		0.35	0.48	0.50	-	0.60	-
Percent surface irradiance	-	61.1	-	93.1	-	74.0	-	81.6	-	69.2	-	50.4
Light attenuation coefficient (m^{-1})	-	2.46	-	0.51	-	0.72	-	0.56	-	0.92	-	0.99

Table 27. Physicochemical measurements for Phase 1 sites in Aransas Bay, Upper Laguna Madre, and Lower Laguna Madre, fall 2010 and 2011.

	Aransas Bay						Upper Laguna Madre				Lower Laguna Madre		
	EX07		EX08		EX09		EX10		EX11		EX12	EX13	EX14
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2011	2011
Temperature (C)	16.3	26.0	14.3	22.3	20.4	24.9	16.5	27.1	15.3	25.5	29.2	30.6	29.5
Salinity (ppt)	11.5	39.2	26.6	42.0	5.8	34.0	30.7	42.0	31.0	43.5	41.2	37.4	41.1
Specific conductance (uS cm^{-1})	19,200	58,800	41,400	62,400	10,200	51,700	47,000	62,500	47,500	64,400	61,200	56,200	61,100
pH	8.4	8.1	8.06	8.7	-	8.2	8.3	8.4	11.1	8.2	8.4	8.5	8.4
Dissolved oxygen (mg L^{-1})	14.0	7.9	8.1	3.8	14.5	7.9	11.7	7.8	8.1	1.7	4.6	8.5	5.8
Dissolved oxygen (%)	153.2	120.8	93.6	56.2	166.9	115.0	143.8	124.6	98.3	27.0	75.8	138.9	94.8
Secchi depth (m)	>0.51	0.56	>0.52	>0.38	>0.59	>0.7	>0.52	0.60	>0.43	0.35	>0.4	-	>0.7
Total water depth (m)	0.51	-	0.52	0.38	0.59	-	0.52	0.60	0.43	0.35	0.40	-	0.70
Percent surface irradiance	-	3.4	-	87.6	-	63.3	-	76.9	-	99.0	83.3	63.6	84.8
Light attenuation coefficient (m^{-1})	-	4.77	-	0.47	-	0.79	-	0.57	-	0.03	0.57	0.65	0.34

Table 28. Sediment and water chemistry for Phase 1 sites in Galveston, West Matagorda, and San Antonio Bays, fall 2010 and 2011. All values reported as greater than the method detection limit were included in the averages. Values reported as non-detect were included at half the reported value. Sample size is one for each monitoring site.

	Galveston Bay						West Matagorda		San Antonio Bay			
	EX01		EX02		EX03		EX04		EX05		EX06	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Sediment												
Porewater ammonia-N (mg L^{-1})	0.64	2.10	0.09	4.34	0.54	0.73	0.09	0.40	1.26	4.45	0.85	2.43
Total organic carbon (mg kg^{-1})	1090	4820	985	1040	995	2210	985	980	2720	3230	2630	3860
Water												
Ammonia-N (mg L^{-1})	0.03	0.01	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.05
Chlorophyll-*a* (µg L^{-1})	2.8	2.8	6.3	3.4	2.7	3.0	4.1	4.1	1.0	4.6	4.0	3.1
Pheophytin-*a* (µg L^{-1})	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.1
Nitrate-N + nitrite-N (mg L^{-1})	0.02	0.05	0.02	0.05	0.05	0.05	0.05	0.05	0.02	0.05	0.02	0.05
Ortho-phosphate-P (mg L^{-1})	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total suspended solids (mg L^{-1})	7.0	9.5	11.1	14.9	6.1	26.3	9.7	17.1	3.5	43.0	4.1	13.5

Table 29. Sediment and water chemistry for Phase 1 sites in Aransas Bay, Upper Laguna Madre, and Lower Laguna Madre, fall 2010 and 2011. All values reported as greater than the method detection limit were included in the averages. Values reported as non-detect were included at half the reported value. Sample size is one for each monitoring site.

	Aransas Bay						Upper Laguna Madre				Lower Laguna Madre		
	EX07		EX08		EX09		EX10		EX11		EX12	EX13	EX14
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2011	2011
Sediment													
Porewater ammonia-N (mg L^{-1})	0.50	0.99	5.09	0.65	0.25	2.55	1.50	7.87	0.61	5.09	2.51	1.87	2.96
Total organic carbon (mg kg^{-1})	1025	1060	990	1075	1060	3360	16100	13700	6990	11100	18400	16900	2860
Water													
Ammonia-N (mg L^{-1})	0.01	0.01	0.02	0.02	0.01	0.01	0.05	0.01	0.03	0.01	0.02	0.01	0.01
Chlorophyll-*a* (µg L^{-1})	1.0	5.6	2.0	3.1	2.2	6.3	2.2	11.3	2.1	1.0	2.0	1.0	1.0
Pheophytin-*a* (µg L^{-1})	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nitrate-N + nitrite-N (mg L^{-1})	0.02	0.05	0.05	0.05	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ortho-phosphate-P (mg L^{-1})	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.02	0.05	0.02	0.02
Total suspended solids (mg L^{-1})	2.9	32.4	6.2	35.5	3.6	25.1	7.2	16.8	6.5	12.4	12.3	5.2	9.9

Table 30. Sediment grain size characteristics for Phase 1 sites, fall 2010 and 2011.

		Clay (%)		Silt (%)		Sand (%)		Gravel (%)	
	Site	2010	2011	2010	2011	2010	2011	2010	2011
Galveston Bay	EX01	5.7	14.2	4.0	2.0	90.2	83.7	0.1	0.1
	EX02	1.4	6.2	4.0	0.0	94.5	93.8	0.1	0.1
	EX03	1.6	8.0	2.0	2.0	94.3	89.8	2.2	0.2
West Matagorda Bay	EX04	3.2	1.2	2.0	0.0	94.7	98.4	0.1	0.3
San Antonio Bay	EX05	11.2	9.2	17.8	18.0	70.7	72.6	0.3	0.2
	EX06	9.2	9.0	6.0	2.0	84.6	88.9	0.2	0.1
Aranasas Bay	EX07	9.2	7.2	2.0	4.0	88.8	88.8	0.1	0.0
	EX08	3.4	9.2	2.0	0.0	94.5	90.7	0.1	0.2
	EX09	3.5	7.1	2.0	0.0	94.4	92.7	0.1	0.1
Upper Laguna Madre	EX10	29.3	33.1	18.0	23.9	52.1	42.3	0.6	0.7
	EX11	9.4	9.0	6.0	6.0	83.6	82.9	1.1	2.1
Lower Laguna Madre	EX12[a]	-	22.8	-	54.1	-	19.9	-	3.1
	EX13[a]	-	12.4	-	59.7	-	15.8	-	12.1
	EX14[a]	-	15.2	-	59.9	-	19.9	-	5.1

[a] No data was collected for EX12, 13 or 14 in 2010.

Table 31. Tier 3 seagrass condition indicators for Phase 1 sites in Galveston Bay, fall 2010 and 2011: root:shoot ratio, shoot density, and biomass from seagrass cores, by species.
Mean values (SE) and number of cores (N).

	Galveston Bay																	
	EX01						EX02						EX03					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
							Halodule											
Root:shoot ratio	3.64	(0.32)	2	2.06	(0.04)	2	10.40	(2.00)	2	3.26	(1.56)	2	4.18	-	1	-	-	-
Shoot density (number m^{-2})	5344	(472)	2	13125	(2436)	2	11082	(1650)	2	8252	(2436)	2	6759	-	1	-	-	-
Below-ground biomass (g m^{-2})	76.9	(5.6)	2	260.0	(38.3)	2	329.3	(31.9)	2	149.2	(41.1)	2	74.6	-	1	-	-	-
Above-ground biomass (g m^{-2})	21.2	(0.3)	2	126.0	(15.9)	2	33.5	(9.5)	2	51.6	(12.1)	2	17.8	-	1	-	-	-
Total biomass (g m^{-2})	98.1	(5.3)	2	386.0	(54.2)	2	362.8	(41.4)	2	200.8	(29.0)	2	92.4	-	1	-	-	-
							Thalassia											
Root:shoot ratio	-	-	-	-	-	-	-	-	-	-	-	-	7.51	-	1	3.80	(0.28)	2
Shoot density (number m^{-2})	-	-	-	-	-	-	-	-	-	-	-	-	453	-	1	1527.9	(396)	2
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	-	-	-	336.3	-	1	510.1	(91.8)	2
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	-	-	-	44.8	-	1	133.1	(14.3)	2
Total biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	-	-	-	381.2	-	1	643.1	(106.1)	2
							Halophila											
Root:shoot ratio	-	-	-	1.11	(0.05)	2	-	-	-	-	-		-	-	-	-	-	-
Shoot density (number m^{-2})	-	-	-	786	(314)	2	-	-	-	-	-		-	-	-	-	-	-
Below-ground biomass (g m^{-2})	-	-	-	3.5	(0.8)	2	-	-	-	-	-		-	-	-	-	-	-
Above-ground biomass (g m^{-2})	-	-	-	3.2	(0.9)	2	-	-	-	-	-		-	-	-	-	-	-
Total biomass (g m^{-2})	-	-	-	6.6	(1.7)	2	-	-	-	-	-		-	-	-	-	-	-

Table 32. Tier 3 seagrass condition indicators for Phase 1 sites in West Matagorda and San Antonio Bays, fall 2010 and 2011: root:shoot ratio, shoot density, and biomass from seagrass cores, by species.
Mean values (SE) and number of cores (N).

	West Matagorda						San Antonio Bay											
	EX04						EX05						EX06					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
Halodule																		
Root:shoot ratio	5.60	(1.68)	2	2.62	(0.75)	2	6.54	(1.09)	2	2.81	(1.66)	2	2.94	(1.32)	2	2.07	(0.58)	2
Shoot density (number m^{-2})	10453	(2122)	2	12968	(1650)	2	8803	(2987)	2	6366	(79)	2	6995	(550)	2	7074	(1100)	2
Below-ground biomass (g m^{-2})	522.3	(81.1)	2	330.6	(49.1)	2	231.0	(13.4)	2	155.0	(45.6)	2	139.8	(47.2)	2	174.6	(38.1)	2
Above-ground biomass (g m^{-2})	97.8	(14.9)	2	131.8	(19.1)	2	36.7	(8.2)	2	69.8	(25.0)	2	50.5	(6.5)	2	86.2	(6.0)	2
Total biomass (g m^{-2})	620.1	(66.2)	2	462.4	(30.0)	2	267.6	(21.6)	2	224.8	(20.6)	2	190.2	(40.7)	2	260.8	(32.1)	2
Ruppia																		
Root:shoot ratio	4.95	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shoot density (number m^{-2})	472	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Below-ground biomass (g m^{-2})	3.1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Above-ground biomass (g m^{-2})	0.6	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total biomass (g m^{-2})	3.7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 33. Tier 3 seagrass condition indicators for Phase 1 sites in Aransas Bay, fall 2010 and 2011: root:shoot ratio, shoot density, and biomass from seagrass cores, by species.
Mean values (SE) and number of cores (N).

	Aransas Bay																	
	EX07						EX08						EX09					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
										Halodule								
Root:shoot ratio	2.10	(1.43)	2	3.34	(1.03)	2	13.17	(1.63)	2	-	-	-	7.57	(1.09)	2	1.17	(0.16)	2
Shoot density (number m^{-2})	3537	(1022)	2	3773	(472)	2	1273	(538)	2	-	-	-	9667	(707)	2	10767	(4951)	2
Below-ground biomass (g m^{-2})	33.4	(28.2)	2	69.6	(1.5)	2	44.9	(19.0)	2	-	-	-	147.1	(12.1)	2	169.7	(80.5)	2
Above-ground biomass (g m^{-2})	12.6	(4.8)	2	23.2	(7.6)	2	3.3	(1.0)	2	-	-	-	20.1	(4.5)	2	137.6	(49.3)	2
Total biomass (g m^{-2})	46.0	(33.0)	2	92.8	(9.1)	2	48.2	(20.1)	2	-	-	-	167.1	(16.6)	2	307.3	(129.8)	2
										Thalassia								
Root:shoot ratio	-	-	-	-	-	-	14.48	(5.26)	2	-	-	-	-	-	-	-	-	-
Shoot density (number m^{-2})	-	-	-	-	-	-	1217	(141)	2	-	-	-	-	-	-	-	-	-
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	618.6	(165.9)	2	-	-	-	-	-	-	-	-	-
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	54.0	(31.1)	2	-	-	-	-	-	-	-	-	-
Total biomass (g m^{-2})	-	-	-	-	-	-	672.6	(197.0)	2	-	-	-	-	-	-	-	-	-
										Ruppia								
Root:shoot ratio	-	-	-	-	-	-	-	-	-	3.74	(0.23)	2	1.41	-	1	-	-	-
Shoot density (number m^{-2})	-	-	-	-	-	-	-	-	-	11318	(472)	2	1572	-	1	-	-	-
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	427.7	(31.3)	2	6.1	-	1	-	-	-
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	114.3	(1.3)	2	4.3	-	1	-	-	-
Total biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	542.0	(32.7)	2	10.5	-	1	-	-	-

Table 34. Tier 3 seagrass condition indicators for Phase 1 sites in the Upper Laguna Madre, fall 2010 and 2011: root:shoot ratio, shoot density, and biomass from seagrass cores, by species.
Mean values (SE) and number of cores (N).

	Upper Laguna Madre											
	EX10						EX11					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
						Halodule						
Root:shoot ratio	-	-	-	-	-	-	-	-	-	3.87	(0.35)	2
Shoot density (number m^{-2})	-	-	-	-	-	-	-	-	-	12890	(1415)	2
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	137.9	(71.6)	2
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	37.6	(21.8)	2
Total biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	175.4	(93.5)	2
						Syringodium						
Root:shoot ratio	2.16	(0.69)	2	2.03	(0.87)	2	15.21	(10.02)	2	-	-	-
Shoot density (number m^{-2})	4559	(1572)	2	4008	(550)	2	6523	(1493)	2	-	-	-
Below-ground biomass (g m^{-2})	230.1	(98.9)	2	257.7	(12.2)	2	830.8	(104.3)	2	-	-	-
Above-ground biomass (g m^{-2})	102.3	(12.9)	2	158.7	(74.2)	2	104.6	(75.8)	2	-	-	-
Total biomass (g m^{-2})	332.4	(111.8)	2	416.4	(86.4)	2	935.4	(180.1)	2	-	-	-
						Halophila						
Root:shoot ratio	-	-	-	-	-	-	-	-	-	0.86	-	1
Shoot density (number m^{-2})	-	-	-	-	-	-	-	-	-	1415	-	1
Below-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	3.0	-	1
Above-ground biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	3.5	-	1
Total biomass (g m^{-2})	-	-	-	-	-	-	-	-	-	6.5	-	1

Table 35. Tier 3 seagrass condition indicators for Phase 1 sites in the Lower Laguna Madre, fall 2010 and 2011: root:shoot ratio, shoot density, and biomass from seagrass cores, by species.
Mean values (SE) and number of cores (N).

	Lower Laguna Madre								
	EX12			EX13			EX14		
	2011	(SE)	N	2011	(SE)	N	2011	(SE)	N
				Halodule					
Root:shoot ratio	2.02	(0.07)	2	-	-	-	-	-	-
Shoot density (number m^{-2})	10375	(1100)	2	-	-	-	-	-	-
Below-ground biomass (g m^{-2})	119.0	(23.9)	2	-	-	-	-	-	-
Above-ground biomass (g m^{-2})	59.4	(13.9)	2	-	-	-	-	-	-
Total biomass (g m^{-2})	178.4	(37.8)	2	-	-	-	-	-	-
				Thalassia					
Root:shoot ratio	-	-	-	8.54	(0.08)	2	-	-	-
Shoot density (number m^{-2})	-	-	-	2829	(1358)	2	-	-	-
Below-ground biomass (g m^{-2})	-	-	-	1550.8	(181.9)	2	-	-	-
Above-ground biomass (g m^{-2})	-	-	-	181.7	(22.9)	2	-	-	-
Total biomass (g m^{-2})	-	-	-	1732.5	(204.8)	2	-	-	-
				Syringodium					
Root:shoot ratio	-	-	-	0.00	-	1	1.41	(0.79)	2
Shoot density (number m^{-2})	-	-	-	509	-	1	4008	(2279)	2
Below-ground biomass (g m^{-2})	-	-	-	0.0	-	1	123.5	(9.0)	2
Above-ground biomass (g m^{-2})	-	-	-	12.3	-	1	123.8	(63.6)	2
Total biomass (g m^{-2})	-	-	-	12.3	-	1	247.3	(54.6)	2

Table 36. Tier 3 seagrass condition indicators for Phase 1 sites in Galveston Bay, fall 2010 and 2011: leaf morphometrics. Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N). Leaf Area Index (LAI) is calculated as a product of leaf width, leaf length and shoot density.

	Galveston Bay																	
	EX01						EX02						EX03					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
							Halodule											
Leaves (number per shoot)	2.5	(0.1)	2	2.7	(0.2)	2	1.7	(0.2)	2	2.4	(0.3)	2	2.4	-	1	-	-	-
Leaf length (cm)	12.6	(0.2)	2	20.8	(0.2)	2	11.6	(0.3)	2	12.3	(2.7)	2	9.1	-	1	-	-	-
Leaf width (mm)	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	1.0	-	1	-	-	-
LAI	0.67	(0.04)	2	2.72	(0.48)	2	1.29	(0.23)	2	0.93	(0.01)	2	0.61	-	1	-	-	-
							Thalassia											
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	-	-	-	2.4	-	1	2.4	-	1
Leaf length (cm)	-	-	-	-	-	-	-	-	-	-	-	-	18.1	-	1	26.8	-	1
Leaf width (mm)	-	-	-	-	-	-	-	-	-	-	-	-	5.6	-	1	5.4	-	1
LAI	-	-	-	-	-	-	-	-	-	-	-	-	0.46	-	1	1.64	-	1

Table 37. Tier 3 seagrass condition indicators for Phase 1 sites in West Matagorda and San Antonio Bays, fall 2010 and 2011: leaf morphometrics. Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N). Leaf Area Index (LAI) is calculated as a product of leaf width, leaf length and shoot density.

	West Matagorda						San Antonio Bay											
	EX04						EX05						EX06					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
							Halodule											
Leaves (number per shoot)	2.4	(0.0)	2	2.8	(0.1)	2	2.2	(0.1)	2	2.7	(0.1)	2	2.2	(0.1)	2	2.3	(0.1)	2
Leaf length (cm)	17.5	(0.4)	2	12.8	(1.3)	2	12.1	(1.8)	2	19.9	(2.6)	2	15.7	(0.7)	2	16.4	(0.4)	2
Leaf width (mm)	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2
LAI	1.81	(0.32)	2	1.69	(0.43)	2	1.13	(0.57)	2	1.27	(0.24)	2	1.09	(0.02)	2	1.17	(0.22)	2
							Ruppia											
Leaves (number per shoot)	2.0	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf length (cm)	3.7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf width (mm)	1.0	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAI	0.02	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 38. Tier 3 seagrass condition indicators for Phase 1 sites in Aransas Bay, fall 2010 and 2011: leaf morphometrics.
Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N). Leaf Area Index (LAI) is calculated as a product of leaf width, leaf length and shoot density.

	Aransas Bay																	
	EX07						EX08						EX09					
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N
									Halodule									
Leaves (number per shoot)	2.7	(0.1)	2	2.3	(0.1)	2	2.1	(0.1)	2	-	-	-	2.6	(0.0)	2	2.7	(0.1)	2
Leaf length (cm)	7.0	(0.2)	2	12.4	(2.4)	2	6.9	(0.6)	2	-	-	-	13.2	(0.8)	2	24.1	(2.1)	2
Leaf width (mm)	1.0	(0.0)	2	1.0	(0.0)	2	1.0	(0.0)	2	-	-	-	1.0	(0.0)	2	1.0	(0.0)	2
LAI	0.25	(0.08)	2	0.48	(0.18)	2	0.08	(0.02)	2	-	-	-	1.29	(0.20)	2	2.74	(1.50)	2
									Thalassia									
Leaves (number per shoot)	-	-	-	-	-	-	2.8	(0.3)	2	-	-	-	-	-	-	-	-	-
Leaf length (cm)	-	-	-	-	-	-	10.2	(2.7)	2	-	-	-	-	-	-	-	-	-
Leaf width (mm)	-	-	-	-	-	-	6.0	(0.9)	2	-	-	-	-	-	-	-	-	-
LAI	-	-	-	-	-	-	0.8	(0.49)	2	-	-	-	-	-	-	-	-	-
									Syringodium									
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
									Ruppia									
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	3.0	(0.1)	2	3.0	-	1	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	12.7	(0.9)	2	8.6	-	1	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	1.0	(0.0)	2	1.0	-	1	-	-	-
LAI	-	-	-	-	-	-	-	-	-	1.4	(0.08)	2	0.1	-	1	-	-	-

Table 39. Tier 3 seagrass condition indicators for Phase 1 sites in Upper and Lower Laguna Madre, fall 2010 and 2011: leaf morphometrics. Weighted mean number of leaves per shoot (weighted SE), weighted mean leaf length and width (weighted SE), mean leaf area index (LAI) (SE), and number of cores (N). Leaf Area Index (LAI) is calculated as a product of leaf width, leaf length and shoot density.

	Upper Laguna Madre												Lower Laguna Madre[a]								
	EX10						EX11						EX12			EX13			EX14		
	2010	(SE)	N	2011	(SE)	N	2010	(SE)	N	2011	(SE)	N	2011	(SE)	N	2011	(SE)	N	2011	(SE)	N
										Halodule											
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	2.6	-	1	-	-	-	-	-	-	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	12.2	-	1	-	-	-	-	-	-	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	1.0	-	1	-	-	-	-	-	-	-	-	-
LAI	-	-	-	-	-	-	-	-	-	1.75	-	1	-	-	-	-	-	-	-	-	-
										Thalassia											
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	1	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.8	-	1	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.8	-	1	-	-	-
LAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.45	-	1	-	-	-
										Syringodium											
Leaves (number per shoot)	1.8	(0.1)	2	2.3	(0.2)	2	2.0	(0.0)	2	-	-	-	-	-	-	-	-	-	2.6	-	1
Leaf length (cm)	23.4	(4.8)	2	17.8	(2.8)	2	17.8	(2.4)	2	-	-	-	-	-	-	-	-	-	18.0	-	1
Leaf width (mm)	1.5	(0.4)	2	1.0	(0.0)	2	1.5	(0.4)	2	-	-	-	-	-	-	-	-	-	2.0	-	1
LAI	2.09	(1.58)	2	0.73	(0.25)	2	1.64	(0.47)	2	-	-	-	-	-	-	-	-	-	0.62	-	1
										Ruppia											
Leaves (number per shoot)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf length (cm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leaf width (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a] No data was collected for the Lower Laguna Madre in 2010.

Table 40. Tier 3 seagrass condition indicators for Phase 1 sites in Galveston, West Matagorda and Aransas Bays, fall 2010 and 2011: epiphyte biomass, by species (N=1).

	Galveston Bay						West Matagorda Bay		San Antonio Bay			
	EX01		EX02		EX03		EX04		EX05		EX06	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Halodule												
Epiphyte load (mg cm^{-2})	0.85	0.55	0.58	0.11	-	-	0.08	0.26	1.14	1.93	0.93	1.21
Epiphyte load (mg g^{-1})	610	329	397	64	-	-	36	-	773	946	1033	422
Thalassia												
Epiphyte load (mg cm^{-2})	-	-	-	-	0.87	0.18	-	-	-	-	-	-
Epiphyte load (mg g^{-1})	-	-	-	-	371	84	-	-	-	-	-	-

Table 41. Tier 3 seagrass condition indicators for Phase 1 sites in Aransas Bay and the Upper and Lower Laguna Madre, fall 2010 and 2011: epiphyte biomass, by species (N=1).

	Aransas Bay						Upper Laguna Madre				Lower Laguna Madre		
	EX07		EX08		EX09		EX10		EX11		EX12	EX13	EX14
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2011	2011
Halodule													
Epiphyte load (mg cm^{-2})	2.08	0.24	-	0.03	0.21	0.10	-	-	-	0.26	0.17	-	-
Epiphyte load (mg g^{-1})	2537	273	-	-	281	90	-	-	-	233	165	-	-
Thalassia													
Epiphyte load (mg cm^{-2})	-	-	3.59	-	-	-	-	-	-	-	-	0.14	-
Epiphyte load (mg g^{-1})	-	-	1490	-	-	-	-	-	-	-	-	64	-
Syringodium													
Epiphyte load (mg cm^{-2})	-	-	-	-	-	-	0.62	0.68	0.96	-	-	-	1.13
Epiphyte load (mg g^{-1})	-	-	-	-	-	-	172	243	259	-	-	-	810

Table 42. Phase 1 and 2 seagrass monitoring sites, 2010 – 2012.
Existing sites were sampled during the Phase 1 project in 2010 and 2011. Existing, coastwide, Redfish Bay, and San Antonio Bay sites were sampled during the Phase 2 project in 2012. Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
			Phase 1 - Existing				
EX01	Galveston Bay	17 Nov 2010	620	31	29.21352	-94.95810	0.35
EX01	Galveston Bay	13 Sep 2011	620	31	29.21351	-94.95798	0.58
EX01	Galveston Bay	01 Aug 2012	620	31	29.21346	-94.95811	0.60
EX02	Galveston Bay	17 Nov 2010	684	114	29.10275	-95.10922	0.25
EX02	Galveston Bay	13 Sep 2011	684	114	29.10277	-95.10925	0.24
EX02	Galveston Bay	01 Aug 2012	684	114	29.10276	-95.10921	0.28
EX03	Galveston Bay	17 Nov 2010	717	105	29.03849	-95.18800	0.85
EX03	Galveston Bay	13 Sep 2011	717	105	29.03849	-95.18797	0.68
EX03	Galveston Bay	02 Aug 2012	717	105	29.03847	-95.18797	0.75
EX04	West Matagorda Bay	01 Dec 2010	450	52	28.49303	-96.24503	0.35
EX04	West Matagorda Bay	04 Oct 2011	450	52	28.49298	-96.24493	0.48
EX04	West Matagorda Bay	14 Aug 2012	450	52	28.49310	-96.24506	0.95
EX05	San Antonio Bay	02 Dec 2010	270	76	28.32407	-96.62881	0.50
EX05	San Antonio Bay	05 Oct 2011	270	76	28.32412	-96.62885	0.60
EX05	San Antonio Bay	05 Sep 2012	270	76	28.32405	-96.62880	0.69
EX06	San Antonio Bay	02 Dec 2010	129	118	28.27019	-96.61948	0.60
EX06	San Antonio Bay	05 Oct 2011	129	118	28.27023	-96.61959	0.94
EX06	San Antonio Bay	29 Aug 2012	129	118	28.27018	-96.61952	0.93
EX07	Aransas Bay	01 Dec 2010	99	37	28.14567	-96.94905	-
EX07	Aransas Bay	04 Oct 2011	99	37	28.14558	-96.94947	-
EX07	Aransas Bay	07 Aug 2012	99	37	28.14569	-96.94911	0.76
EX08	Aransas Bay	01 Dec 2010	307	93	27.93940	-97.02179	-
EX08	Aransas Bay	04 Oct 2011	307	93	27.93940	-97.02179	-
EX08	Aransas Bay	02 Aug 2012	307	93	27.93940	-97.02183	0.68
EX09	Aransas Bay	17 Nov 2010	247	77	28.02558	-97.14429	-
EX09	Aransas Bay	04 Oct 2011	247	77	28.02289	-97.14400	-
EX09	Aransas Bay	03 Aug 2012	247	77	28.02562	-97.14433	0.71
EX10	Upper Laguna Madre	02 Dec 2010	7	113	27.66989	-97.26089	-
EX10	Upper Laguna Madre	07 Sep 2011	7	113	27.66982	-97.26092	-
EX10	Upper Laguna Madre	08 Aug 2012	7	113	27.66988	-97.26090	0.78
EX11	Upper Laguna Madre	02 Dec 2010	49	26	27.57942	-97.26403	-

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
EX11	Upper Laguna Madre	07 Sep 2011	49	26	27.57919	-97.26390	-
EX11	Upper Laguna Madre	08 Aug 2012	49	26	27.57945	-97.26408	0.49
EX12	Lower Laguna Madre	20 Sep 2011	189	110	26.35368	-97.31420	0.54
EX12	Lower Laguna Madre	14 Aug 2012	189	110	26.35368	-97.31419	0.64
EX12	Lower Laguna Madre	14 Aug 2012	189	110	26.35364	-97.31402	0.59
EX13	Lower Laguna Madre	20 Sep 2011	306	79	26.14057	-97.19077	0.95
EX13	Lower Laguna Madre	14 Aug 2012	306	79	26.14059	-97.19081	1.32
EX14	Lower Laguna Madre	20 Sep 2011	374	125	26.03505	-97.17722	-
EX14	Lower Laguna Madre	14 Aug 2012	374	125	26.03507	-97.17725	1.01
Phase 2 - Coastwide							
CW06	Galveston Bay	01 Aug 2012	619	34	29.21320	-94.97012	0.74
CW08	Galveston Bay	01 Aug 2012	602	127	29.21888	-94.95743	0.49
CW81	Galveston Bay	01 Aug 2012	602	140	29.21741	-94.95628	0.44
CW84	Galveston Bay	01 Aug 2012	620	18	29.21461	-94.95905	0.73
CW86	Galveston Bay	01 Aug 2012	620	55	29.21052	-94.95771	0.49
CW88	Galveston Bay	02 Aug 2012	711	86	29.05651	-95.16422	0.37
CW89	Galveston Bay	02 Aug 2012	718	23	29.04792	-95.16881	0.50
CW13	East Matagorda Bay	15 Aug 2012	52	103	28.72121	-95.72413	0.35
CW16	East Matagorda Bay	15 Aug 2012	76	84	28.69061	-95.80067	0.31
CW17	East Matagorda Bay	15 Aug 2012	87	105	28.67120	-95.83768	0.44
CW156	East Matagorda Bay	15 Aug 2012	77	35	28.69659	-95.78523	0.38
CW158	East Matagorda Bay	15 Aug 2012	96	66	28.65892	-95.85889	0.48
CW159	East Matagorda Bay	15 Aug 2012	103	3	28.64925	-95.87991	0.39
CW26	West Matagorda Bay	14 Aug 2012	468	27	28.48016	-96.26350	0.50
CW29	West Matagorda Bay	14 Aug 2012	493	71	28.40917	-96.36876	0.78
CW94	West Matagorda Bay	14 Aug 2012	468	28	28.47998	-96.26176	0.52
CW96	West Matagorda Bay	14 Aug 2012	485	132	28.41903	-96.40086	0.40
CW97	West Matagorda Bay	14 Aug 2012	485	133	28.41748	-96.41576	0.36
CW98	West Matagorda Bay	14 Aug 2012	485	134	28.41740	-96.41459	0.38
CW99	West Matagorda Bay	14 Aug 2012	488	128	28.41898	-96.35660	0.34
CW31	San Antonio Bay	29 Aug 2012	115	35	28.29650	-96.55210	0.66
CW36	San Antonio Bay	30 Aug 2012	245	117	28.35349	-96.58823	0.46
CW37	San Antonio Bay	30 Aug 2012	258	128	28.33539	-96.60665	0.30
CW39	San Antonio Bay	05 Sep 2012	270	39	28.32850	-96.62989	0.56
CW40	San Antonio Bay	29 Aug 2012	285	36	28.31317	-96.53397	0.99
CW102	San Antonio Bay	05 Sep 2012	171	127	28.21882	-96.69090	0.66
CW103	San Antonio Bay	05 Sep 2012	173	42	28.22850	-96.65900	0.48
CW41	Aransas Bay	07 Aug 2012	154	42	28.11232	-96.89218	0.67
CW42	Aransas Bay	14 Aug 2012	232	32	28.04615	-97.15613	0.17
CW44	Aransas Bay	02 Aug 2012	295	71	27.95902	-97.06878	-

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
CW46	Aransas Bay	01 Aug 2012	320	27	27.91327	-97.11322	0.69
CW116	Aransas Bay	02 Aug 2012	303	137	27.93452	-97.09386	0.83
CW118	Aransas Bay	02 Aug 2012	322	74	27.90724	-97.08104	0.46
CW121	Aransas Bay	07 Aug 2012	55	7	27.89936	-97.12431	0.82
CW51	Corpus Christi Bay	07 Aug 2012	55	136	27.88401	-97.12850	0.33
CW54	Corpus Christi Bay	07 Aug 2012	136	83	27.80753	-97.11886	0.65
CW123	Corpus Christi Bay	07 Aug 2012	77	58	27.86028	-97.15374	0.67
CW124	Corpus Christi Bay	07 Aug 2012	77	79	27.85757	-97.15775	0.71
CW128	Corpus Christi Bay	07 Aug 2012	93	50	27.84359	-97.16498	0.76
CW71	Lower Laguna Madre	14 Aug 2012	100	124	26.53558	-97.37817	0.67
CW72	Lower Laguna Madre	14 Aug 2012	121	119	26.48695	-97.36885	0.93
CW147	Lower Laguna Madre	14 Aug 2012	234	78	26.27174	-97.29214	0.54
CW161	Lower Laguna Madre	02 Oct 2012	114	63	26.50883	-97.37997	0.87
CW162	Lower Laguna Madre	02 Oct 2012	120	122	26.48532	-97.39856	0.62
CW164	Lower Laguna Madre	17 Sep 2012	208	67	26.32564	-97.29103	0.50
CW170	Lower Laguna Madre	18 Sep 2012	306	119	26.13679	-97.18545	1.20
CW63	Upper Laguna Madre	08 Aug 2012	34	84	27.60761	-97.26740	0.84
CW66	Upper Laguna Madre	09 Aug 2012	88	95	27.42287	-97.35211	0.76
CW68	Upper Laguna Madre	09 Aug 2012	255	133	27.23396	-97.39931	0.52
CW132	Upper Laguna Madre	08 Aug 2012	57	102	27.53817	-97.32565	1.24
CW133	Upper Laguna Madre	08 Aug 2012	61	119	27.52008	-97.33540	1.18
CW138	Upper Laguna Madre	09 Aug 2012	290	30	27.09652	-97.42569	0.11
CW139	Upper Laguna Madre	09 Aug 2012	291	142	27.08402	-97.40349	0.57
Phase 2 - Redfish Bay							
RF02	Aransas Bay	02 Aug 2012	294	95	27.95629	-97.08543	0.81
RF04	Aransas Bay	02 Aug 2012	295	80	27.95760	-97.07787	0.43
RF06	Aransas Bay	02 Aug 2012	303	76	27.94080	-97.09507	1.17
RF12	Aransas Bay	02 Aug 2012	312	144	27.91746	-97.08390	0.45
RF14	Aransas Bay	02 Aug 2012	313	123	27.91883	-97.07995	0.45
RF16	Aransas Bay	01 Aug 2012	319	69	27.90903	-97.12151	0.72
RF17	Aransas Bay	01 Aug 2012	319	116	27.90351	-97.12285	0.77
RF20	Aransas Bay	01 Aug 2012	320	25	27.91324	-97.11600	0.80
RF24	Aransas Bay	01 Aug 2012	321	26	27.91335	-97.09785	0.81
RF25	Aransas Bay	01 Aug 2012	321	94	27.90638	-97.08679	0.56
RF32	Aransas Bay	01 Aug 2012	330	16	27.89808	-97.09521	0.46
RF33	Aransas Bay	01 Aug 2012	330	119	27.88685	-97.08534	0.40
RF42	Aransas Bay	07 Aug 2012	56	66	27.89229	-97.10888	0.40
RF53	Aransas Bay	07 Aug 2012	67	54	27.87690	-97.09257	0.17
RF76	Aransas Bay	02 Aug 2012	294	92	27.95625	-97.08948	1.16
RF77	Aransas Bay	02 Aug 2012	294	130	27.95208	-97.08678	0.89

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
RF79	Aransas Bay	02 Aug 2012	295	66	27.95903	-97.07572	0.45
RF80	Aransas Bay	02 Aug 2012	295	73	27.95761	-97.08260	0.81
RF81	Aransas Bay	02 Aug 2012	295	111	27.95352	-97.07996	0.63
RF85	Aransas Bay	02 Aug 2012	304	37	27.94515	-97.08264	0.68
RF87	Aransas Bay	02 Aug 2012	304	62	27.94247	-97.08137	0.72
RF88	Aransas Bay	02 Aug 2012	304	63	27.94245	-97.07994	0.64
RF90	Aransas Bay	01 Aug 2012	310	141	27.91723	-97.12121	0.49
RF94	Aransas Bay	01 Aug 2012	311	120	27.92019	-97.10072	1.00
RF96	Aransas Bay	02 Aug 2012	312	39	27.92877	-97.09693	0.76
RF98	Aransas Bay	02 Aug 2012	312	143	27.91740	-97.08537	0.74
RF99	Aransas Bay	02 Aug 2012	313	38	27.92858	-97.08134	1.14
RF101	Aransas Bay	01 Aug 2012	319	11	27.91602	-97.11881	0.79
RF104	Aransas Bay	01 Aug 2012	320	89	27.90635	-97.11044	0.90
RF105	Aransas Bay	02 Aug 2012	321	15	27.91463	-97.09653	0.56
RF29	Corpus Christi Bay	01 Aug 2012	327	142	27.88392	-97.13689	1.08
RF31	Corpus Christi Bay	01 Aug 2012	328	134	27.88414	-97.13133	0.92
RF45	Corpus Christi Bay	07 Aug 2012	64	45	27.87851	-97.13813	0.23
RF47	Corpus Christi Bay	07 Aug 2012	64	130	27.86881	-97.13684	0.90
RF55	Corpus Christi Bay	07 Aug 2012	77	65	27.85915	-97.16044	0.73
RF59	Corpus Christi Bay	07 Aug 2012	78	69	27.85893	-97.13819	0.84
RF111	Corpus Christi Bay	07 Aug 2012	54	72	27.89214	-97.13417	0.36
RF117	Corpus Christi Bay	07 Aug 2012	55	92	27.89000	-97.12299	0.52
RF125	Corpus Christi Bay	07 Aug 2012	64	131	27.86878	-97.13537	0.47
RF126	Corpus Christi Bay	07 Aug 2012	64	137	27.86692	-97.14379	0.74
RF127	Corpus Christi Bay	07 Aug 2012	64	141	27.86733	-97.13821	0.81
RF134	Corpus Christi Bay	07 Aug 2012	77	110	27.85350	-97.16461	0.34
RF135	Corpus Christi Bay	07 Aug 2012	77	121	27.85172	-97.16553	0.76
RF136	Corpus Christi Bay	07 Aug 2012	77	128	27.85219	-97.15623	0.67
RF137	Corpus Christi Bay	07 Aug 2012	78	86	27.85633	-97.14789	0.62
RF139	Corpus Christi Bay	07 Aug 2012	80	61	27.85909	-97.11603	0.52
RF140	Corpus Christi Bay	07 Aug 2012	80	134	27.85071	-97.11440	0.21
RF141	Corpus Christi Bay	07 Aug 2012	92	44	27.84532	-97.17270	0.88
RF144	Corpus Christi Bay	07 Aug 2012	93	20	27.84810	-97.15633	0.75
RF145	Corpus Christi Bay	07 Aug 2012	93	52	27.84396	-97.16227	0.88
Phase 2 - San Antonio Bay							
SA12	San Antonio Bay	29 Aug 2012	114	48	28.29508	-96.56741	0.92
SA14	San Antonio Bay	29 Aug 2012	115	3	28.29926	-96.56322	0.77
SA16	San Antonio Bay	29 Aug 2012	115	55	28.29378	-96.55757	0.74
SA18	San Antonio Bay	29 Aug 2012	129	72	28.27583	-96.61750	0.49
SA22	San Antonio Bay	05 Sep 2012	171	118	28.22019	-96.68684	0.63

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
SA23	San Antonio Bay	05 Sep 2012	172	70	28.22515	-96.67020	0.34
SA24	San Antonio Bay	05 Sep 2012	173	38	28.22823	-96.66501	0.47
SA28	San Antonio Bay	05 Sep 2012	192	96	28.18982	-96.73404	0.55
SA31	San Antonio Bay	14 Aug 2012	213	124	28.41891	-96.41168	0.16
SA33	San Antonio Bay	14 Aug 2012	219	59	28.41061	-96.41927	0.36
SA35	San Antonio Bay	28 Aug 2012	227	106	28.38795	-96.43662	0.62
SA37	San Antonio Bay	28 Aug 2012	227	123	28.38556	-96.44666	1.01
SA38	San Antonio Bay	28 Aug 2012	228	121	28.38540	-96.43256	0.63
SA44	San Antonio Bay	28 Aug 2012	238	67	28.37530	-96.44061	0.95
SA45	San Antonio Bay	28 Aug 2012	238	132	28.36879	-96.43399	0.66
SA50	San Antonio Bay	06 Sep 2012	258	74	28.34104	-96.61453	0.46
SA51	San Antonio Bay	06 Sep 2012	258	92	28.33992	-96.60620	0.41
SA52	San Antonio Bay	06 Sep 2012	258	102	28.33813	-96.60914	0.50
SA53	San Antonio Bay	30 Aug 2012	258	104	28.33816	-96.60631	0.35
SA54	San Antonio Bay	30 Aug 2012	258	115	28.33675	-96.60767	0.44
SA55	San Antonio Bay	30 Aug 2012	259	13	28.34791	-96.59929	0.51
SA56	San Antonio Bay	30 Aug 2012	259	50	28.34380	-96.59790	0.38
SA58	San Antonio Bay	06 Sep 2012	270	18	28.33130	-96.62566	0.61
SA59	San Antonio Bay	30 Aug 2012	270	60	28.32711	-96.61737	0.54
SA60	San Antonio Bay	06 Sep 2012	270	61	28.32552	-96.63253	0.48
SA61	San Antonio Bay	05 Sep 2012	270	85	28.32307	-96.63240	0.66
SA65	San Antonio Bay	28 Aug 2012	277	100	28.32149	-96.51184	0.84
SA66	San Antonio Bay	29 Aug 2012	277	133	28.31738	-96.51601	1.28
SA71	San Antonio Bay	29 Aug 2012	285	107	28.30492	-96.53542	0.75
SA72	San Antonio Bay	29 Aug 2012	286	61	28.30896	-96.53259	0.72
SA74	San Antonio Bay	29 Aug 2012	287	49	28.31036	-96.51599	0.86
SA75	San Antonio Bay	29 Aug 2012	287	50	28.31046	-96.51463	0.76
SA89	San Antonio Bay	29 Aug 2012	114	44	28.29508	-96.57288	0.74
SA90	San Antonio Bay	29 Aug 2012	114	68	28.29239	-96.57292	0.75
SA92	San Antonio Bay	29 Aug 2012	116	8	28.29927	-96.53962	0.65
SA94	San Antonio Bay	29 Aug 2012	129	118	28.27015	-96.62011	1.02
SA96	San Antonio Bay	29 Aug 2012	130	87	28.27288	-96.61324	0.67
SA113	San Antonio Bay	28 Aug 2012	227	128	28.38543	-96.43969	0.74
SA117	San Antonio Bay	28 Aug 2012	228	122	28.38535	-96.43127	0.46
SA126	San Antonio Bay	28 Aug 2012	253	23	28.36460	-96.45209	0.96
SA130	San Antonio Bay	06 Sep 2012	257	132	28.33542	-96.61741	0.53
SA132	San Antonio Bay	06 Sep 2012	258	55	28.34371	-96.60757	0.45
SA135	San Antonio Bay	30 Aug 2012	259	14	28.34792	-96.59794	0.48
SA139	San Antonio Bay	06 Sep 2012	270	59	28.32731	-96.61877	0.50
SA140	San Antonio Bay	28 Aug 2012	277	120	28.32012	-96.50071	0.95

Site	Bay	Sample date	Grid	Gridlet	Latitude	Longitude	Water depth (m)
SA141	San Antonio Bay	28 Aug 2012	277	129	28.31879	-96.50489	1.22
SA145	San Antonio Bay	28 Aug 2012	278	68	28.32569	-96.48956	0.68
SA146	San Antonio Bay	28 Aug 2012	278	97	28.32150	-96.49928	0.93
SA147	San Antonio Bay	28 Aug 2012	278	133	28.31769	-96.49904	0.77
SA149	San Antonio Bay	29 Aug 2012	286	42	28.31180	-96.52570	0.83

Table 43. Probabilistically-selected coordinate sets for San Antonio Bay.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid. Desktop site ratings generally mean: 1 – good site, 2 – may be difficult to navigate to/may not have seagrass, 3 – very difficult to navigate to/no seagrass, 4 – cannot navigate to/no seagrass.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Desktop assessment	Desktop site rating	Priority / Alternative	Random number	Date visited	Valid site
SA01	San Antonio Bay	11	100	28.4549	-96.7951	in flats, too shallow	4		9727		
SA02	San Antonio Bay	16	11	28.4493	-96.8021	in flats, too shallow	4		1964		
SA03	San Antonio Bay	17	27	28.4465	-96.7965	in flats, too shallow	4		2862		
SA04	San Antonio Bay	34	50	28.4104	-96.7813	in flats, too shallow	4		788		
SA05	San Antonio Bay	36	81	28.4076	-96.7382	doable	1	P	4683	6 Sep 2012	N
SA06	San Antonio Bay	76	2	28.3493	-96.6479	private, no access	4		4577		
SA07	San Antonio Bay	85	96	28.3229	-96.6674	shallow	2	P	3683	6 Sep 2012	N
SA08	San Antonio Bay	85	107	28.3215	-96.6688	okay, might be in rip-rap	2	A	9347	6 Sep 2012	N
SA09	San Antonio Bay	86	131	28.3188	-96.6521	too shallow, may get stuck	4		5359		
SA10	San Antonio Bay	100	79	28.2910	-96.8076	mud and may have grass	2	P	605	6 Sep 2012	N
SA11	San Antonio Bay	114	47	28.2951	-96.5688	doable	1	A	7149		
SA12	San Antonio Bay	114	48	28.2951	-96.5674	shallow, need high tide	2	P	5124	29 Aug 2012	Y
SA13	San Antonio Bay	114	68	28.2924	-96.5729	shallow, need high tide	2	A	8944		
SA14	San Antonio Bay	115	3	28.2993	-96.5632	doable	1	P	786	29 Aug 2012	Y
SA15	San Antonio Bay	115	28	28.2965	-96.5618	shallow, need high tide	2	A	6565		
SA16	San Antonio Bay	115	55	28.2938	-96.5576	shallow, need high tide	2	P	1297	29 Aug 2012	Y
SA17	San Antonio Bay	116	10	28.2993	-96.5368	maybe, shallow, need high tide	2	A	6967		
SA18	San Antonio Bay	129	72	28.2757	-96.6174	doable, wading	1	P	5199	29 Aug 2012	Y
SA19	San Antonio Bay	129	135	28.2674	-96.6299	doable	1	A	8259		
SA20	San Antonio Bay	130	70	28.2757	-96.6035	shallow, need high tide, tough	3		9610		
SA21	San Antonio Bay	160	54	28.2438	-96.6424	culvert built so site inaccessible	4		4926		
SA22	San Antonio Bay	171	118	28.2201	-96.6868	doable	1	A	5754	5 Sep 2012	Y
SA23	San Antonio Bay	172	70	28.2257	-96.6701	doable, wading	1	A	9143	5 Sep 2012	Y
SA24	San Antonio Bay	173	38	28.2285	-96.6646	doable, wading	2	P	2114	5 Sep 2012	Y
SA25	San Antonio Bay	184	20	28.2146	-96.6896	shallow, need high tide	2	P	2696	5 Sep 2012	N
SA26	San Antonio Bay	184	39	28.2118	-96.6965	doable	1	P	3032	5 Sep 2012	N
SA27	San Antonio Bay	191	132	28.1854	-96.7507	doable if there are not culverts	2	A	9503	5 Sep 2012	N
SA28	San Antonio Bay	192	96	28.1896	-96.7340	doable if there are not culverts	2	P	2197	5 Sep 2012	Y

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Desktop assessment	Desktop site rating	Priority / Alternative	Random number	Date visited	Valid site
SA29	San Antonio Bay	200	39	28.1785	-96.7799	culvert built so site inaccessible	4		3487		
SA30	San Antonio Bay	212	109	28.4201	-96.4326	shallow	2	P	1869	14 Aug 2012	N
SA31	San Antonio Bay	213	124	28.4188	-96.4118	shallow	1	P	1975	14 Aug 2012	Y
SA32	San Antonio Bay	213	144	28.4174	-96.4007	tough, no	4		2119		
SA33	San Antonio Bay	219	59	28.4104	-96.4188	shallow	1	P	2563	14 Aug 2012	Y
SA34	San Antonio Bay	223	69	28.3924	-96.5049	shallow, need high tide	3		83		
SA35	San Antonio Bay	227	106	28.3882	-96.4368	shallow, need high tide	2	P	2221	28 Aug 2012	Y
SA36	San Antonio Bay	227	121	28.3854	-96.4493	really shallow	3		889		
SA37	San Antonio Bay	227	123	28.3854	-96.4465	doable	1	P	2676	28 Aug 2012	Y
SA38	San Antonio Bay	228	121	28.3854	-96.4326	doable	2	P	4187	28 Aug 2012	Y
SA39	San Antonio Bay	231	115	28.3701	-96.5576	shallow, need high tide	3		9483		
SA40	San Antonio Bay	232	46	28.3785	-96.5368	shallow, need high tide	3		5217		
SA41	San Antonio Bay	232	100	28.3715	-96.5451	shallow, need high tide	3		9685		
SA42	San Antonio Bay	237	91	28.3729	-96.4576	shallow, lots of mud and grass	2	A	6029		
SA43	San Antonio Bay	237	101	28.3715	-96.4604	shallow, lots of mud and grass	2	A	5931		
SA44	San Antonio Bay	238	67	28.3757	-96.4410	doable	1	P	899	28 Aug 2012	Y
SA45	San Antonio Bay	238	132	28.3688	-96.4340	shallow	2	P	1720	28 Aug 2012	Y
SA46	San Antonio Bay	239	72	28.3757	-96.4174	shallow, long walk	3		3704		
SA47	San Antonio Bay	254	103	28.3549	-96.4410	doable	1	A	7463		
SA48	San Antonio Bay	254	144	28.3507	-96.4340	shallow, need high tide	3		473		
SA49	San Antonio Bay	257	64	28.3424	-96.6285	private, no access	4		3717		
SA50	San Antonio Bay	258	74	28.3410	-96.6146	shallow	2	A	9364	6 Sep 2012	Y
SA51	San Antonio Bay	258	92	28.3396	-96.6063	shallow	2	A	6250	6 Sep 2012	Y
SA52	San Antonio Bay	258	102	28.3382	-96.6090	shallow	2	A	9014	6 Sep 2012	Y
SA53	San Antonio Bay	258	104	28.3382	-96.6063	shallow	2	P	3620	30 Aug 2012	Y
SA54	San Antonio Bay	258	115	28.3368	-96.6076	shallow	2	P	3139	30 Aug 2012	Y
SA55	San Antonio Bay	259	13	28.3479	-96.5993	shallow	2	P	60	30 Aug 2012	Y
SA56	San Antonio Bay	259	50	28.3438	-96.5979	shallow	2	P	2482	30 Aug 2012	Y
SA57	San Antonio Bay	268	44	28.3451	-96.4396	doable	1	A	6201		
SA58	San Antonio Bay	270	18	28.3313	-96.6257	need high tide	2	A	5673	6 Sep 2012	Y
SA59	San Antonio Bay	270	60	28.3271	-96.6174	need high tide (changed from alternate to primary 8/21/12)	2	P	5567	30 Aug 2012	Y
SA60	San Antonio Bay	270	61	28.3257	-96.6326	need high tide	2	A	7439	6 Sep 2012	Y
SA61	San Antonio Bay	270	85	28.3229	-96.6326	need high tide	2	P	2538	5 Sep 2012	Y
SA62	San Antonio Bay	276	88	28.3229	-96.5285	good	1	A	9584		
SA63	San Antonio Bay	276	104	28.3215	-96.5229	shallow	2	A	9067		

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Desktop assessment	Desktop site rating	Priority / Alternative	Random number	Date visited	Valid site
SA64	San Antonio Bay	276	129	28.3188	-96.5215	doable	1	A	9763		
SA65	San Antonio Bay	277	100	28.3215	-96.5118	doable	1	A	6991	28 Aug 2012	Y
SA66	San Antonio Bay	277	133	28.3174	-96.5160	doable	1	P	804	29 Aug 2012	Y
SA67	San Antonio Bay	277	140	28.3174	-96.5063	doable	1	P	2257	28 Aug 2012	N
SA68	San Antonio Bay	279	22	28.3313	-96.4701	shallow with hard bottom	2	A	7687		
SA69	San Antonio Bay	279	25	28.3299	-96.4826	shallow with hard bottom	2	A	6015		
SA70	San Antonio Bay	285	44	28.3118	-96.5396	shallow	2	A	8088		
SA71	San Antonio Bay	285	107	28.3049	-96.5354	good	1	P	5229	29 Aug 2012	Y
SA72	San Antonio Bay	286	61	28.3090	-96.5326	doable	1	P	2632	29 Aug 2012	Y
SA73	San Antonio Bay	287	34	28.3132	-96.5035	good	1	P	5163	28 Aug 2012	N
SA74	San Antonio Bay	287	49	28.3104	-96.5160	doable	1	A	5656	29 Aug 2012	Y
SA75	San Antonio Bay	287	50	28.3104	-96.5146	doable	1	P	2073	29 Aug 2012	Y
SA76	San Antonio Bay	25	1	28.4326	-96.7993	land locked	4		4860		
SA77	San Antonio Bay	75	46	28.3451	-96.6535	no	4		8976		
SA78	San Antonio Bay	75	56	28.3438	-96.6563	no	4		9737		
SA79	San Antonio Bay	75	115	28.3368	-96.6576	no	4		3070		
SA80	San Antonio Bay	85	21	28.3313	-96.6715	very shallow	3		5417		
SA81	San Antonio Bay	85	31	28.3299	-96.6743	very shallow	3		9269		
SA82	San Antonio Bay	85	55	28.3271	-96.6743	very shallow	3		1383		
SA83	San Antonio Bay	85	63	28.3257	-96.6799	very shallow	2	P	4030	6 Sep 2012	N
SA84	San Antonio Bay	85	64	28.3257	-96.6785	very shallow	2	A	7916	6 Sep 2012	N
SA85	San Antonio Bay	87	33	28.3299	-96.6382	need high tide	3		1597		
SA86	San Antonio Bay	87	98	28.3215	-96.6479	need high tide	3		1949		
SA87	San Antonio Bay	100	66	28.2924	-96.8090	most likely mud	3		4644		
SA88	San Antonio Bay	114	35	28.2965	-96.5688	shallow	2	A	6383		
SA89	San Antonio Bay	114	44	28.2951	-96.5729	shallow	2	P	2232	29 Aug 2012	Y
SA90	San Antonio Bay	114	68	28.2924	-96.5729	same as SA13, need high tide	2	P	370	29 Aug 2012	Y
SA91	San Antonio Bay	115	6	28.2993	-96.5590	on land	4		2215		
SA92	San Antonio Bay	116	8	28.2993	-96.5396	maybe, need high tide	2	P	474	29 Aug 2012	Y
SA93	San Antonio Bay	129	72	28.2757	-96.6174	accessible, same as SA18	1	P	4546		
SA94	San Antonio Bay	129	118	28.2701	-96.6201	accessible	1	P	1701	29 Aug 2012	Y
SA95	San Antonio Bay	130	22	28.2813	-96.6035	accessible	1	A	6762		
SA96	San Antonio Bay	130	87	28.2729	-96.6132	accessible	1	P	1898	29 Aug 2012	Y
SA97	San Antonio Bay	130	103	28.2715	-96.6076	shallow	2	A	9835		
SA98	San Antonio Bay	135	106	28.2549	-96.7868	grass questionable	3		2575		
SA99	San Antonio Bay	144	95	28.2563	-96.6354	no, on sand	4		6417		

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Desktop assessment	Desktop site rating	Priority / Alternative	Random number	Date visited	Valid site
SA100	San Antonio Bay	151	101	28.2382	-96.7938	shallow, seagrass is questionable	2	P	5022	6 Sep 2012	N
SA101	San Antonio Bay	171	127	28.2188	-96.6910	same as CW102	1	A	9909		
SA102	San Antonio Bay	184	45	28.2118	-96.6882	need high tide	3		6727		
SA103	San Antonio Bay	197	118	28.1701	-96.8201	shallow, need high tide (removed from dataset, data logged as SA-EXTRA)	1	P	5064	5 Sep 2012	Y
SA104	San Antonio Bay	199	77	28.1743	-96.7938	hard to get to	4		3290		
SA105	San Antonio Bay	200	54	28.1771	-96.7757	culvert, inaccessible	4		8865		
SA106	San Antonio Bay	212	139	28.4174	-96.4243	shallow	2	A	9096		
SA107	San Antonio Bay	219	48	28.4118	-96.4174	shallow, more than SA33	2	P	3643	14 Aug 2012	N
SA108	San Antonio Bay	222	120	28.3868	-96.5174	very shallow	3		9375		
SA109	San Antonio Bay	223	58	28.3938	-96.5035	very shallow	3		1666		
SA110	San Antonio Bay	223	79	28.3910	-96.5076	very shallow	3		7548		
SA111	San Antonio Bay	227	101	28.3882	-96.4438	accessible	1	A	9821		
SA112	San Antonio Bay	227	114	28.3868	-96.4424	shallow, approach from the west	2	A	5687		
SA113	San Antonio Bay	227	128	28.3854	-96.4396	shallow, accessible	1	P	5265	28 Aug 2012	Y
SA114	San Antonio Bay	227	129	28.3854	-96.4382	very shallow	3		2631		
SA115	San Antonio Bay	227	139	28.3840	-96.4410	accessible	1	A	8182		
SA116	San Antonio Bay	228	111	28.3868	-96.4299	shallow, on shoreline	3		3257		
SA117	San Antonio Bay	228	122	28.3854	-96.4313	shallow, close to open water	2	P	3304	28 Aug 2012	Y
SA118	San Antonio Bay	232	65	28.3757	-96.5438	very shallow, high tide	3		7644		
SA119	San Antonio Bay	238	8	28.3826	-96.4396	shallow, high tide	2	A	8181		
SA120	San Antonio Bay	239	10	28.3826	-96.4201	shallow	3		4851		
SA121	San Antonio Bay	239	96	28.3729	-96.4174	shallow	3		7301		
SA122	San Antonio Bay	240	61	28.3757	-96.4160	shallow, long walk	3		1189		
SA123	San Antonio Bay	240	87	28.3729	-96.4132	shallow	4		2595		
SA124	San Antonio Bay	245	115	28.3535	-96.5910	really shallow	3		1411		
SA125	San Antonio Bay	246	53	28.3604	-96.5771	really shallow	3		9951		
SA126	San Antonio Bay	253	23	28.3646	-96.4521	accessible	1	P	2790	28 Aug 2012	Y
SA127	San Antonio Bay	254	1	28.3660	-96.4493	land locked	4		79		
SA128	San Antonio Bay	257	44	28.3451	-96.6229	shallow	3		7486		
SA129	San Antonio Bay	257	63	28.3424	-96.6299	private, no access	4		5311		
SA130	San Antonio Bay	257	132	28.3354	-96.6174	shallow	2	A	7295	6 Sep 2012	Y
SA131	San Antonio Bay	258	23	28.3479	-96.6021	very shallow, near shoreline	3		7539		
SA132	San Antonio Bay	258	55	28.3438	-96.6076	shallow	2	A	6696	6 Sep 2012	Y
SA133	San Antonio Bay	258	139	28.3340	-96.6076	shallow	2	A	7191		
SA134	San Antonio Bay	259	7	28.3493	-96.5910	shallow	2	A	9457		

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Desktop assessment	Desktop site rating	Priority / Alternative	Random number	Date visited	Valid site
SA135	San Antonio Bay	259	14	28.3479	-96.5979	shallow	2	P	2984	30 Aug 2012	Y
SA136	San Antonio Bay	259	18	28.3479	-96.5924	on land	4		9568		
SA137	San Antonio Bay	259	29	28.3465	-96.5938	sandy	3		1307		
SA138	San Antonio Bay	268	76	28.3410	-96.4451	maybe, on sandy area	3		2772		
SA139	San Antonio Bay	270	59	28.3271	-96.6188	need high tide	2	A	7743	6 Sep 2012	Y
SA140	San Antonio Bay	277	120	28.3201	-96.5007	accessible	1	P	2882	28 Aug 2012	Y
SA141	San Antonio Bay	277	129	28.3188	-96.5049	accessible	1	A	8095	28 Aug 2012	Y
SA142	San Antonio Bay	277	136	28.3174	-96.5118	accessible	1	A	7081	28 Aug 2012	N
SA143	San Antonio Bay	277	137	28.3174	-96.5104	accessible	1	A	6981	28 Aug 2012	N
SA144	San Antonio Bay	277	140	28.3174	-96.5063	accessible	1	A	6790		
SA145	San Antonio Bay	278	68	28.3257	-96.4896	accessible	1	P	3266	28 Aug 2012	Y
SA146	San Antonio Bay	278	97	28.3215	-96.4993	accessible	1	P	5199	28 Aug 2012	Y
SA147	San Antonio Bay	278	133	28.3174	-96.4993	accessible	1	P	3162	28 Aug 2012	Y
SA148	San Antonio Bay	279	49	28.3271	-96.4826	maybe, tricky navigation	3		6223		
SA149	San Antonio Bay	286	42	28.3118	-96.5257	accessible	1	P	1226	29 Aug 2012	Y
SA150	San Antonio Bay	286	107	28.3049	-96.5188	shallow, high tide	2	P	3452	29 Aug 2012	N

Appendix B. Probabilistically-Selected Coordinate Sets

Table 44. Probabilistically-selected coordinate sets for Galveston Bay.
Only 146 coordinate sets are available based on seagrass coverage. Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
GAL01	Galveston Bay	552	135	29.2840	-94.9299	1.0000	1.00	6251
GAL02	Galveston Bay	553	20	29.2979	-94.9063	1.0000	1.00	1052
GAL03	Galveston Bay	564	96	29.2729	-94.9174	1.0000	1.00	685
GAL04	Galveston Bay	565	85	29.2729	-94.9160	1.0000	1.00	9601
GAL05	Galveston Bay	602	124	29.2188	-94.9618	1.0000	1.00	595
GAL06	Galveston Bay	602	125	29.2188	-94.9604	1.0000	1.00	4331
GAL07	Galveston Bay	602	126	29.2188	-94.9590	1.0000	1.00	4607
GAL08	Galveston Bay	602	127	29.2188	-94.9576	1.0000	1.00	4990
GAL09	Galveston Bay	602	136	29.2174	-94.9618	1.0000	1.00	5098
GAL10	Galveston Bay	602	137	29.2174	-94.9604	1.0000	1.00	7094
GAL11	Galveston Bay	602	138	29.2174	-94.9590	1.0000	1.00	4477
GAL12	Galveston Bay	602	139	29.2174	-94.9576	1.0000	1.00	3509
GAL13	Galveston Bay	602	140	29.2174	-94.9563	1.0000	1.00	1098
GAL14	Galveston Bay	602	141	29.2174	-94.9549	1.0000	1.00	9143
GAL15	Galveston Bay	603	64	29.2257	-94.9451	1.0000	1.00	3701
GAL16	Galveston Bay	619	33	29.2132	-94.9715	1.0000	1.00	1144
GAL17	Galveston Bay	619	34	29.2132	-94.9701	1.0000	1.00	903
GAL18	Galveston Bay	619	35	29.2132	-94.9688	1.0000	1.00	2838
GAL19	Galveston Bay	619	36	29.2132	-94.9674	1.0000	1.00	8435
GAL20	Galveston Bay	619	43	29.2118	-94.9743	1.0000	1.00	6692
GAL21	Galveston Bay	619	44	29.2118	-94.9729	1.0000	1.00	4004
GAL22	Galveston Bay	619	45	29.2118	-94.9715	1.0000	1.00	5000
GAL23	Galveston Bay	619	46	29.2118	-94.9701	1.0000	1.00	3861
GAL24	Galveston Bay	619	54	29.2104	-94.9757	1.0000	1.00	1309
GAL25	Galveston Bay	619	55	29.2104	-94.9743	1.0000	1.00	90
GAL26	Galveston Bay	619	58	29.2104	-94.9701	1.0000	1.00	238
GAL27	Galveston Bay	619	59	29.2104	-94.9688	1.0000	1.00	6705
GAL28	Galveston Bay	619	67	29.2090	-94.9743	1.0000	1.00	1796
GAL29	Galveston Bay	619	71	29.2090	-94.9688	1.0000	1.00	3749
GAL30	Galveston Bay	619	72	29.2090	-94.9674	1.0000	1.00	7908
GAL31	Galveston Bay	620	3	29.2160	-94.9632	1.0000	1.00	4543
GAL32	Galveston Bay	620	4	29.2160	-94.9618	1.0000	1.00	3846
GAL33	Galveston Bay	620	5	29.2160	-94.9604	1.0000	1.00	9624
GAL34	Galveston Bay	620	6	29.2160	-94.9590	1.0000	1.00	5964
GAL35	Galveston Bay	620	7	29.2160	-94.9576	1.0000	1.00	2138
GAL36	Galveston Bay	620	8	29.2160	-94.9563	1.0000	1.00	4985
GAL37	Galveston Bay	620	9	29.2160	-94.9549	1.0000	1.00	5382
GAL38	Galveston Bay	620	15	29.2146	-94.9632	1.0000	1.00	1665
GAL39	Galveston Bay	620	16	29.2146	-94.9618	1.0000	1.00	6713
GAL40	Galveston Bay	620	17	29.2146	-94.9604	1.0000	1.00	6182
GAL41	Galveston Bay	620	18	29.2146	-94.9590	1.0000	1.00	7312
GAL42	Galveston Bay	620	19	29.2146	-94.9576	1.0000	1.00	9335
GAL43	Galveston Bay	620	20	29.2146	-94.9563	1.0000	1.00	8967

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
GAL44	Galveston Bay	620	28	29.2132	-94.9618	1.0000	1.00	3222
GAL45	Galveston Bay	620	29	29.2132	-94.9604	1.0000	1.00	5851
GAL46	Galveston Bay	620	30	29.2132	-94.9590	1.0000	1.00	1805
GAL47	Galveston Bay	620	31	29.2132	-94.9576	1.0000	1.00	3208
GAL48	Galveston Bay	620	32	29.2132	-94.9563	1.0000	1.00	1532
GAL49	Galveston Bay	620	37	29.2118	-94.9660	1.0000	1.00	1496
GAL50	Galveston Bay	620	38	29.2118	-94.9646	1.0000	1.00	4847
GAL51	Galveston Bay	620	39	29.2118	-94.9632	1.0000	1.00	4604
GAL52	Galveston Bay	620	40	29.2118	-94.9618	1.0000	1.00	300
GAL53	Galveston Bay	620	41	29.2118	-94.9604	1.0000	1.00	1759
GAL54	Galveston Bay	620	42	29.2118	-94.9590	1.0000	1.00	7891
GAL55	Galveston Bay	620	43	29.2118	-94.9576	1.0000	1.00	6167
GAL56	Galveston Bay	620	44	29.2118	-94.9563	1.0000	1.00	3731
GAL57	Galveston Bay	620	51	29.2104	-94.9632	1.0000	1.00	2924
GAL58	Galveston Bay	620	52	29.2104	-94.9618	1.0000	1.00	3130
GAL59	Galveston Bay	620	53	29.2104	-94.9604	1.0000	1.00	4045
GAL60	Galveston Bay	620	54	29.2104	-94.9590	1.0000	1.00	4454
GAL61	Galveston Bay	620	66	29.2090	-94.9590	1.0000	1.00	6487
GAL62	Galveston Bay	684	103	29.1049	-95.1076	1.0000	1.00	9544
GAL63	Galveston Bay	684	114	29.1035	-95.1090	1.0000	1.00	1894
GAL64	Galveston Bay	684	115	29.1035	-95.1076	1.0000	1.00	4558
GAL65	Galveston Bay	684	126	29.1021	-95.1090	1.0000	1.00	8047
GAL66	Galveston Bay	695	60	29.0938	-95.1174	1.0000	1.00	7251
GAL67	Galveston Bay	695	70	29.0924	-95.1201	1.0000	1.00	8459
GAL68	Galveston Bay	695	82	29.0910	-95.1201	1.0000	1.00	6630
GAL69	Galveston Bay	696	49	29.0938	-95.1160	1.0000	1.00	1719
GAL70	Galveston Bay	702	83	29.0743	-95.1854	1.0000	1.00	8611
GAL71	Galveston Bay	702	93	29.0729	-95.1882	1.0000	1.00	7448
GAL72	Galveston Bay	702	103	29.0715	-95.1910	1.0000	1.00	1361
GAL73	Galveston Bay	702	113	29.0701	-95.1938	1.0000	1.00	8362
GAL74	Galveston Bay	702	124	29.0688	-95.1951	1.0000	1.00	5086
GAL75	Galveston Bay	702	134	29.0674	-95.1979	1.0000	1.00	2380
GAL76	Galveston Bay	702	135	29.0674	-95.1965	1.0000	1.00	9541
GAL77	Galveston Bay	703	43	29.0785	-95.1743	1.0000	1.00	854
GAL78	Galveston Bay	703	52	29.0771	-95.1785	1.0000	1.00	4982
GAL79	Galveston Bay	703	53	29.0771	-95.1771	1.0000	1.00	9640
GAL80	Galveston Bay	703	62	29.0757	-95.1813	1.0000	1.00	7691
GAL81	Galveston Bay	703	144	29.0674	-95.1674	1.0000	1.00	9063
GAL82	Galveston Bay	704	121	29.0688	-95.1660	1.0000	1.00	3248
GAL83	Galveston Bay	708	24	29.0646	-95.2007	1.0000	1.00	6290
GAL84	Galveston Bay	708	35	29.0632	-95.2021	1.0000	1.00	6891
GAL85	Galveston Bay	708	36	29.0632	-95.2007	1.0000	1.00	6724
GAL86	Galveston Bay	708	90	29.0563	-95.2090	1.0000	1.00	4626
GAL87	Galveston Bay	708	101	29.0549	-95.2104	1.0000	1.00	3085
GAL88	Galveston Bay	709	1	29.0660	-95.1993	1.0000	1.00	3593
GAL89	Galveston Bay	711	37	29.0618	-95.1660	1.0000	1.00	8326
GAL90	Galveston Bay	711	49	29.0604	-95.1660	1.0000	1.00	4407
GAL91	Galveston Bay	711	61	29.0590	-95.1660	1.0000	1.00	6871
GAL92	Galveston Bay	711	74	29.0576	-95.1646	1.0000	1.00	3412
GAL93	Galveston Bay	711	86	29.0563	-95.1646	1.0000	1.00	5110
GAL94	Galveston Bay	711	98	29.0549	-95.1646	1.0000	1.00	5841

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
GAL95	Galveston Bay	711	99	29.0549	-95.1632	1.0000	1.00	2361
GAL96	Galveston Bay	711	122	29.0521	-95.1646	1.0000	1.00	5146
GAL97	Galveston Bay	711	133	29.0507	-95.1660	1.0000	1.00	7060
GAL98	Galveston Bay	715	45	29.0451	-95.2215	1.0000	1.00	5142
GAL99	Galveston Bay	715	56	29.0438	-95.2229	1.0000	1.00	203
GAL100	Galveston Bay	715	68	29.0424	-95.2229	1.0000	1.00	126
GAL101	Galveston Bay	715	91	29.0396	-95.2243	1.0000	1.00	8095
GAL102	Galveston Bay	715	143	29.0340	-95.2188	1.0000	1.00	1360
GAL103	Galveston Bay	717	93	29.0396	-95.1882	1.0000	1.00	508
GAL104	Galveston Bay	717	94	29.0396	-95.1868	1.0000	1.00	6169
GAL105	Galveston Bay	717	95	29.0396	-95.1854	1.0000	1.00	8885
GAL106	Galveston Bay	717	96	29.0396	-95.1840	1.0000	1.00	2578
GAL107	Galveston Bay	717	103	29.0382	-95.1910	1.0000	1.00	9135
GAL108	Galveston Bay	717	104	29.0382	-95.1896	1.0000	1.00	4494
GAL109	Galveston Bay	717	106	29.0382	-95.1868	1.0000	1.00	7445
GAL110	Galveston Bay	717	115	29.0368	-95.1910	1.0000	1.00	1413
GAL111	Galveston Bay	717	125	29.0354	-95.1938	1.0000	1.00	4819
GAL112	Galveston Bay	717	126	29.0354	-95.1924	1.0000	1.00	1952
GAL113	Galveston Bay	717	135	29.0340	-95.1965	1.0000	1.00	8483
GAL114	Galveston Bay	717	136	29.0340	-95.1951	1.0000	1.00	206
GAL115	Galveston Bay	718	22	29.0479	-95.1701	1.0000	1.00	3944
GAL116	Galveston Bay	718	23	29.0479	-95.1688	1.0000	1.00	4086
GAL117	Galveston Bay	718	24	29.0479	-95.1674	1.0000	1.00	3347
GAL118	Galveston Bay	718	33	29.0465	-95.1715	1.0000	1.00	6070
GAL119	Galveston Bay	718	34	29.0465	-95.1701	1.0000	1.00	5659
GAL120	Galveston Bay	718	35	29.0465	-95.1688	1.0000	1.00	674
GAL121	Galveston Bay	718	43	29.0451	-95.1743	1.0000	1.00	6445
GAL122	Galveston Bay	718	44	29.0451	-95.1729	1.0000	1.00	74
GAL123	Galveston Bay	718	45	29.0451	-95.1715	1.0000	1.00	532
GAL124	Galveston Bay	718	46	29.0451	-95.1701	1.0000	1.00	5871
GAL125	Galveston Bay	718	53	29.0438	-95.1771	1.0000	1.00	9167
GAL126	Galveston Bay	718	54	29.0438	-95.1757	1.0000	1.00	365
GAL127	Galveston Bay	718	55	29.0438	-95.1743	1.0000	1.00	2408
GAL128	Galveston Bay	718	56	29.0438	-95.1729	1.0000	1.00	5740
GAL129	Galveston Bay	718	63	29.0424	-95.1799	1.0000	1.00	6157
GAL130	Galveston Bay	718	64	29.0424	-95.1785	1.0000	1.00	8256
GAL131	Galveston Bay	718	65	29.0424	-95.1771	1.0000	1.00	8097
GAL132	Galveston Bay	718	66	29.0424	-95.1757	1.0000	1.00	6550
GAL133	Galveston Bay	718	73	29.0410	-95.1826	1.0000	1.00	2296
GAL134	Galveston Bay	718	74	29.0410	-95.1813	1.0000	1.00	6644
GAL135	Galveston Bay	723	24	29.0313	-95.2007	1.0000	1.00	6143
GAL136	Galveston Bay	723	106	29.0215	-95.2035	1.0000	1.00	5069
GAL137	Galveston Bay	723	117	29.0201	-95.2049	1.0000	1.00	1241
GAL138	Galveston Bay	723	128	29.0188	-95.2063	1.0000	1.00	7310
GAL139	Galveston Bay	723	129	29.0188	-95.2049	1.0000	1.00	3606
GAL140	Galveston Bay	723	138	29.0174	-95.2090	1.0000	1.00	4536
GAL141	Galveston Bay	723	139	29.0174	-95.2076	1.0000	1.00	1164
GAL142	Galveston Bay	723	140	29.0174	-95.2063	1.0000	1.00	1125
GAL143	Galveston Bay	724	1	29.0326	-95.1993	1.0000	1.00	6680
GAL144	Galveston Bay	724	2	29.0326	-95.1979	1.0000	1.00	6968
GAL145	Galveston Bay	724	3	29.0326	-95.1965	1.0000	1.00	7171

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
GAL146	Galveston Bay	724	13	29.0313	-95.1993	1.0000	1.00	5967

Table 45. Probabilistically-selected coordinate sets for East Matagorda Bay.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
EM01	East Matagorda Bay	12	36	28.7799	-95.6674	0.5792	1.73	126
EM02	East Matagorda Bay	13	1	28.7826	-95.6660	0.5792	1.73	2176
EM03	East Matagorda Bay	13	38	28.7785	-95.6646	0.5792	1.73	3649
EM04	East Matagorda Bay	18	87	28.7563	-95.7965	0.5792	1.73	9499
EM05	East Matagorda Bay	27	28	28.7465	-95.8785	0.5792	1.73	9606
EM06	East Matagorda Bay	27	40	28.7451	-95.8785	0.5792	1.73	8292
EM07	East Matagorda Bay	27	64	28.7424	-95.8785	0.5792	1.73	9712
EM08	East Matagorda Bay	27	80	28.7410	-95.8729	0.5792	1.73	7237
EM09	East Matagorda Bay	32	36	28.7465	-95.7840	0.5792	1.73	3055
EM10	East Matagorda Bay	33	26	28.7465	-95.7813	0.5792	1.73	352
EM11	East Matagorda Bay	33	47	28.7451	-95.7688	0.5792	1.73	6901
EM12	East Matagorda Bay	34	21	28.7479	-95.7549	0.5792	1.73	7014
EM13	East Matagorda Bay	34	30	28.7465	-95.7590	0.5792	1.73	6747
EM14	East Matagorda Bay	35	99	28.7382	-95.7465	0.5792	1.73	3790
EM15	East Matagorda Bay	37	116	28.7368	-95.7063	0.5792	1.73	4182
EM16	East Matagorda Bay	37	117	28.7368	-95.7049	0.5792	1.73	5506
EM17	East Matagorda Bay	38	88	28.7396	-95.6951	0.5792	1.73	7532
EM18	East Matagorda Bay	41	105	28.7215	-95.9215	0.5792	1.73	3978
EM19	East Matagorda Bay	43	6	28.7326	-95.8757	0.5792	1.73	719
EM20	East Matagorda Bay	43	9	28.7326	-95.8715	0.5792	1.73	9351
EM21	East Matagorda Bay	52	84	28.7243	-95.7174	0.5792	1.73	9608
EM22	East Matagorda Bay	52	113	28.7201	-95.7271	0.5792	1.73	1875
EM23	East Matagorda Bay	52	114	28.7201	-95.7257	0.5792	1.73	1900
EM24	East Matagorda Bay	52	121	28.7188	-95.7326	0.5792	1.73	4464
EM25	East Matagorda Bay	52	123	28.7188	-95.7299	0.5792	1.73	5688
EM26	East Matagorda Bay	53	18	28.7313	-95.7090	0.5792	1.73	5424
EM27	East Matagorda Bay	53	29	28.7299	-95.7104	0.5792	1.73	377
EM28	East Matagorda Bay	53	63	28.7257	-95.7132	0.5792	1.73	5766
EM29	East Matagorda Bay	53	66	28.7257	-95.7090	0.5792	1.73	8450
EM30	East Matagorda Bay	65	132	28.7021	-95.7674	0.5792	1.73	5599
EM31	East Matagorda Bay	66	90	28.7063	-95.7590	0.5792	1.73	6829
EM32	East Matagorda Bay	66	99	28.7049	-95.7632	0.5792	1.73	9904
EM33	East Matagorda Bay	66	101	28.7049	-95.7604	0.5792	1.73	1655
EM34	East Matagorda Bay	67	40	28.7118	-95.7451	0.5792	1.73	3938

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
EM35	East Matagorda Bay	76	117	28.6868	-95.8049	0.5792	1.73	7168
EM36	East Matagorda Bay	76	118	28.6868	-95.8035	0.5792	1.73	9678
EM37	East Matagorda Bay	76	126	28.6854	-95.8090	0.5792	1.73	20
EM38	East Matagorda Bay	76	135	28.6840	-95.8132	0.5792	1.73	25
EM39	East Matagorda Bay	76	136	28.6840	-95.8118	0.5792	1.73	9161
EM40	East Matagorda Bay	77	35	28.6965	-95.7854	0.5792	1.73	6504
EM41	East Matagorda Bay	77	44	28.6951	-95.7896	0.5792	1.73	4642
EM42	East Matagorda Bay	77	45	28.6951	-95.7882	0.5792	1.73	971
EM43	East Matagorda Bay	77	88	28.6896	-95.7951	0.5792	1.73	6119
EM44	East Matagorda Bay	78	9	28.6993	-95.7715	0.5792	1.73	7755
EM45	East Matagorda Bay	78	10	28.6993	-95.7701	0.5792	1.73	9605
EM46	East Matagorda Bay	78	25	28.6965	-95.7826	0.5792	1.73	3457
EM47	East Matagorda Bay	78	62	28.6924	-95.7813	0.5792	1.73	2950
EM48	East Matagorda Bay	87	83	28.6743	-95.8354	0.5792	1.73	287
EM49	East Matagorda Bay	87	130	28.6688	-95.8368	0.5792	1.73	2135
EM50	East Matagorda Bay	87	131	28.6688	-95.8354	0.5792	1.73	5556
EM51	East Matagorda Bay	87	143	28.6674	-95.8354	0.5792	1.73	8793
EM52	East Matagorda Bay	88	12	28.6826	-95.8174	0.5792	1.73	5906
EM53	East Matagorda Bay	88	23	28.6813	-95.8188	0.5792	1.73	5773
EM54	East Matagorda Bay	88	52	28.6771	-95.8285	0.5792	1.73	4832
EM55	East Matagorda Bay	88	62	28.6757	-95.8313	0.5792	1.73	9008
EM56	East Matagorda Bay	90	129	28.6521	-95.9549	0.5792	1.73	4471
EM57	East Matagorda Bay	91	38	28.6618	-95.9479	0.5792	1.73	1280
EM58	East Matagorda Bay	95	130	28.6521	-95.8701	0.5792	1.73	4394
EM59	East Matagorda Bay	96	56	28.6604	-95.8563	0.5792	1.73	9837
EM60	East Matagorda Bay	96	66	28.6590	-95.8590	0.5792	1.73	4810
EM61	East Matagorda Bay	96	73	28.6576	-95.8660	0.5792	1.73	441
EM62	East Matagorda Bay	97	15	28.6646	-95.8465	0.5792	1.73	8941
EM63	East Matagorda Bay	98	7	28.6493	-95.9576	0.5792	1.73	6358
EM64	East Matagorda Bay	103	8	28.6493	-95.8729	0.5792	1.73	6527
EM65	East Matagorda Bay	104	14	28.6313	-95.9646	0.5792	1.73	7289
EM66	East Matagorda Bay	104	19	28.6313	-95.9576	0.5792	1.73	1543
EM67	East Matagorda Bay	104	20	28.6313	-95.9563	0.5792	1.73	3745
EM68	East Matagorda Bay	104	29	28.6299	-95.9604	0.5792	1.73	2611
EM69	East Matagorda Bay	104	106	28.6215	-95.9535	0.5792	1.73	2106
EM70	East Matagorda Bay	104	107	28.6215	-95.9521	0.5792	1.73	4285
EM71	East Matagorda Bay	105	109	28.6201	-95.9493	0.5792	1.73	7057
EM72	East Matagorda Bay	105	124	28.6188	-95.9451	0.5792	1.73	2609
EM73	East Matagorda Bay	108	17	28.7979	-95.5938	0.5792	1.73	134
EM74	East Matagorda Bay	108	30	28.7965	-95.5924	0.5792	1.73	6321
EM75	East Matagorda Bay	109	16	28.7979	-95.5785	0.5792	1.73	1626

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
EM76	East Matagorda Bay	12	24	28.7813	-95.6674	0.5792	1.73	3091
EM77	East Matagorda Bay	13	26	28.7799	-95.6646	0.5792	1.73	9600
EM78	East Matagorda Bay	13	28	28.7799	-95.6618	0.5792	1.73	7278
EM79	East Matagorda Bay	13	40	28.7785	-95.6618	0.5792	1.73	3974
EM80	East Matagorda Bay	13	53	28.7771	-95.6604	0.5792	1.73	5001
EM81	East Matagorda Bay	19	76	28.7576	-95.7785	0.5792	1.73	5740
EM82	East Matagorda Bay	23	128	28.7521	-95.6896	0.5792	1.73	5562
EM83	East Matagorda Bay	27	21	28.7479	-95.8715	0.5792	1.73	3971
EM84	East Matagorda Bay	27	52	28.7438	-95.8785	0.5792	1.73	9379
EM85	East Matagorda Bay	27	79	28.7410	-95.8743	0.5792	1.73	7558
EM86	East Matagorda Bay	27	138	28.7340	-95.8757	0.5792	1.73	8460
EM87	East Matagorda Bay	27	140	28.7340	-95.8729	0.5792	1.73	4622
EM88	East Matagorda Bay	31	40	28.7451	-95.8118	0.5792	1.73	9397
EM89	East Matagorda Bay	31	44	28.7451	-95.8063	0.5792	1.73	6905
EM90	East Matagorda Bay	32	15	28.7479	-95.7965	0.5792	1.73	7982
EM91	East Matagorda Bay	34	40	28.7451	-95.7618	0.5792	1.73	8413
EM92	East Matagorda Bay	36	98	28.7382	-95.7313	0.5792	1.73	4041
EM93	East Matagorda Bay	43	20	28.7313	-95.8729	0.5792	1.73	3100
EM94	East Matagorda Bay	51	143	28.7174	-95.7354	0.5792	1.73	4458
EM95	East Matagorda Bay	52	95	28.7229	-95.7188	0.5792	1.73	1128
EM96	East Matagorda Bay	52	112	28.7201	-95.7285	0.5792	1.73	5341
EM97	East Matagorda Bay	52	122	28.7188	-95.7313	0.5792	1.73	2522
EM98	East Matagorda Bay	65	143	28.7007	-95.7688	0.5792	1.73	6276
EM99	East Matagorda Bay	66	71	28.7090	-95.7521	0.5792	1.73	6955
EM100	East Matagorda Bay	66	89	28.7063	-95.7604	0.5792	1.73	3236
EM101	East Matagorda Bay	67	10	28.7160	-95.7368	0.5792	1.73	5025
EM102	East Matagorda Bay	67	30	28.7132	-95.7424	0.5792	1.73	170
EM103	East Matagorda Bay	67	39	28.7118	-95.7465	0.5792	1.73	8523
EM104	East Matagorda Bay	67	50	28.7104	-95.7479	0.5792	1.73	9090
EM105	East Matagorda Bay	67	51	28.7104	-95.7465	0.5792	1.73	1551
EM106	East Matagorda Bay	67	62	28.7090	-95.7479	0.5792	1.73	1347
EM107	East Matagorda Bay	76	70	28.6924	-95.8035	0.5792	1.73	850
EM108	East Matagorda Bay	77	99	28.6882	-95.7965	0.5792	1.73	9781
EM109	East Matagorda Bay	77	100	28.6882	-95.7951	0.5792	1.73	2846
EM110	East Matagorda Bay	78	26	28.6965	-95.7813	0.5792	1.73	4092
EM111	East Matagorda Bay	78	27	28.6965	-95.7799	0.5792	1.73	8443
EM112	East Matagorda Bay	78	30	28.6965	-95.7757	0.5792	1.73	3684
EM113	East Matagorda Bay	87	119	28.6701	-95.8354	0.5792	1.73	6691
EM114	East Matagorda Bay	87	132	28.6688	-95.8340	0.5792	1.73	4612
EM115	East Matagorda Bay	87	141	28.6674	-95.8382	0.5792	1.73	3844
EM116	East Matagorda Bay	87	144	28.6674	-95.8340	0.5792	1.73	2986

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
EM117	East Matagorda Bay	89	16	28.6813	-95.8118	0.5792	1.73	4877
EM118	East Matagorda Bay	89	18	28.6813	-95.8090	0.5792	1.73	4614
EM119	East Matagorda Bay	89	30	28.6799	-95.8090	0.5792	1.73	9028
EM120	East Matagorda Bay	90	117	28.6535	-95.9549	0.5792	1.73	1928
EM121	East Matagorda Bay	91	29	28.6632	-95.9438	0.5792	1.73	4864
EM122	East Matagorda Bay	91	50	28.6604	-95.9479	0.5792	1.73	6665
EM123	East Matagorda Bay	95	96	28.6563	-95.8674	0.5792	1.73	7299
EM124	East Matagorda Bay	95	106	28.6549	-95.8701	0.5792	1.73	3582
EM125	East Matagorda Bay	95	129	28.6521	-95.8715	0.5792	1.73	1321
EM126	East Matagorda Bay	95	136	28.6507	-95.8785	0.5792	1.73	5855
EM127	East Matagorda Bay	95	138	28.6507	-95.8757	0.5792	1.73	7066
EM128	East Matagorda Bay	96	24	28.6646	-95.8507	0.5792	1.73	9891
EM129	East Matagorda Bay	96	46	28.6618	-95.8535	0.5792	1.73	4293
EM130	East Matagorda Bay	96	65	28.6590	-95.8604	0.5792	1.73	7193
EM131	East Matagorda Bay	96	67	28.6590	-95.8576	0.5792	1.73	4585
EM132	East Matagorda Bay	97	11	28.6660	-95.8354	0.5792	1.73	8265
EM133	East Matagorda Bay	98	43	28.6451	-95.9576	0.5792	1.73	5606
EM134	East Matagorda Bay	98	92	28.6396	-95.9563	0.5792	1.73	1915
EM135	East Matagorda Bay	103	3	28.6493	-95.8799	0.5792	1.73	2341
EM136	East Matagorda Bay	103	7	28.6493	-95.8743	0.5792	1.73	7336
EM137	East Matagorda Bay	103	12	28.6493	-95.8674	0.5792	1.73	2575
EM138	East Matagorda Bay	104	17	28.6313	-95.9604	0.5792	1.73	8978
EM139	East Matagorda Bay	104	26	28.6299	-95.9646	0.5792	1.73	8437
EM140	East Matagorda Bay	104	28	28.6299	-95.9618	0.5792	1.73	7456
EM141	East Matagorda Bay	104	30	28.6299	-95.9590	0.5792	1.73	7852
EM142	East Matagorda Bay	104	120	28.6201	-95.9507	0.5792	1.73	8045
EM143	East Matagorda Bay	105	110	28.6201	-95.9479	0.5792	1.73	9525
EM144	East Matagorda Bay	105	123	28.6188	-95.9465	0.5792	1.73	7179
EM145	East Matagorda Bay	106	59	28.6271	-95.9188	0.5792	1.73	6197
EM146	East Matagorda Bay	108	11	28.7993	-95.5854	0.5792	1.73	2165
EM147	East Matagorda Bay	108	14	28.7979	-95.5979	0.5792	1.73	3534
EM148	East Matagorda Bay	108	20	28.7979	-95.5896	0.5792	1.73	8776
EM149	East Matagorda Bay	109	4	28.7993	-95.5785	0.5792	1.73	7825
EM150	East Matagorda Bay	109	17	28.7979	-95.5771	0.5792	1.73	8865

Table 46. Probabilistically-selected coordinate sets for West Matagorda Bay.
Only 81 coordinate sets are available based on seagrass coverage. Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
WM1	West Matagorda Bay	103	32	28.6799	-95.9896	1.0000	1.00	5445
WM2	West Matagorda Bay	170	44	28.6451	-95.9563	1.0000	1.00	4977
WM3	West Matagorda Bay	170	79	28.6410	-95.9576	1.0000	1.00	8375
WM4	West Matagorda Bay	450	22	28.4979	-96.2368	1.0000	1.00	6368
WM5	West Matagorda Bay	450	23	28.4979	-96.2354	1.0000	1.00	5028
WM6	West Matagorda Bay	450	34	28.4965	-96.2368	1.0000	1.00	6264
WM7	West Matagorda Bay	450	46	28.4951	-96.2368	1.0000	1.00	5368
WM8	West Matagorda Bay	450	48	28.4951	-96.2340	1.0000	1.00	7878
WM9	West Matagorda Bay	450	58	28.4938	-96.2368	1.0000	1.00	1033
WM10	West Matagorda Bay	450	59	28.4938	-96.2354	1.0000	1.00	3860
WM11	West Matagorda Bay	450	81	28.4910	-96.2382	1.0000	1.00	1315
WM12	West Matagorda Bay	450	91	28.4896	-96.2410	1.0000	1.00	9134
WM13	West Matagorda Bay	450	93	28.4896	-96.2382	1.0000	1.00	7546
WM14	West Matagorda Bay	450	113	28.4868	-96.2438	1.0000	1.00	8370
WM15	West Matagorda Bay	457	4	28.4826	-96.4451	1.0000	1.00	399
WM16	West Matagorda Bay	457	15	28.4813	-96.4465	1.0000	1.00	2888
WM17	West Matagorda Bay	457	28	28.4799	-96.4451	1.0000	1.00	4156
WM18	West Matagorda Bay	457	58	28.4771	-96.4368	1.0000	1.00	2362
WM19	West Matagorda Bay	457	59	28.4771	-96.4354	1.0000	1.00	4394
WM20	West Matagorda Bay	457	71	28.4757	-96.4354	1.0000	1.00	1356
WM21	West Matagorda Bay	457	72	28.4757	-96.4340	1.0000	1.00	6442
WM22	West Matagorda Bay	457	82	28.4743	-96.4368	1.0000	1.00	6068
WM23	West Matagorda Bay	457	95	28.4729	-96.4354	1.0000	1.00	264
WM24	West Matagorda Bay	458	61	28.4757	-96.4326	1.0000	1.00	1156
WM25	West Matagorda Bay	458	98	28.4715	-96.4313	1.0000	1.00	7457
WM26	West Matagorda Bay	466	141	28.4674	-96.2882	1.0000	1.00	12
WM27	West Matagorda Bay	467	102	28.4715	-96.2757	1.0000	1.00	6845
WM28	West Matagorda Bay	467	103	28.4715	-96.2743	1.0000	1.00	3184
WM29	West Matagorda Bay	467	113	28.4701	-96.2771	1.0000	1.00	4218
WM30	West Matagorda Bay	467	114	28.4701	-96.2757	1.0000	1.00	4678
WM31	West Matagorda Bay	467	115	28.4701	-96.2743	1.0000	1.00	7054
WM32	West Matagorda Bay	467	116	28.4701	-96.2729	1.0000	1.00	2242
WM33	West Matagorda Bay	467	128	28.4688	-96.2729	1.0000	1.00	3284
WM34	West Matagorda Bay	468	27	28.4799	-96.2632	1.0000	1.00	4470

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
WM35	West Matagorda Bay	477	30	28.4632	-96.2924	1.0000	1.00	2183
WM36	West Matagorda Bay	477	43	28.4618	-96.2910	1.0000	1.00	3697
WM37	West Matagorda Bay	477	44	28.4618	-96.2896	1.0000	1.00	31
WM38	West Matagorda Bay	485	17	28.4313	-96.4104	1.0000	1.00	976
WM39	West Matagorda Bay	485	38	28.4285	-96.4146	1.0000	1.00	2625
WM40	West Matagorda Bay	485	39	28.4285	-96.4132	1.0000	1.00	7628
WM41	West Matagorda Bay	485	49	28.4271	-96.4160	1.0000	1.00	3909
WM42	West Matagorda Bay	485	119	28.4201	-96.4021	1.0000	1.00	2138
WM43	West Matagorda Bay	485	123	28.4188	-96.4132	1.0000	1.00	1340
WM44	West Matagorda Bay	485	124	28.4188	-96.4118	1.0000	1.00	2136
WM45	West Matagorda Bay	485	125	28.4188	-96.4104	1.0000	1.00	8562
WM46	West Matagorda Bay	485	132	28.4188	-96.4007	1.0000	1.00	2558
WM47	West Matagorda Bay	485	133	28.4174	-96.4160	1.0000	1.00	8790
WM48	West Matagorda Bay	485	134	28.4174	-96.4146	1.0000	1.00	2522
WM49	West Matagorda Bay	485	136	28.4174	-96.4118	1.0000	1.00	2559
WM50	West Matagorda Bay	485	144	28.4174	-96.4007	1.0000	1.00	8085
WM51	West Matagorda Bay	488	106	28.4215	-96.3535	1.0000	1.00	2441
WM52	West Matagorda Bay	488	117	28.4201	-96.3549	1.0000	1.00	9467
WM53	West Matagorda Bay	488	128	28.4188	-96.3563	1.0000	1.00	5799
WM54	West Matagorda Bay	489	40	28.4285	-96.3451	1.0000	1.00	4798
WM55	West Matagorda Bay	491	1	28.4160	-96.4160	1.0000	1.00	3983
WM56	West Matagorda Bay	491	2	28.4160	-96.4146	1.0000	1.00	7600
WM57	West Matagorda Bay	491	12	28.4160	-96.4007	1.0000	1.00	6810
WM58	West Matagorda Bay	491	24	28.4146	-96.4007	1.0000	1.00	8170
WM59	West Matagorda Bay	491	71	28.4090	-96.4021	1.0000	1.00	9049
WM60	West Matagorda Bay	493	71	28.4090	-96.3688	1.0000	1.00	6428
WM61	West Matagorda Bay	493	72	28.4090	-96.3674	1.0000	1.00	9456
WM62	West Matagorda Bay	493	82	28.4076	-96.3701	1.0000	1.00	5523
WM63	West Matagorda Bay	493	83	28.4076	-96.3688	1.0000	1.00	2283
WM64	West Matagorda Bay	493	126	28.4021	-96.3757	1.0000	1.00	8010
WM65	West Matagorda Bay	498	61	28.3757	-96.4160	1.0000	1.00	5485
WM66	West Matagorda Bay	498	87	28.3729	-96.4132	1.0000	1.00	4923
WM67	West Matagorda Bay	498	97	28.3715	-96.4160	1.0000	1.00	5640
WM68	West Matagorda Bay	498	98	28.3715	-96.4146	1.0000	1.00	5766
WM69	West Matagorda Bay	498	99	28.3715	-96.4132	1.0000	1.00	5333
WM70	West Matagorda Bay	531	130	28.6688	-95.9535	1.0000	1.00	463
WM71	West Matagorda Bay	134	128	28.6521	-95.9563	1.0000	1.00	7994
WM72	West Matagorda Bay	450	47	28.4951	-96.2354	1.0000	1.00	7135
WM73	West Matagorda Bay	450	92	28.4896	-96.2396	1.0000	1.00	9004
WM74	West Matagorda Bay	457	70	28.4757	-96.4368	1.0000	1.00	4796
WM75	West Matagorda Bay	457	83	28.4743	-96.4354	1.0000	1.00	63

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
WM76	West Matagorda Bay	467	90	28.4729	-96.2757	1.0000	1.00	2444
WM77	West Matagorda Bay	468	28	28.4799	-96.2618	1.0000	1.00	5457
WM78	West Matagorda Bay	485	50	28.4271	-96.4146	1.0000	1.00	9618
WM79	West Matagorda Bay	485	135	28.4174	-96.4132	1.0000	1.00	6172
WM80	West Matagorda Bay	491	59	28.4104	-96.4021	1.0000	1.00	3605
WM81	West Matagorda Bay	491	83	28.4076	-96.4021	1.0000	1.00	6807

Table 47. Probabilistically-selected coordinate sets for Aransas Bay.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
AR01	Aransas Bay	34	64	28.1924	-96.9451	0.0425	23.54	5061
AR02	Aransas Bay	34	132	28.1854	-96.9340	0.0425	23.54	6387
AR03	Aransas Bay	38	86	28.1896	-96.8479	0.0425	23.54	6282
AR04	Aransas Bay	51	32	28.1799	-96.9396	0.0425	23.54	414
AR05	Aransas Bay	51	83	28.1743	-96.9354	0.0425	23.54	3073
AR06	Aransas Bay	54	114	28.1701	-96.8757	0.0425	23.54	2813
AR07	Aransas Bay	71	97	28.1549	-97.0160	0.0425	23.54	1311
AR08	Aransas Bay	85	131	28.1354	-97.1688	0.0425	23.54	1545
AR09	Aransas Bay	101	18	28.1479	-96.9090	0.0425	23.54	4720
AR10	Aransas Bay	101	54	28.1438	-96.9090	0.0425	23.54	1281
AR11	Aransas Bay	107	40	28.1451	-96.8118	0.0425	23.54	5846
AR12	Aransas Bay	125	96	28.1229	-96.9340	0.0425	23.54	3921
AR13	Aransas Bay	127	121	28.1188	-96.9160	0.0425	23.54	6359
AR14	Aransas Bay	130	131	28.1188	-96.8521	0.0425	23.54	5791
AR15	Aransas Bay	155	73	28.1076	-96.8826	0.0425	23.54	4759
AR16	Aransas Bay	155	75	28.1076	-96.8799	0.0425	23.54	4002
AR17	Aransas Bay	155	86	28.1063	-96.8813	0.0425	23.54	4650
AR18	Aransas Bay	177	102	28.0882	-96.9257	0.0425	23.54	1791
AR19	Aransas Bay	184	56	28.0771	-97.2396	0.0425	23.54	4474
AR20	Aransas Bay	212	112	28.0535	-97.1785	0.0425	23.54	3167
AR21	Aransas Bay	213	142	28.0507	-97.1535	0.0425	23.54	3330
AR22	Aransas Bay	215	90	28.0563	-97.1257	0.0425	23.54	3983
AR23	Aransas Bay	215	115	28.0535	-97.1243	0.0425	23.54	6286
AR24	Aransas Bay	232	20	28.0479	-97.1563	0.0425	23.54	2336
AR25	Aransas Bay	232	77	28.0410	-97.1604	0.0425	23.54	9287
AR26	Aransas Bay	246	59	28.0271	-97.1521	0.0425	23.54	6978
AR27	Aransas Bay	246	143	28.0174	-97.1521	0.0425	23.54	6291
AR28	Aransas Bay	247	53	28.0271	-97.1438	0.0425	23.54	4376
AR29	Aransas Bay	260	93	28.0063	-97.1549	0.0425	23.54	4753
AR30	Aransas Bay	261	50	28.0104	-97.1479	0.0425	23.54	3695
AR31	Aransas Bay	268	6	28.0160	-96.9590	0.0425	23.54	8888
AR32	Aransas Bay	274	135	27.9840	-97.0799	0.0425	23.54	1580
AR33	Aransas Bay	280	51	27.9938	-96.9799	0.0425	23.54	677
AR34	Aransas Bay	280	136	27.9840	-96.9785	0.0425	23.54	1103
AR35	Aransas Bay	282	107	27.9715	-97.1854	0.0425	23.54	8193
AR36	Aransas Bay	283	76	27.9743	-97.1785	0.0425	23.54	5235
AR37	Aransas Bay	294	95	27.9563	-97.0854	0.0425	23.54	7640
AR38	Aransas Bay	294	138	27.9507	-97.0924	0.0425	23.54	8057
AR39	Aransas Bay	295	80	27.9576	-97.0729	0.0425	23.54	3523
AR40	Aransas Bay	303	61	27.9424	-97.0993	0.0425	23.54	7218
AR41	Aransas Bay	303	76	27.9410	-97.0951	0.0425	23.54	5893
AR42	Aransas Bay	303	97	27.9382	-97.0993	0.0425	23.54	8600
AR43	Aransas Bay	304	17	27.9479	-97.0771	0.0425	23.54	3829

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
AR44	Aransas Bay	307	71	27.9424	-97.0188	0.0425	23.54	8313
AR45	Aransas Bay	308	84	27.9410	-97.0007	0.0425	23.54	6113
AR46	Aransas Bay	310	120	27.9201	-97.1174	0.0425	23.54	6709
AR47	Aransas Bay	311	143	27.9174	-97.1021	0.0425	23.54	4679
AR48	Aransas Bay	312	128	27.9188	-97.0896	0.0425	23.54	79
AR49	Aransas Bay	312	144	27.9174	-97.0840	0.0425	23.54	6027
AR50	Aransas Bay	313	51	27.9271	-97.0799	0.0425	23.54	3990
AR51	Aransas Bay	313	123	27.9188	-97.0799	0.0425	23.54	7110
AR52	Aransas Bay	315	31	27.9299	-97.0410	0.0425	23.54	3045
AR53	Aransas Bay	319	20	27.9146	-97.1229	0.0425	23.54	7944
AR54	Aransas Bay	319	69	27.9090	-97.1215	0.0425	23.54	3821
AR55	Aransas Bay	319	116	27.9035	-97.1229	0.0425	23.54	7403
AR56	Aransas Bay	319	138	27.9007	-97.1257	0.0425	23.54	1007
AR57	Aransas Bay	320	11	27.9160	-97.1021	0.0425	23.54	2711
AR58	Aransas Bay	320	25	27.9132	-97.1160	0.0425	23.54	6646
AR59	Aransas Bay	320	28	27.9132	-97.1118	0.0425	23.54	6196
AR60	Aransas Bay	320	30	27.9132	-97.1090	0.0425	23.54	5407
AR61	Aransas Bay	321	17	27.9146	-97.0938	0.0425	23.54	9225
AR62	Aransas Bay	321	26	27.9132	-97.0979	0.0425	23.54	6746
AR63	Aransas Bay	321	94	27.9063	-97.0868	0.0425	23.54	8338
AR64	Aransas Bay	322	81	27.9076	-97.0715	0.0425	23.54	2360
AR65	Aransas Bay	322	117	27.9035	-97.0715	0.0425	23.54	2789
AR66	Aransas Bay	322	121	27.9021	-97.0826	0.0425	23.54	4557
AR67	Aransas Bay	327	142	27.8840	-97.1368	0.0425	23.54	3309
AR68	Aransas Bay	328	2	27.8993	-97.1313	0.0425	23.54	7185
AR69	Aransas Bay	328	134	27.8840	-97.1313	0.0425	23.54	6723
AR70	Aransas Bay	330	16	27.8979	-97.0951	0.0425	23.54	6204
AR71	Aransas Bay	330	119	27.8868	-97.0854	0.0425	23.54	4693
AR72	Aransas Bay	331	106	27.8882	-97.0701	0.0425	23.54	258
AR73	Aransas Bay	333	54	27.8938	-97.0424	0.0425	23.54	8140
AR74	Aransas Bay	337	86	27.8729	-97.0979	0.0425	23.54	5909
AR75	Aransas Bay	343	2	27.8660	-97.0646	0.0425	23.54	5952
AR76	Aransas Bay	13	65	28.2257	-96.9604	0.0425	23.54	3394
AR77	Aransas Bay	16	71	28.2257	-96.8188	0.0425	23.54	9215
AR78	Aransas Bay	16	83	28.2243	-96.8188	0.0425	23.54	9609
AR79	Aransas Bay	23	93	28.2063	-96.9549	0.0425	23.54	1820
AR80	Aransas Bay	35	109	28.1868	-96.9326	0.0425	23.54	8706
AR81	Aransas Bay	37	130	28.1854	-96.8535	0.0425	23.54	3134
AR82	Aransas Bay	37	141	28.1840	-96.8549	0.0425	23.54	9339
AR83	Aransas Bay	47	71	28.1757	-97.0188	0.0425	23.54	5734
AR84	Aransas Bay	54	81	28.1743	-96.8715	0.0425	23.54	8440
AR85	Aransas Bay	55	29	28.1799	-96.8604	0.0425	23.54	5813
AR86	Aransas Bay	77	18	28.1646	-96.8757	0.0425	23.54	3879
AR87	Aransas Bay	86	141	28.1340	-97.1549	0.0425	23.54	8394
AR88	Aransas Bay	101	121	28.1354	-96.9160	0.0425	23.54	6500
AR89	Aransas Bay	103	139	28.1340	-96.8743	0.0425	23.54	4053
AR90	Aransas Bay	122	71	28.1257	-96.9854	0.0425	23.54	8147

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
AR91	Aransas Bay	126	144	28.1174	-96.9174	0.0425	23.54	4477
AR92	Aransas Bay	136	35	28.1132	-97.1854	0.0425	23.54	5175
AR93	Aransas Bay	152	30	28.1132	-96.9257	0.0425	23.54	8776
AR94	Aransas Bay	182	22	28.0979	-96.8368	0.0425	23.54	6375
AR95	Aransas Bay	212	98	28.0549	-97.1813	0.0425	23.54	6893
AR96	Aransas Bay	214	133	28.0507	-97.1493	0.0425	23.54	1616
AR97	Aransas Bay	215	117	28.0535	-97.1215	0.0425	23.54	1567
AR98	Aransas Bay	232	10	28.0493	-97.1535	0.0425	23.54	2855
AR99	Aransas Bay	260	32	28.0132	-97.1563	0.0425	23.54	5385
AR100	Aransas Bay	267	82	28.0076	-96.9701	0.0425	23.54	8296
AR101	Aransas Bay	268	7	28.0160	-96.9576	0.0425	23.54	7108
AR102	Aransas Bay	269	7	28.0160	-96.9410	0.0425	23.54	9055
AR103	Aransas Bay	275	29	27.9965	-97.0604	0.0425	23.54	6591
AR104	Aransas Bay	280	33	27.9965	-96.9715	0.0425	23.54	8947
AR105	Aransas Bay	285	74	27.9743	-97.0813	0.0425	23.54	4148
AR106	Aransas Bay	285	110	27.9701	-97.0813	0.0425	23.54	2282
AR107	Aransas Bay	294	46	27.9618	-97.0868	0.0425	23.54	1399
AR108	Aransas Bay	294	55	27.9604	-97.0910	0.0425	23.54	1160
AR109	Aransas Bay	294	81	27.9576	-97.0882	0.0425	23.54	7609
AR110	Aransas Bay	294	135	27.9507	-97.0965	0.0425	23.54	8116
AR111	Aransas Bay	294	140	27.9507	-97.0896	0.0425	23.54	6392
AR112	Aransas Bay	295	99	27.9549	-97.0799	0.0425	23.54	826
AR113	Aransas Bay	295	121	27.9521	-97.0826	0.0425	23.54	3396
AR114	Aransas Bay	295	137	27.9507	-97.0771	0.0425	23.54	9243
AR115	Aransas Bay	302	47	27.9451	-97.1021	0.0425	23.54	7319
AR116	Aransas Bay	302	104	27.9382	-97.1063	0.0425	23.54	759
AR117	Aransas Bay	302	144	27.9340	-97.1007	0.0425	23.54	608
AR118	Aransas Bay	303	99	27.9382	-97.0965	0.0425	23.54	9988
AR119	Aransas Bay	303	102	27.9382	-97.0924	0.0425	23.54	5576
AR120	Aransas Bay	303	123	27.9354	-97.0965	0.0425	23.54	7582
AR121	Aransas Bay	304	5	27.9493	-97.0771	0.0425	23.54	3078
AR122	Aransas Bay	306	108	27.9382	-97.0340	0.0425	23.54	5220
AR123	Aransas Bay	307	69	27.9424	-97.0215	0.0425	23.54	7843
AR124	Aransas Bay	311	65	27.9257	-97.1104	0.0425	23.54	103
AR125	Aransas Bay	313	88	27.9229	-97.0785	0.0425	23.54	9731
AR126	Aransas Bay	319	9	27.9160	-97.1215	0.0425	23.54	550
AR127	Aransas Bay	319	93	27.9063	-97.1215	0.0425	23.54	6127
AR128	Aransas Bay	319	130	27.9021	-97.1201	0.0425	23.54	2589
AR129	Aransas Bay	320	29	27.9132	-97.1104	0.0425	23.54	2151
AR130	Aransas Bay	320	116	27.9035	-97.1063	0.0425	23.54	5005
AR131	Aransas Bay	320	122	27.9021	-97.1146	0.0425	23.54	2961

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
AR132	Aransas Bay	321	27	27.9132	-97.0965	0.0425	23.54	3671
AR133	Aransas Bay	321	33	27.9132	-97.0882	0.0425	23.54	2192
AR134	Aransas Bay	321	34	27.9132	-97.0868	0.0425	23.54	347
AR135	Aransas Bay	321	117	27.9035	-97.0882	0.0425	23.54	2907
AR136	Aransas Bay	322	110	27.9035	-97.0813	0.0425	23.54	9797
AR137	Aransas Bay	323	127	27.9021	-97.0576	0.0425	23.54	1590
AR138	Aransas Bay	327	84	27.8910	-97.1340	0.0425	23.54	6449
AR139	Aransas Bay	328	79	27.8910	-97.1243	0.0425	23.54	9065
AR140	Aransas Bay	330	18	27.8979	-97.0924	0.0425	23.54	8324
AR141	Aransas Bay	330	142	27.8840	-97.0868	0.0425	23.54	1886
AR142	Aransas Bay	331	4	27.8993	-97.0785	0.0425	23.54	5962
AR143	Aransas Bay	332	59	27.8938	-97.0521	0.0425	23.54	229
AR144	Aransas Bay	332	63	27.8924	-97.0632	0.0425	23.54	1440
AR145	Aransas Bay	332	110	27.8868	-97.0646	0.0425	23.54	9266
AR146	Aransas Bay	337	49	27.8771	-97.0993	0.0425	23.54	7574
AR147	Aransas Bay	337	110	27.8701	-97.0979	0.0425	23.54	760
AR148	Aransas Bay	338	103	27.8715	-97.0743	0.0425	23.54	6971
AR149	Aransas Bay	339	44	27.8785	-97.0563	0.0425	23.54	4271
AR150	Aransas Bay	339	115	27.8701	-97.0576	0.0425	23.54	2224

Table 48. Probabilistically-selected coordinate sets for Corpus Christi Bay.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
CC01	Corpus Christi Bay	9	118	27.8701	-97.4535	0.0554	18.05	140
CC02	Corpus Christi Bay	13	73	27.8743	-97.3993	0.0554	18.05	4249
CC03	Corpus Christi Bay	14	84	27.8743	-97.3674	0.0554	18.05	7570
CC04	Corpus Christi Bay	16	1	27.8826	-97.3493	0.0554	18.05	4809
CC05	Corpus Christi Bay	26	96	27.8563	-97.3674	0.0554	18.05	7840
CC06	Corpus Christi Bay	27	112	27.8535	-97.3618	0.0554	18.05	4991
CC07	Corpus Christi Bay	54	96	27.8896	-97.1340	0.0554	18.05	6619
CC08	Corpus Christi Bay	54	118	27.8868	-97.1368	0.0554	18.05	1529
CC09	Corpus Christi Bay	55	128	27.8854	-97.1229	0.0554	18.05	8521
CC10	Corpus Christi Bay	55	141	27.8840	-97.1215	0.0554	18.05	524
CC11	Corpus Christi Bay	56	7	27.8993	-97.1076	0.0554	18.05	9899
CC12	Corpus Christi Bay	56	66	27.8924	-97.1090	0.0554	18.05	9912
CC13	Corpus Christi Bay	63	107	27.8715	-97.1521	0.0554	18.05	3584
CC14	Corpus Christi Bay	64	38	27.8785	-97.1479	0.0554	18.05	141
CC15	Corpus Christi Bay	64	45	27.8785	-97.1382	0.0554	18.05	9283
CC16	Corpus Christi Bay	64	64	27.8757	-97.1451	0.0554	18.05	465
CC17	Corpus Christi Bay	64	130	27.8688	-97.1368	0.0554	18.05	8321
CC18	Corpus Christi Bay	64	133	27.8674	-97.1493	0.0554	18.05	125
CC19	Corpus Christi Bay	65	28	27.8799	-97.1285	0.0554	18.05	1992
CC20	Corpus Christi Bay	66	81	27.8743	-97.1049	0.0554	18.05	8966
CC21	Corpus Christi Bay	66	96	27.8729	-97.1007	0.0554	18.05	6320
CC22	Corpus Christi Bay	67	20	27.8813	-97.0896	0.0554	18.05	2240
CC23	Corpus Christi Bay	67	54	27.8771	-97.0924	0.0554	18.05	280
CC24	Corpus Christi Bay	67	135	27.8674	-97.0965	0.0554	18.05	3784
CC25	Corpus Christi Bay	77	65	27.8590	-97.1604	0.0554	18.05	4161
CC26	Corpus Christi Bay	77	83	27.8576	-97.1521	0.0554	18.05	5818
CC27	Corpus Christi Bay	78	1	27.8660	-97.1493	0.0554	18.05	5524
CC28	Corpus Christi Bay	78	38	27.8618	-97.1479	0.0554	18.05	691
CC29	Corpus Christi Bay	78	69	27.8590	-97.1382	0.0554	18.05	2360
CC30	Corpus Christi Bay	79	143	27.8507	-97.1188	0.0554	18.05	5511
CC31	Corpus Christi Bay	80	7	27.8660	-97.1076	0.0554	18.05	5504
CC32	Corpus Christi Bay	80	114	27.8535	-97.1090	0.0554	18.05	729
CC33	Corpus Christi Bay	80	127	27.8521	-97.1076	0.0554	18.05	5456
CC34	Corpus Christi Bay	92	31	27.8465	-97.1743	0.0554	18.05	8566
CC35	Corpus Christi Bay	92	134	27.8340	-97.1813	0.0554	18.05	561
CC36	Corpus Christi Bay	93	43	27.8451	-97.1576	0.0554	18.05	861
CC37	Corpus Christi Bay	93	88	27.8396	-97.1618	0.0554	18.05	2540
CC38	Corpus Christi Bay	94	17	27.8479	-97.1438	0.0554	18.05	5475
CC39	Corpus Christi Bay	94	33	27.8465	-97.1382	0.0554	18.05	1583
CC40	Corpus Christi Bay	95	23	27.8479	-97.1188	0.0554	18.05	8417
CC41	Corpus Christi Bay	96	45	27.8451	-97.1049	0.0554	18.05	3819

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
CC42	Corpus Christi Bay	96	49	27.8438	-97.1160	0.0554	18.05	6478
CC43	Corpus Christi Bay	111	97	27.8215	-97.2160	0.0554	18.05	6672
CC44	Corpus Christi Bay	116	142	27.8174	-97.1201	0.0554	18.05	5259
CC45	Corpus Christi Bay	117	44	27.8285	-97.1063	0.0554	18.05	4515
CC46	Corpus Christi Bay	136	20	27.8146	-97.1229	0.0554	18.05	475
CC47	Corpus Christi Bay	136	141	27.8007	-97.1215	0.0554	18.05	4099
CC48	Corpus Christi Bay	137	5	27.8160	-97.1104	0.0554	18.05	421
CC49	Corpus Christi Bay	137	18	27.8146	-97.1090	0.0554	18.05	8072
CC50	Corpus Christi Bay	137	21	27.8146	-97.1049	0.0554	18.05	2895
CC51	Corpus Christi Bay	137	90	27.8063	-97.1090	0.0554	18.05	7540
CC52	Corpus Christi Bay	137	93	27.8063	-97.1049	0.0554	18.05	8188
CC53	Corpus Christi Bay	138	52	27.8104	-97.0951	0.0554	18.05	6113
CC54	Corpus Christi Bay	156	11	27.7993	-97.1188	0.0554	18.05	8514
CC55	Corpus Christi Bay	156	23	27.7979	-97.1188	0.0554	18.05	5077
CC56	Corpus Christi Bay	156	129	27.7854	-97.1215	0.0554	18.05	6130
CC57	Corpus Christi Bay	157	52	27.7938	-97.1118	0.0554	18.05	6266
CC58	Corpus Christi Bay	157	62	27.7924	-97.1146	0.0554	18.05	5110
CC59	Corpus Christi Bay	175	75	27.7743	-97.1299	0.0554	18.05	7764
CC60	Corpus Christi Bay	175	91	27.7729	-97.1243	0.0554	18.05	1701
CC61	Corpus Christi Bay	207	47	27.7451	-97.1521	0.0554	18.05	9011
CC62	Corpus Christi Bay	208	26	27.7465	-97.1479	0.0554	18.05	8287
CC63	Corpus Christi Bay	208	41	27.7451	-97.1438	0.0554	18.05	5462
CC64	Corpus Christi Bay	208	109	27.7368	-97.1493	0.0554	18.05	9169
CC65	Corpus Christi Bay	222	1	27.7326	-97.1660	0.0554	18.05	6232
CC66	Corpus Christi Bay	222	27	27.7299	-97.1632	0.0554	18.05	8478
CC67	Corpus Christi Bay	237	49	27.6938	-97.2993	0.0554	18.05	6831
CC68	Corpus Christi Bay	241	118	27.6868	-97.2035	0.0554	18.05	4961
CC69	Corpus Christi Bay	241	143	27.6840	-97.2021	0.0554	18.05	9735
CC70	Corpus Christi Bay	241	144	27.6840	-97.2007	0.0554	18.05	4932
CC71	Corpus Christi Bay	246	117	27.6701	-97.3215	0.0554	18.05	2004
CC72	Corpus Christi Bay	247	78	27.6743	-97.3090	0.0554	18.05	6403
CC73	Corpus Christi Bay	253	60	27.6604	-97.3174	0.0554	18.05	5275
CC74	Corpus Christi Bay	268	139	27.8674	-97.5743	0.0554	18.05	5274
CC75	Corpus Christi Bay	272	12	27.8660	-97.5674	0.0554	18.05	7547
CC76	Corpus Christi Bay	11	129	27.8688	-97.4215	0.0554	18.05	2324
CC77	Corpus Christi Bay	15	23	27.8813	-97.3521	0.0554	18.05	5188
CC78	Corpus Christi Bay	26	11	27.8660	-97.3688	0.0554	18.05	6022
CC79	Corpus Christi Bay	27	13	27.8646	-97.3660	0.0554	18.05	6861
CC80	Corpus Christi Bay	27	25	27.8632	-97.3660	0.0554	18.05	2571
CC81	Corpus Christi Bay	54	114	27.8868	-97.1424	0.0554	18.05	9224
CC82	Corpus Christi Bay	55	16	27.8979	-97.1285	0.0554	18.05	7933
CC83	Corpus Christi Bay	55	88	27.8896	-97.1285	0.0554	18.05	7156
CC84	Corpus Christi Bay	55	91	27.8896	-97.1243	0.0554	18.05	8164
CC85	Corpus Christi Bay	55	106	27.8882	-97.1201	0.0554	18.05	653
CC86	Corpus Christi Bay	55	135	27.8840	-97.1299	0.0554	18.05	2556
CC87	Corpus Christi Bay	56	23	27.8979	-97.1021	0.0554	18.05	3576
CC88	Corpus Christi Bay	56	137	27.8840	-97.1104	0.0554	18.05	683
CC89	Corpus Christi Bay	56	138	27.8840	-97.1090	0.0554	18.05	2121
CC90	Corpus Christi Bay	57	122	27.8688	-97.3313	0.0554	18.05	9387
CC91	Corpus Christi Bay	60	108	27.8715	-97.2674	0.0554	18.05	7784
CC92	Corpus Christi Bay	63	46	27.8785	-97.1535	0.0554	18.05	6713

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
CC93	Corpus Christi Bay	63	91	27.8729	-97.1576	0.0554	18.05	214
CC94	Corpus Christi Bay	63	95	27.8729	-97.1521	0.0554	18.05	3804
CC95	Corpus Christi Bay	63	141	27.8674	-97.1549	0.0554	18.05	5972
CC96	Corpus Christi Bay	64	59	27.8771	-97.1354	0.0554	18.05	3498
CC97	Corpus Christi Bay	64	140	27.8674	-97.1396	0.0554	18.05	7538
CC98	Corpus Christi Bay	66	105	27.8715	-97.1049	0.0554	18.05	2529
CC99	Corpus Christi Bay	67	98	27.8715	-97.0979	0.0554	18.05	4177
CC100	Corpus Christi Bay	67	123	27.8688	-97.0965	0.0554	18.05	9793
CC101	Corpus Christi Bay	77	6	27.8660	-97.1590	0.0554	18.05	5499
CC102	Corpus Christi Bay	77	113	27.8535	-97.1604	0.0554	18.05	7916
CC103	Corpus Christi Bay	77	125	27.8521	-97.1604	0.0554	18.05	445
CC104	Corpus Christi Bay	77	143	27.8507	-97.1521	0.0554	18.05	6929
CC105	Corpus Christi Bay	78	41	27.8618	-97.1438	0.0554	18.05	7234
CC106	Corpus Christi Bay	78	67	27.8590	-97.1410	0.0554	18.05	522
CC107	Corpus Christi Bay	78	81	27.8576	-97.1382	0.0554	18.05	1712
CC108	Corpus Christi Bay	79	119	27.8535	-97.1188	0.0554	18.05	9523
CC109	Corpus Christi Bay	80	31	27.8632	-97.1076	0.0554	18.05	3931
CC110	Corpus Christi Bay	80	98	27.8549	-97.1146	0.0554	18.05	3187
CC111	Corpus Christi Bay	80	137	27.8507	-97.1104	0.0554	18.05	5209
CC112	Corpus Christi Bay	81	63	27.8590	-97.0965	0.0554	18.05	3657
CC113	Corpus Christi Bay	82	34	27.8632	-97.0701	0.0554	18.05	3430
CC114	Corpus Christi Bay	91	54	27.8438	-97.2257	0.0554	18.05	2750
CC115	Corpus Christi Bay	92	21	27.8479	-97.1715	0.0554	18.05	9571
CC116	Corpus Christi Bay	92	54	27.8438	-97.1757	0.0554	18.05	4609
CC117	Corpus Christi Bay	92	71	27.8424	-97.1688	0.0554	18.05	4221
CC118	Corpus Christi Bay	93	77	27.8410	-97.1604	0.0554	18.05	6854
CC119	Corpus Christi Bay	95	69	27.8424	-97.1215	0.0554	18.05	3684
CC120	Corpus Christi Bay	96	7	27.8493	-97.1076	0.0554	18.05	5782
CC121	Corpus Christi Bay	97	25	27.8465	-97.0993	0.0554	18.05	8860
CC122	Corpus Christi Bay	112	111	27.8201	-97.1965	0.0554	18.05	2539
CC123	Corpus Christi Bay	113	30	27.8299	-97.1757	0.0554	18.05	4394
CC124	Corpus Christi Bay	116	141	27.8174	-97.1215	0.0554	18.05	7342
CC125	Corpus Christi Bay	136	69	27.8090	-97.1215	0.0554	18.05	6294
CC126	Corpus Christi Bay	136	118	27.8035	-97.1201	0.0554	18.05	6041
CC127	Corpus Christi Bay	136	130	27.8021	-97.1201	0.0554	18.05	4039
CC128	Corpus Christi Bay	137	30	27.8132	-97.1090	0.0554	18.05	6447
CC129	Corpus Christi Bay	137	40	27.8118	-97.1118	0.0554	18.05	9869
CC130	Corpus Christi Bay	137	89	27.8063	-97.1104	0.0554	18.05	4486
CC131	Corpus Christi Bay	137	111	27.8035	-97.1132	0.0554	18.05	6097
CC132	Corpus Christi Bay	156	96	27.7896	-97.1174	0.0554	18.05	370
CC133	Corpus Christi Bay	190	104	27.7549	-97.1729	0.0554	18.05	5239
CC134	Corpus Christi Bay	191	117	27.7535	-97.1549	0.0554	18.05	1579
CC135	Corpus Christi Bay	192	39	27.7618	-97.1465	0.0554	18.05	6002
CC136	Corpus Christi Bay	192	62	27.7590	-97.1479	0.0554	18.05	7966
CC137	Corpus Christi Bay	192	140	27.7507	-97.1396	0.0554	18.05	6143
CC138	Corpus Christi Bay	193	27	27.7632	-97.1299	0.0554	18.05	8654
CC139	Corpus Christi Bay	208	14	27.7479	-97.1479	0.0554	18.05	4947
CC140	Corpus Christi Bay	208	31	27.7465	-97.1410	0.0554	18.05	7147
CC141	Corpus Christi Bay	208	46	27.7451	-97.1368	0.0554	18.05	5153
CC142	Corpus Christi Bay	221	140	27.7174	-97.1729	0.0554	18.05	7052
CC143	Corpus Christi Bay	225	64	27.7090	-97.3285	0.0554	18.05	9138

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
CC144	Corpus Christi Bay	239	133	27.6840	-97.2493	0.0554	18.05	3598
CC145	Corpus Christi Bay	241	136	27.6840	-97.2118	0.0554	18.05	217
CC146	Corpus Christi Bay	252	80	27.6576	-97.3396	0.0554	18.05	6844
CC147	Corpus Christi Bay	253	40	27.6618	-97.3285	0.0554	18.05	6996
CC148	Corpus Christi Bay	253	82	27.6576	-97.3201	0.0554	18.05	9834
CC149	Corpus Christi Bay	254	3	27.6660	-97.3132	0.0554	18.05	6181
CC150	Corpus Christi Bay	268	57	27.8771	-97.5715	0.0554	18.05	5378

Table 49. Probabilistically-selected coordinate sets for the Upper Laguna Madre.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
ULM01	Upper Laguna Madre	7	127	27.6688	-97.2576	0.0134	74.88	6697
ULM02	Upper Laguna Madre	9	24	27.6813	-97.2174	0.0134	74.88	5623
ULM03	Upper Laguna Madre	10	16	27.6813	-97.2118	0.0134	74.88	3592
ULM04	Upper Laguna Madre	10	24	27.6813	-97.2007	0.0134	74.88	9949
ULM05	Upper Laguna Madre	14	90	27.6563	-97.2424	0.0134	74.88	6516
ULM06	Upper Laguna Madre	14	105	27.6549	-97.2382	0.0134	74.88	1680
ULM07	Upper Laguna Madre	16	122	27.6521	-97.2146	0.0134	74.88	9050
ULM08	Upper Laguna Madre	17	86	27.6563	-97.1979	0.0134	74.88	2764
ULM09	Upper Laguna Madre	19	44	27.6451	-97.2729	0.0134	74.88	8785
ULM10	Upper Laguna Madre	19	114	27.6368	-97.2757	0.0134	74.88	8396
ULM11	Upper Laguna Madre	21	34	27.6465	-97.2368	0.0134	74.88	8804
ULM12	Upper Laguna Madre	21	56	27.6438	-97.2396	0.0134	74.88	1695
ULM13	Upper Laguna Madre	21	68	27.6424	-97.2396	0.0134	74.88	2079
ULM14	Upper Laguna Madre	26	4	27.6326	-97.2785	0.0134	74.88	1677
ULM15	Upper Laguna Madre	26	13	27.6313	-97.2826	0.0134	74.88	8778
ULM16	Upper Laguna Madre	27	143	27.6174	-97.2521	0.0134	74.88	2804
ULM17	Upper Laguna Madre	33	142	27.6007	-97.2868	0.0134	74.88	9075
ULM18	Upper Laguna Madre	35	71	27.6090	-97.2521	0.0134	74.88	2363
ULM19	Upper Laguna Madre	40	124	27.5854	-97.2951	0.0134	74.88	6347
ULM20	Upper Laguna Madre	41	70	27.5924	-97.2701	0.0134	74.88	1925
ULM21	Upper Laguna Madre	41	125	27.5854	-97.2771	0.0134	74.88	4122
ULM22	Upper Laguna Madre	45	143	27.5674	-97.3188	0.0134	74.88	3894
ULM23	Upper Laguna Madre	46	132	27.5688	-97.3007	0.0134	74.88	1810
ULM24	Upper Laguna Madre	48	86	27.5729	-97.2813	0.0134	74.88	2469
ULM25	Upper Laguna Madre	49	1	27.5826	-97.2660	0.0134	74.88	3883
ULM26	Upper Laguna Madre	49	102	27.5715	-97.2590	0.0134	74.88	8161
ULM27	Upper Laguna Madre	53	53	27.5604	-97.2938	0.0134	74.88	7727
ULM28	Upper Laguna Madre	54	17	27.5646	-97.2771	0.0134	74.88	7205
ULM29	Upper Laguna Madre	54	35	27.5632	-97.2688	0.0134	74.88	4787
ULM30	Upper Laguna Madre	54	90	27.5563	-97.2757	0.0134	74.88	6160
ULM31	Upper Laguna Madre	54	105	27.5549	-97.2715	0.0134	74.88	696
ULM32	Upper Laguna Madre	55	49	27.5604	-97.2660	0.0134	74.88	4688
ULM33	Upper Laguna Madre	57	69	27.5424	-97.3215	0.0134	74.88	989

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
ULM34	Upper Laguna Madre	58	9	27.5493	-97.3049	0.0134	74.88	2439
ULM35	Upper Laguna Madre	58	26	27.5465	-97.3146	0.0134	74.88	9206
ULM36	Upper Laguna Madre	59	41	27.5451	-97.2938	0.0134	74.88	6252
ULM37	Upper Laguna Madre	59	119	27.5368	-97.2854	0.0134	74.88	3310
ULM38	Upper Laguna Madre	61	108	27.5215	-97.3340	0.0134	74.88	5178
ULM39	Upper Laguna Madre	61	131	27.5188	-97.3354	0.0134	74.88	6389
ULM40	Upper Laguna Madre	62	25	27.5299	-97.3326	0.0134	74.88	7520
ULM41	Upper Laguna Madre	64	117	27.5201	-97.2882	0.0134	74.88	8531
ULM42	Upper Laguna Madre	66	8	27.5160	-97.3396	0.0134	74.88	5543
ULM43	Upper Laguna Madre	66	125	27.5021	-97.3438	0.0134	74.88	8786
ULM44	Upper Laguna Madre	68	53	27.5104	-97.3104	0.0134	74.88	7879
ULM45	Upper Laguna Madre	68	58	27.5104	-97.3035	0.0134	74.88	96
ULM46	Upper Laguna Madre	72	3	27.4993	-97.3299	0.0134	74.88	444
ULM47	Upper Laguna Madre	72	59	27.4938	-97.3188	0.0134	74.88	7689
ULM48	Upper Laguna Madre	81	52	27.4604	-97.3285	0.0134	74.88	4691
ULM49	Upper Laguna Madre	84	23	27.4479	-97.3521	0.0134	74.88	5704
ULM50	Upper Laguna Madre	85	1	27.4493	-97.3493	0.0134	74.88	4237
ULM51	Upper Laguna Madre	88	24	27.4313	-97.3507	0.0134	74.88	101
ULM52	Upper Laguna Madre	92	61	27.4090	-97.3660	0.0134	74.88	6367
ULM53	Upper Laguna Madre	92	121	27.4021	-97.3660	0.0134	74.88	7914
ULM54	Upper Laguna Madre	95	12	27.3993	-97.3674	0.0134	74.88	9869
ULM55	Upper Laguna Madre	96	91	27.3896	-97.3576	0.0134	74.88	4581
ULM56	Upper Laguna Madre	98	106	27.3715	-97.3868	0.0134	74.88	7320
ULM57	Upper Laguna Madre	99	8	27.3826	-97.3729	0.0134	74.88	3440
ULM58	Upper Laguna Madre	99	58	27.3771	-97.3701	0.0134	74.88	1416
ULM59	Upper Laguna Madre	102	67	27.3590	-97.3910	0.0134	74.88	7231
ULM60	Upper Laguna Madre	103	76	27.3576	-97.3785	0.0134	74.88	5329
ULM61	Upper Laguna Madre	111	7	27.3326	-97.3910	0.0134	74.88	3551
ULM62	Upper Laguna Madre	170	99	27.3049	-97.4132	0.0134	74.88	771
ULM63	Upper Laguna Madre	171	80	27.3076	-97.3896	0.0134	74.88	5891
ULM64	Upper Laguna Madre	171	101	27.3049	-97.3938	0.0134	74.88	6222
ULM65	Upper Laguna Madre	189	120	27.2868	-97.4174	0.0134	74.88	9135
ULM66	Upper Laguna Madre	191	112	27.2868	-97.3951	0.0134	74.88	6226
ULM67	Upper Laguna Madre	191	117	27.2868	-97.3882	0.0134	74.88	7312
ULM68	Upper Laguna Madre	254	35	27.2465	-97.4021	0.0134	74.88	7616
ULM69	Upper Laguna Madre	286	136	27.1007	-97.4285	0.0134	74.88	2027
ULM70	Upper Laguna Madre	291	94	27.0896	-97.4035	0.0134	74.88	6532
ULM71	Upper Laguna Madre	295	48	27.0785	-97.4007	0.0134	74.88	5328
ULM72	Upper Laguna Madre	299	110	27.0535	-97.4146	0.0134	74.88	8890
ULM73	Upper Laguna Madre	299	130	27.0521	-97.4035	0.0134	74.88	2110

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
ULM74	Upper Laguna Madre	299	135	27.0507	-97.4132	0.0134	74.88	7787
ULM75	Upper Laguna Madre	344	32	26.8132	-97.4729	0.0134	74.88	7568
ULM76	Upper Laguna Madre	7	93	27.6729	-97.2549	0.0134	74.88	2672
ULM77	Upper Laguna Madre	8	114	27.6701	-97.2424	0.0134	74.88	8314
ULM78	Upper Laguna Madre	10	40	27.6785	-97.2118	0.0134	74.88	4628
ULM79	Upper Laguna Madre	10	135	27.6674	-97.2132	0.0134	74.88	6170
ULM80	Upper Laguna Madre	15	12	27.6660	-97.2174	0.0134	74.88	5039
ULM81	Upper Laguna Madre	15	89	27.6563	-97.2271	0.0134	74.88	1772
ULM82	Upper Laguna Madre	16	111	27.6535	-97.2132	0.0134	74.88	2980
ULM83	Upper Laguna Madre	19	30	27.6465	-97.2757	0.0134	74.88	8087
ULM84	Upper Laguna Madre	19	99	27.6382	-97.2799	0.0134	74.88	9959
ULM85	Upper Laguna Madre	20	104	27.6382	-97.2563	0.0134	74.88	3596
ULM86	Upper Laguna Madre	20	107	27.6382	-97.2521	0.0134	74.88	2626
ULM87	Upper Laguna Madre	23	56	27.6438	-97.2063	0.0134	74.88	6062
ULM88	Upper Laguna Madre	26	140	27.6174	-97.2729	0.0134	74.88	5117
ULM89	Upper Laguna Madre	30	57	27.6271	-97.2049	0.0134	74.88	5125
ULM90	Upper Laguna Madre	33	9	27.6160	-97.2882	0.0134	74.88	909
ULM91	Upper Laguna Madre	40	55	27.5938	-97.2910	0.0134	74.88	3516
ULM92	Upper Laguna Madre	41	35	27.5965	-97.2688	0.0134	74.88	736
ULM93	Upper Laguna Madre	42	55	27.5938	-97.2576	0.0134	74.88	8686
ULM94	Upper Laguna Madre	46	41	27.5785	-97.3104	0.0134	74.88	7299
ULM95	Upper Laguna Madre	46	72	27.5757	-97.3007	0.0134	74.88	67
ULM96	Upper Laguna Madre	47	69	27.5757	-97.2882	0.0134	74.88	4841
ULM97	Upper Laguna Madre	48	29	27.5799	-97.2771	0.0134	74.88	446
ULM98	Upper Laguna Madre	49	113	27.5701	-97.2604	0.0134	74.88	3459
ULM99	Upper Laguna Madre	49	124	27.5688	-97.2618	0.0134	74.88	797
ULM100	Upper Laguna Madre	53	24	27.5646	-97.2840	0.0134	74.88	3545
ULM101	Upper Laguna Madre	53	32	27.5632	-97.2896	0.0134	74.88	1122
ULM102	Upper Laguna Madre	53	102	27.5549	-97.2924	0.0134	74.88	7567
ULM103	Upper Laguna Madre	57	74	27.5410	-97.3313	0.0134	74.88	4728
ULM104	Upper Laguna Madre	57	84	27.5410	-97.3174	0.0134	74.88	3779
ULM105	Upper Laguna Madre	58	69	27.5424	-97.3049	0.0134	74.88	9856
ULM106	Upper Laguna Madre	66	114	27.5035	-97.3424	0.0134	74.88	4694
ULM107	Upper Laguna Madre	66	136	27.5007	-97.3451	0.0134	74.88	5698
ULM108	Upper Laguna Madre	68	105	27.5049	-97.3049	0.0134	74.88	8285
ULM109	Upper Laguna Madre	68	122	27.5021	-97.3146	0.0134	74.88	3121
ULM110	Upper Laguna Madre	69	112	27.5035	-97.2951	0.0134	74.88	1619
ULM111	Upper Laguna Madre	72	4	27.4993	-97.3285	0.0134	74.88	5196
ULM112	Upper Laguna Madre	72	48	27.4951	-97.3174	0.0134	74.88	6879
ULM113	Upper Laguna Madre	77	35	27.4799	-97.3188	0.0134	74.88	2006

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
ULM114	Upper Laguna Madre	79	19	27.4646	-97.3576	0.0134	74.88	9059
ULM115	Upper Laguna Madre	79	127	27.4521	-97.3576	0.0134	74.88	3990
ULM116	Upper Laguna Madre	79	136	27.4507	-97.3618	0.0134	74.88	9281
ULM117	Upper Laguna Madre	81	79	27.4576	-97.3243	0.0134	74.88	8458
ULM118	Upper Laguna Madre	84	125	27.4354	-97.3604	0.0134	74.88	4246
ULM119	Upper Laguna Madre	84	139	27.4340	-97.3576	0.0134	74.88	4048
ULM120	Upper Laguna Madre	85	139	27.4340	-97.3410	0.0134	74.88	3488
ULM121	Upper Laguna Madre	88	57	27.4271	-97.3549	0.0134	74.88	3176
ULM122	Upper Laguna Madre	92	40	27.4118	-97.3618	0.0134	74.88	1873
ULM123	Upper Laguna Madre	95	139	27.3840	-97.3743	0.0134	74.88	8943
ULM124	Upper Laguna Madre	96	109	27.3868	-97.3660	0.0134	74.88	7515
ULM125	Upper Laguna Madre	99	38	27.3785	-97.3813	0.0134	74.88	3915
ULM126	Upper Laguna Madre	102	102	27.3549	-97.3924	0.0134	74.88	6603
ULM127	Upper Laguna Madre	106	11	27.3493	-97.3854	0.0134	74.88	3486
ULM128	Upper Laguna Madre	170	94	27.3063	-97.4035	0.0134	74.88	8909
ULM129	Upper Laguna Madre	171	47	27.3118	-97.3854	0.0134	74.88	4324
ULM130	Upper Laguna Madre	215	18	27.2813	-97.3924	0.0134	74.88	9395
ULM131	Upper Laguna Madre	235	59	27.2604	-97.4021	0.0134	74.88	4195
ULM132	Upper Laguna Madre	236	65	27.2590	-97.3938	0.0134	74.88	1789
ULM133	Upper Laguna Madre	254	83	27.2410	-97.4021	0.0134	74.88	6492
ULM134	Upper Laguna Madre	258	32	27.2299	-97.4063	0.0134	74.88	2515
ULM135	Upper Laguna Madre	258	78	27.2243	-97.4090	0.0134	74.88	7188
ULM136	Upper Laguna Madre	259	99	27.2215	-97.3965	0.0134	74.88	3075
ULM137	Upper Laguna Madre	264	53	27.2104	-97.3938	0.0134	74.88	6447
ULM138	Upper Laguna Madre	271	56	27.1771	-97.4396	0.0134	74.88	9596
ULM139	Upper Laguna Madre	273	70	27.1757	-97.4035	0.0134	74.88	763
ULM140	Upper Laguna Madre	274	62	27.1757	-97.3979	0.0134	74.88	4434
ULM141	Upper Laguna Madre	280	85	27.1396	-97.4326	0.0134	74.88	7445
ULM142	Upper Laguna Madre	283	2	27.1326	-97.4313	0.0134	74.88	9111
ULM143	Upper Laguna Madre	283	101	27.1215	-97.4271	0.0134	74.88	8782
ULM144	Upper Laguna Madre	286	63	27.1090	-97.4299	0.0134	74.88	2897
ULM145	Upper Laguna Madre	295	99	27.0715	-97.4132	0.0134	74.88	4383
ULM146	Upper Laguna Madre	299	57	27.0604	-97.4049	0.0134	74.88	3417
ULM147	Upper Laguna Madre	301	9	27.0493	-97.4215	0.0134	74.88	5248
ULM148	Upper Laguna Madre	302	16	27.0479	-97.4118	0.0134	74.88	9286
ULM149	Upper Laguna Madre	305	25	27.0299	-97.4160	0.0134	74.88	6823
ULM150	Upper Laguna Madre	305	134	27.0174	-97.4146	0.0134	74.88	7953

Table 50. Probabilistically-selected coordinate sets for the Lower Laguna Madre.
Grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid and gridlet 144 is located in the lower right corner of the grid.

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
LLM01	Lower Laguna Madre	7	117	26.7868	-97.4549	0.0067	148.72	2948
LLM02	Lower Laguna Madre	12	28	26.7799	-97.4451	0.0067	148.72	4558
LLM03	Lower Laguna Madre	23	114	26.7368	-97.4257	0.0067	148.72	515
LLM04	Lower Laguna Madre	29	121	26.7188	-97.4160	0.0067	148.72	7207
LLM05	Lower Laguna Madre	34	101	26.7049	-97.4271	0.0067	148.72	8866
LLM06	Lower Laguna Madre	45	85	26.6729	-97.4160	0.0067	148.72	5368
LLM07	Lower Laguna Madre	56	71	26.6424	-97.4021	0.0067	148.72	7106
LLM08	Lower Laguna Madre	57	138	26.6340	-97.3924	0.0067	148.72	6705
LLM09	Lower Laguna Madre	63	142	26.6174	-97.3868	0.0067	148.72	8730
LLM10	Lower Laguna Madre	77	111	26.5868	-97.3799	0.0067	148.72	8615
LLM11	Lower Laguna Madre	83	60	26.5771	-97.3674	0.0067	148.72	4703
LLM12	Lower Laguna Madre	107	93	26.5229	-97.3715	0.0067	148.72	8686
LLM13	Lower Laguna Madre	107	118	26.5201	-97.3701	0.0067	148.72	1914
LLM14	Lower Laguna Madre	128	53	26.4771	-97.3938	0.0067	148.72	4468
LLM15	Lower Laguna Madre	136	11	26.4660	-97.3854	0.0067	148.72	5814
LLM16	Lower Laguna Madre	138	64	26.4590	-97.3618	0.0067	148.72	4263
LLM17	Lower Laguna Madre	138	102	26.4549	-97.3590	0.0067	148.72	2831
LLM18	Lower Laguna Madre	139	58	26.4604	-97.3368	0.0067	148.72	9558
LLM19	Lower Laguna Madre	140	141	26.4507	-97.3215	0.0067	148.72	7917
LLM20	Lower Laguna Madre	146	34	26.4465	-97.3535	0.0067	148.72	4374
LLM21	Lower Laguna Madre	147	96	26.4396	-97.3340	0.0067	148.72	7719
LLM22	Lower Laguna Madre	148	108	26.4382	-97.3174	0.0067	148.72	1735
LLM23	Lower Laguna Madre	149	132	26.4354	-97.3007	0.0067	148.72	3831
LLM24	Lower Laguna Madre	155	11	26.4326	-97.3354	0.0067	148.72	5742
LLM25	Lower Laguna Madre	164	46	26.4118	-97.3035	0.0067	148.72	6288
LLM26	Lower Laguna Madre	169	93	26.3896	-97.3215	0.0067	148.72	9622
LLM27	Lower Laguna Madre	169	132	26.3854	-97.3174	0.0067	148.72	3631
LLM28	Lower Laguna Madre	170	10	26.3993	-97.3035	0.0067	148.72	1252
LLM29	Lower Laguna Madre	200	92	26.3396	-97.2896	0.0067	148.72	6700
LLM30	Lower Laguna Madre	208	87	26.3229	-97.2965	0.0067	148.72	8314
LLM31	Lower Laguna Madre	210	95	26.3229	-97.2521	0.0067	148.72	582
LLM32	Lower Laguna Madre	217	89	26.3063	-97.3104	0.0067	148.72	4489
LLM33	Lower Laguna Madre	220	70	26.3090	-97.2535	0.0067	148.72	3476
LLM34	Lower Laguna Madre	229	108	26.2882	-97.2174	0.0067	148.72	5053
LLM35	Lower Laguna Madre	236	29	26.2799	-97.2604	0.0067	148.72	8746
LLM36	Lower Laguna Madre	236	44	26.2785	-97.2563	0.0067	148.72	117
LLM37	Lower Laguna Madre	237	73	26.2743	-97.2493	0.0067	148.72	3470
LLM38	Lower Laguna Madre	243	29	26.2632	-97.2771	0.0067	148.72	8287
LLM39	Lower Laguna Madre	244	134	26.2507	-97.2646	0.0067	148.72	3147
LLM40	Lower Laguna Madre	245	21	26.2646	-97.2382	0.0067	148.72	2590
LLM41	Lower Laguna Madre	246	144	26.2507	-97.2174	0.0067	148.72	4052

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
LLM42	Lower Laguna Madre	247	45	26.2618	-97.2049	0.0067	148.72	3753
LLM43	Lower Laguna Madre	247	97	26.2549	-97.2160	0.0067	148.72	7706
LLM44	Lower Laguna Madre	251	33	26.2465	-97.2882	0.0067	148.72	3836
LLM45	Lower Laguna Madre	251	36	26.2465	-97.2840	0.0067	148.72	3879
LLM46	Lower Laguna Madre	252	113	26.2368	-97.2771	0.0067	148.72	4710
LLM47	Lower Laguna Madre	253	65	26.2424	-97.2604	0.0067	148.72	7444
LLM48	Lower Laguna Madre	256	98	26.2382	-97.2146	0.0067	148.72	6825
LLM49	Lower Laguna Madre	260	81	26.2243	-97.2882	0.0067	148.72	4454
LLM50	Lower Laguna Madre	264	13	26.2313	-97.2326	0.0067	148.72	6275
LLM51	Lower Laguna Madre	264	39	26.2285	-97.2299	0.0067	148.72	1042
LLM52	Lower Laguna Madre	264	67	26.2257	-97.2243	0.0067	148.72	7533
LLM53	Lower Laguna Madre	266	49	26.2271	-97.1993	0.0067	148.72	6238
LLM54	Lower Laguna Madre	268	103	26.2049	-97.2910	0.0067	148.72	9039
LLM55	Lower Laguna Madre	268	139	26.2007	-97.2910	0.0067	148.72	3252
LLM56	Lower Laguna Madre	270	25	26.2132	-97.2660	0.0067	148.72	3738
LLM57	Lower Laguna Madre	279	56	26.1938	-97.2229	0.0067	148.72	8041
LLM58	Lower Laguna Madre	280	59	26.1938	-97.2021	0.0067	148.72	5359
LLM59	Lower Laguna Madre	281	45	26.1951	-97.1882	0.0067	148.72	2093
LLM60	Lower Laguna Madre	296	117	26.1535	-97.2215	0.0067	148.72	7949
LLM61	Lower Laguna Madre	298	87	26.1563	-97.1965	0.0067	148.72	6511
LLM62	Lower Laguna Madre	298	132	26.1521	-97.1840	0.0067	148.72	7295
LLM63	Lower Laguna Madre	300	10	26.1493	-97.2868	0.0067	148.72	3576
LLM64	Lower Laguna Madre	305	35	26.1465	-97.2021	0.0067	148.72	6722
LLM65	Lower Laguna Madre	306	94	26.1396	-97.1868	0.0067	148.72	1225
LLM66	Lower Laguna Madre	310	40	26.1285	-97.2785	0.0067	148.72	860
LLM67	Lower Laguna Madre	310	111	26.1201	-97.2799	0.0067	148.72	2568
LLM68	Lower Laguna Madre	319	31	26.1132	-97.2743	0.0067	148.72	907
LLM69	Lower Laguna Madre	319	55	26.1104	-97.2743	0.0067	148.72	4491
LLM70	Lower Laguna Madre	324	87	26.1063	-97.1965	0.0067	148.72	9537
LLM71	Lower Laguna Madre	325	42	26.1118	-97.1757	0.0067	148.72	5296
LLM72	Lower Laguna Madre	334	15	26.0979	-97.1965	0.0067	148.72	7216
LLM73	Lower Laguna Madre	334	67	26.0924	-97.1910	0.0067	148.72	8531
LLM74	Lower Laguna Madre	374	131	26.0354	-97.1688	0.0067	148.72	659
LLM75	Lower Laguna Madre	385	35	26.0299	-97.1854	0.0067	148.72	3349
LLM76	Lower Laguna Madre	1	131	26.8188	-97.4854	0.0067	148.72	4666
LLM77	Lower Laguna Madre	1	143	26.8174	-97.4854	0.0067	148.72	9571
LLM78	Lower Laguna Madre	12	80	26.7743	-97.4396	0.0067	148.72	8261
LLM79	Lower Laguna Madre	12	115	26.7701	-97.4410	0.0067	148.72	9381
LLM80	Lower Laguna Madre	16	140	26.7507	-97.4563	0.0067	148.72	2276
LLM81	Lower Laguna Madre	23	51	26.7438	-97.4299	0.0067	148.72	2835
LLM82	Lower Laguna Madre	28	47	26.7285	-97.4188	0.0067	148.72	6338
LLM83	Lower Laguna Madre	40	78	26.6910	-97.4090	0.0067	148.72	1634
LLM84	Lower Laguna Madre	45	18	26.6813	-97.4090	0.0067	148.72	2261
LLM85	Lower Laguna Madre	45	103	26.6715	-97.4076	0.0067	148.72	2842
LLM86	Lower Laguna Madre	49	36	26.6632	-97.4174	0.0067	148.72	1686
LLM87	Lower Laguna Madre	50	24	26.6646	-97.4007	0.0067	148.72	8788
LLM88	Lower Laguna Madre	50	140	26.6507	-97.4063	0.0067	148.72	7827
LLM89	Lower Laguna Madre	51	76	26.6576	-97.3951	0.0067	148.72	522
LLM90	Lower Laguna Madre	63	4	26.6326	-97.3951	0.0067	148.72	5816
LLM91	Lower Laguna Madre	64	74	26.6243	-97.3813	0.0067	148.72	6107
LLM92	Lower Laguna Madre	77	130	26.5854	-97.3701	0.0067	148.72	1741

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
LLM93	Lower Laguna Madre	101	17	26.5479	-97.3604	0.0067	148.72	369
LLM94	Lower Laguna Madre	101	32	26.5465	-97.3563	0.0067	148.72	5896
LLM95	Lower Laguna Madre	112	54	26.5104	-97.4090	0.0067	148.72	2975
LLM96	Lower Laguna Madre	114	74	26.5076	-97.3813	0.0067	148.72	4646
LLM97	Lower Laguna Madre	114	119	26.5035	-97.3688	0.0067	148.72	5270
LLM98	Lower Laguna Madre	121	42	26.4951	-97.3757	0.0067	148.72	2809
LLM99	Lower Laguna Madre	122	62	26.4924	-97.3646	0.0067	148.72	2555
LLM100	Lower Laguna Madre	128	83	26.4743	-97.3854	0.0067	148.72	7200
LLM101	Lower Laguna Madre	128	122	26.4688	-97.3979	0.0067	148.72	8268
LLM102	Lower Laguna Madre	130	44	26.4785	-97.3563	0.0067	148.72	2062
LLM103	Lower Laguna Madre	130	52	26.4771	-97.3618	0.0067	148.72	9135
LLM104	Lower Laguna Madre	139	32	26.4632	-97.3396	0.0067	148.72	1441
LLM105	Lower Laguna Madre	146	27	26.4465	-97.3632	0.0067	148.72	6857
LLM106	Lower Laguna Madre	147	67	26.4424	-97.3410	0.0067	148.72	1647
LLM107	Lower Laguna Madre	148	88	26.4396	-97.3285	0.0067	148.72	7206
LLM108	Lower Laguna Madre	158	112	26.4201	-97.2951	0.0067	148.72	1142
LLM109	Lower Laguna Madre	170	134	26.3840	-97.3146	0.0067	148.72	3699
LLM110	Lower Laguna Madre	171	70	26.3924	-97.2868	0.0067	148.72	6633
LLM111	Lower Laguna Madre	178	114	26.3701	-97.3257	0.0067	148.72	7258
LLM112	Lower Laguna Madre	179	128	26.3688	-97.3063	0.0067	148.72	7283
LLM113	Lower Laguna Madre	190	80	26.3576	-97.2896	0.0067	148.72	9031
LLM114	Lower Laguna Madre	198	77	26.3410	-97.3271	0.0067	148.72	3183
LLM115	Lower Laguna Madre	198	119	26.3368	-97.3188	0.0067	148.72	3861
LLM116	Lower Laguna Madre	209	102	26.3215	-97.2757	0.0067	148.72	2992
LLM117	Lower Laguna Madre	220	34	26.3132	-97.2535	0.0067	148.72	8832
LLM118	Lower Laguna Madre	227	44	26.2951	-97.2563	0.0067	148.72	7115
LLM119	Lower Laguna Madre	228	53	26.2938	-97.2438	0.0067	148.72	9389
LLM120	Lower Laguna Madre	228	87	26.2896	-97.2465	0.0067	148.72	6229
LLM121	Lower Laguna Madre	233	124	26.2688	-97.3118	0.0067	148.72	7136
LLM122	Lower Laguna Madre	238	4	26.2826	-97.2285	0.0067	148.72	2979
LLM123	Lower Laguna Madre	239	75	26.2743	-97.2132	0.0067	148.72	7825
LLM124	Lower Laguna Madre	241	111	26.2535	-97.3132	0.0067	148.72	5366
LLM125	Lower Laguna Madre	244	93	26.2563	-97.2549	0.0067	148.72	1537
LLM126	Lower Laguna Madre	246	95	26.2563	-97.2188	0.0067	148.72	2871
LLM127	Lower Laguna Madre	252	56	26.2438	-97.2729	0.0067	148.72	411
LLM128	Lower Laguna Madre	252	92	26.2396	-97.2729	0.0067	148.72	4657
LLM129	Lower Laguna Madre	252	95	26.2396	-97.2688	0.0067	148.72	2720
LLM130	Lower Laguna Madre	261	139	26.2174	-97.2743	0.0067	148.72	9468
LLM131	Lower Laguna Madre	263	120	26.2201	-97.2340	0.0067	148.72	5850
LLM132	Lower Laguna Madre	264	11	26.2326	-97.2188	0.0067	148.72	1726
LLM133	Lower Laguna Madre	265	96	26.2229	-97.2007	0.0067	148.72	6464
LLM134	Lower Laguna Madre	267	130	26.2021	-97.3035	0.0067	148.72	5633
LLM135	Lower Laguna Madre	269	24	26.2146	-97.2674	0.0067	148.72	7043
LLM136	Lower Laguna Madre	280	72	26.1924	-97.2007	0.0067	148.72	8492
LLM137	Lower Laguna Madre	284	112	26.1701	-97.2785	0.0067	148.72	96
LLM138	Lower Laguna Madre	287	45	26.1785	-97.2215	0.0067	148.72	5677
LLM139	Lower Laguna Madre	293	5	26.1660	-97.2771	0.0067	148.72	3524
LLM140	Lower Laguna Madre	297	125	26.1521	-97.2104	0.0067	148.72	8847
LLM141	Lower Laguna Madre	300	46	26.1451	-97.2868	0.0067	148.72	5451
LLM142	Lower Laguna Madre	301	42	26.1451	-97.2757	0.0067	148.72	4327
LLM143	Lower Laguna Madre	306	128	26.1354	-97.1896	0.0067	148.72	1425

Coordinate set	Bay	Grid	Gridlet	Latitude	Longitude	Selection probability	Sampling weight	Random number
LLM144	Lower Laguna Madre	313	14	26.1313	-97.2313	0.0067	148.72	2731
LLM145	Lower Laguna Madre	315	99	26.1215	-97.1965	0.0067	148.72	3341
LLM146	Lower Laguna Madre	316	42	26.1285	-97.1757	0.0067	148.72	6526
LLM147	Lower Laguna Madre	325	37	26.1118	-97.1826	0.0067	148.72	5063
LLM148	Lower Laguna Madre	335	20	26.0979	-97.1729	0.0067	148.72	5644
LLM149	Lower Laguna Madre	345	45	26.0785	-97.2215	0.0067	148.72	2145
LLM150	Lower Laguna Madre	385	111	26.0201	-97.1965	0.0067	148.72	7424

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