A Long-Term Seagrass Monitoring Program for Upper Laguna Madre and Corpus Christi Bay

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Seagrass Monitoring CBBEP Contract Number 1429

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Final Report

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Introduction

This study is part of the Texas seagrass monitoring program, with specific focus on Corpus Christi Bay (CCB) and the Upper Laguna Madre (ULM; Figure 1), following protocols that evaluate seagrass condition based on landscape-scale dynamics. The program is based on a hierarchical strategy for seagrass monitoring outlined by Neckles et al. (2012) to establish the quantitative relationships between physical and biotic parameters that ultimately control seagrass condition, distribution, persistence, and overall health. This approach follows a broad template adopted by several federal and state agencies across the country, but which is uniquely designed for Texas (Dunton et al. 2011) and integrates plant condition indicators with landscape feature indicators to detect and interpret seagrass bed disturbances.

The objectives of this study were to (1) continue long-term monitoring to detect environmental changes with a focus on the ecological integrity of seagrass habitats, (2) collect measurements of seagrass condition coincident with environmental variables that can provide insight to the ecological consequences of observed changes, and (3) help decision makers (e.g. various state and federal agencies) determine if any observed changes in seagrass condition or extent necessitates a revision of regulatory or management policy or practices. We define ecological integrity as the capacity of the seagrass system to support and maintain a balanced, integrated, and adaptive community of flora and fauna including its historically characteristic seagrass species. Ecological integrity was assessed using a suite of condition indicators (physical, biological, hydrological, and chemical) measured on different spatial and temporal scales.
Our annual Tier-2 surveys are designed to address three primary questions:

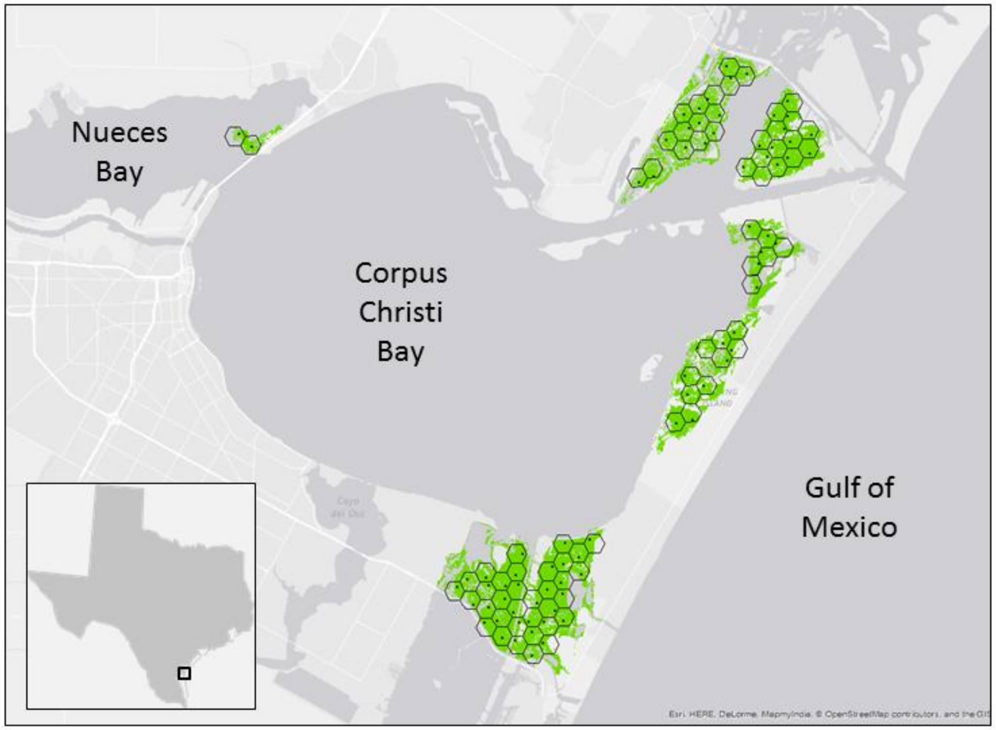
1) What are the spatial and temporal patterns in the distribution of seagrasses over both annual and decadal scales?
2) What are the characteristics of these plant communities, including their species composition and percent cover?
3) Are changes in seagrass percent cover and species composition related to variations in water transparency or some other measured abiotic factor?

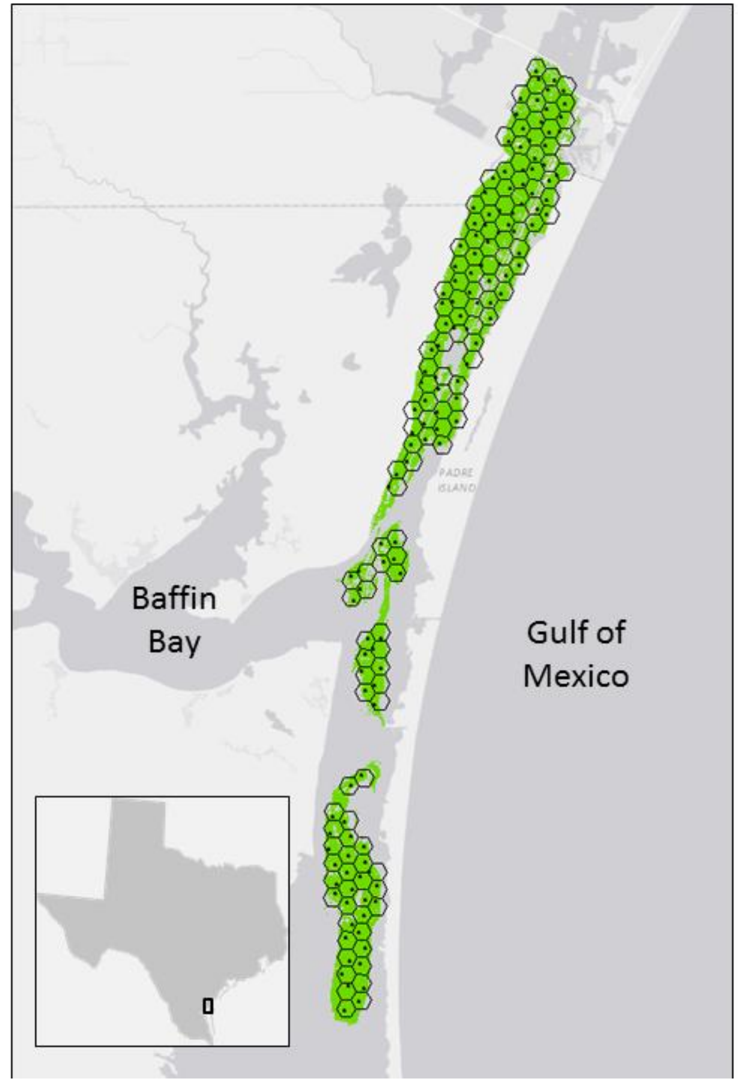
Completion of the Final Report on this portion of the statewide survey funded by CBBEP on contract number 1429 is expected on 31 January 2015 (as contractually scheduled). Integration of the results from the CBBEP study with data collected from the full statewide program for 2014 is ongoing. We plan to submit a four-year comprehensive report for years 2011-2014 to all program partners in May 2015. The comprehensive report, GIS maps, and data will be posted to www.texasseagrass.org.

Methods

Tier-2 sampling was completed at 81 permanent rapid-assessment stations in CCB, and at 144 stations in ULM (Figure 1). Stations in CCB were sampled from July to early August and stations in ULM were sampled from mid-August to early September. Each station was visited by boat using a handheld GPS to arrive within 10 m of the fixed station coordinate. Water quality measurements of temperature, salinity, dissolved oxygen (D.O.), pH, and chlorophyll *a* were

Figure 1. Map of sampling stations (n=81) in Corpus Christi Bay (below) and stations (n=144) in Upper Laguna Madre (right).





taken with a YSI 6920 datasonde. Depth was measured with a meter stick and Secchi depth was measured with a Secchi disc. At each station, a 1 L water sample was collected for measurement of total suspended solids (TSS) at the laboratory. TSS was calculated by filtering the water sample over a pre-weighed 0.7 µm Whatman GF/F filter (47 mm diam.), rinsing the filter and retained particles with distilled water, and weighing the filter after drying to constant weight in an oven at 60 °C. Measurements of underwater photosynthetically active radiation were taken at each station using two LI-COR spherical quantum sensors mounted to a custom lowering frame at a fixed distance in order to calculate the light attenuation coefficient (k_d) using the Beer-Lambert equation.

After water quality measurements were taken, technicians entered the water and measured seagrass percent cover at four ordinal locations around the boat. Seagrass percent cover was measured using visual estimations with a 0.25 m^2 quadrat subdivided with monofilament line into 100 cells. At each of the four ordinal locations, seagrass was gathered by hand and measured with a ruler to determine canopy height. Finally, if *Halodule wrightii* or *Thalassia testudinum* was present at the station, a small sample was gathered by hand and placed in a Whirlpak on ice for transport to the laboratory for stable isotope and elemental analysis (data not included in this report).

In 2014, seagrass cores were taken at representative stations in order to calculate biomass at various amounts of seagrass percent cover for *H. wrightii*, *T. testudinum*, and *S. filiforme*. Tissue elemental data collected from our statewide monitoring program in previous years provide estimates of total carbon in *H. wrightii* and *T. testudinum*, and estimates for *S. filiforme* were obtained from a literature search. Hence, by estimating seagrass biomass based on percent cover, we can calculate a rough estimate of carbon stored in seagrasses for this area.

Water Quality Measurements

Water quality parameters for CCB and ULM are reported in Table 1. CCB stations had an average depth of 54.3 ± 2.4 cm, and were more shallow than ULM stations, which had an average depth of 81.7 ± 3.8 cm. Water temperatures were very similar in CCB (30.5 ± 0.2 °C) and ULM (31.5 ± 0.1 °C), as was pH (CCB: 8.2 ± 0.05; ULM: 8.4 ± 0.02). Salinities were much higher in ULM (50.3 ± 0.4) than CCB (44.1 ± 0.4), which was expected given longer water residence times and very limited freshwater inflow to ULM. The D.O. levels were higher in CCB (6.4 ± 0.2 mg L^{-1}) than ULM (5.7 ± 0.1 mg L^{-1}), perhaps due to the fact that ULM had deeper sites that were not as well-mixed by winds. Finally, measures of water clarity were very similar between systems. Secchi depth was nearly identical for CCB (51.6 ± 2.1 cm) and ULM (52.8 ± 1.7), as was the light attenuation coefficient k_d (1.4 ± 0.1 m^{-1} at both), although it should be noted that as ULM stations were deeper, this may indicate lower light levels at the benthos. Two other measures of water transparency, chlorophyll *a* and TSS, were slightly lower in CCB (Chlorophyll *a*: 5.0 ± 0.4 µg L^{-1}; TSS: 12.2 ± 1.3 mg L^{-1}) than in ULM (Chlorophyll *a*: 11.1 ± 0.6 µg L^{-1}; TSS: 18.7 ± 0.8 mg L^{-1}), indicating better clarity.

Table 1. Water quality parameters (mean ± S.E.) for Corpus Christi Bay and Upper Laguna Madre from 2014 sampling.

	Corpus Christi Bay (n=81)	**Upper Laguna Madre** (n=144)
Depth (cm)	54.3 ± 2.4	81.7 ± 3.8
Secchi depth (cm)	51.6 ± 2.1	52.8 ± 1.7
Temperature (°C)	30.5 ± 0.2	31.5 ± 0.1
Salinity	44.1 ± 0.4	50.3 ± 0.4
D.O. (mg L^{-1})	6.4 ± 0.2	5.7 ± 0.1
pH	8.2 ± 0.05	8.4 ± 0.02
Chlorophyll *a* (µg L^{-1})	5.0 ± 0.4	11.1 ± 0.6
TSS (mg L^{-1})	12.2 ± 1.3	18.7 ± 0.8
K_d (m^{-1})	1.4 ± 0.1	1.4 ± 0.1

Seagrass Condition Indicators

Seagrass percent cover and canopy height for CCB and ULM are reported in Table 2. *H. wrightii* was the dominant species in both areas, but its cover was greater in ULM (64.1 ± 3.2 %) than in CCB (40.5 ± 4.3). However, CCB had higher percent cover of all four other species (*T. testudinum*: 16.4 ± 3.4 %; *S. filiforme*: 9.7 ± 2.5 %; *Halophila engelmannii*: 1.1 ± 0.8 %; *Ruppia maritima*: 1.2 ± 0.5 %) than ULM (*T. testudinum*: 0.0 ± 0.1 %; *S. filiforme*: 1.7 ± 0.7 %; *H. engelmannii*: 0.2 ± 0.2 %; *R. maritima*: 0.2 ± 0.2 %). *T. testudinum* was only observed in CCB and was not present in ULM. Seagrass canopy height was very similar in CCB (21.4 ± 0.3 cm) and ULM (20.0 ± 0.2 cm).

Table 2. Seagrass percent cover and canopy height (mean ± S.E.) for Corpus Christi Bay and Upper Laguna Madre from 2014 sampling.

	Corpus Christi Bay (n=81)	**Upper Laguna Madre** (n=144)
***H. wrightii* (%)**	40.5 ± 4.3	64.1 ± 3.2
***T. testudinum* (%)**	16.4 ± 3.4	0.0 ± 0.0
***S. filiforme* (%)**	9.7 ± 2.5	1.7 ± 0.7
***H. engelmannii* (%)**	1.1 ± 0.8	0.2 ± 0.2
***R. maritima* (%)**	1.2 ± 0.5	0.2 ± 0.2
Canopy height (cm)	21.4 ± 0.3	20.0 ± 0.2

Seagrass Biomass and Carbon Storage Estimates

Seagrass cores were taken at various amounts of percent cover in monospecific beds of *H. wrightii*, *T. testudinum*, and *S. filiforme*. Due to sampling constraints, only one *S. filiforme* sample was obtained, so S.E. for *S. filiforme* is not reported. Aboveground (leaves and sheaths) and belowground (roots and rhizomes) biomass was regressed against percent cover to calculate biomass estimations for each species at their observed percent cover in CCB and ULM. After this, we multiplied the average biomass (g) by the average percent carbon (% C) by weight (Table 3) to calculate total carbon. Results from carbon calculations and estimates for region-wide carbon storage in seagrasses are reported in Tables 4 and 5. We report carbon in Megagrams (Mg) where 1 Mg = 10^6 g.

Table 3. Aboveground (AG) and belowground (BG) biomass (mean ± S.E.) and percent carbon by weight for each species of seagrass.

		Average biomass (g m^{-2}) at 100 % cover	% C	References
H. wrightii	*AG*	115.3 ± 33.9	38.2 %	(S. Wilson, unpub. data)
	BG	151.8 ± 26.8	38.3 %	(Kowalski et al. 2009)
T. testudinum	*AG*	244.0 ± 37.4	38.3 %	(S. Wilson, unpub. data)
	BG	601.4 ± 54.7	35.6 %	(Kaldy and Dunton 2000)
S. filiforme	*AG*	207.9	38.9 %	(Campbell and Fourqurean 2009)
	BG	189.1	37.1 %	(Short et al. 1985)

Table 4. Calculated estimations (mean ± S.E.) of carbon storage ha^{-1} and total carbon storage in CCB for each species, assuming their observed mean percent cover.

	Percent cover	Mg C ha^{-1}	Mg C stored
H. wrightii	40.5	0.41 ± 0.09	2,176.6 ± 494.5
T. testudinum	16.4	0.50 ± 0.06	2,653.5 ± 291.5
S. filiforme	9.7	0.15	770.8
Total	-	1.06 ± 0.15	5,600.9 ± 786.0

Table 5. Calculated estimations (mean ± S.E.) of carbon storage ha^{-1} and total carbon storage in ULM for each species, assuming their observed mean percent cover.

	Percent cover	Mg C ha^{-1}	Mg C stored
H. wrightii	64.1	0.65 ± 0.15	13,799.8 ± 3,130.4
T. testudinum	0.0	0.0	0.0
S. filiforme	1.7	0.03	540.3
Total	-	0.68 ± 0.15	14,340.1 ± 3,130.4

With these calculations, we estimate a total of 5,600.9 ± 786.0 Mg C stored by seagrasses in CCB, and 14,340.1 ± 3,130.4 Mg C stored by seagrasses in ULM. These are considerably rough estimates based upon specific amounts of percent cover, and it should be noted that biomass of Texas seagrasses fluctuates with season, as does % C by weight (Kaldy and Dunton 2000; Kowalski et al. 2009). Further studies with additional replicates and % C values obtained from Texas seagrasses should be conducted before basing management decisions upon this data. Additionally, sediments below seagrass meadows can store vast amounts of carbon (Fourqurean et al. 2012), and should be considered in future analyses. Nevertheless, our estimates of biomass and carbon storage seem quite reasonable. A study by Onuf (1996) reported lower mean biomasses (g m^{-2}) for all species, but these were measured across different amounts of percent cover, whereas ours were calculated for 100 % cover. Our estimates of carbon storage (g C ha^{-1}) in Texas seagrasses are within the range of seagrass carbon storage around the world reported by Fourqurean et al. (2012), which calculated a median of 1.000 Mg C ha^{-1}. To our knowledge, this is the first large-scale estimate of carbon storage by seagrasses in Texas.

Conclusions

Results from the monitoring study conducted in summer 2014 reveal that both CCB and ULM were characterized by relatively high salinities and high amounts of seagrass percent cover. Water transparency was similar in CCB and ULM despite higher amounts of chlorophyll *a* and TSS in ULM. CCB continues to support a fairly diverse seagrass population--representatives from all five seagrass species were noted based on observations made at rapid-assessment stations. In contrast, ULM is almost exclusively dominated by *H. wrightii*. As expected, water quality parameters were variable between stations but averaged parameters were remarkably similar between sites. Further analyses utilizing GIS software will allow us to detect any fine-scale difference among stations and between sites. As predicted, the first estimates of carbon storage by Texas seagrasses show that a very large pool of organic carbon exists in this region.

Acknowledgements

We greatly appreciate the continued support from the CBBEP for the continuation of monitoring studies that assess the long-term health of our seagrass ecosystems in Corpus Christi Bay and Upper Laguna Madre. In particular, we thank Ray Allen and Jace Tunnell for the provision of funds and field support. Their long-term vision and appreciation for the gathering baseline data for a threatened resource is commendable.

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