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**Monitoring and Evaluation of Constructed Marsh Terraces and Marsh Creation
Projects in South Louisiana**

Final Report

Submitted by

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Introduction

The first section of this report covers the evaluation of Cajun Corals and Oyster Stakes placed along a marsh edge west of Golden Meadow (Winter and Summer 2022) and along newly built terraces near Pointe aux Chenes (Summer 2022, only). The second section of this report covers the Summer 2022 evaluation of marsh vegetation west of Golden Meadow and at newly created terraces near Pointe aux Chenes.

Section 1. Cajun Coral and Oyster Stake Evaluation

Cajun Coral and Oyster Stakes were installed to promote oyster reef development so that a living reef would be established and provide long-term protection for the adjacent marsh. We made a preliminary visit on 7 October 2021 to the Golden Meadow site and observed that the Cajun Coral were completely submerged and only the tops of the poles of the Oyster Stakes were visible (Figures 1 through 3). We visually observed oysters and barnacles growing on the Oyster Stakes (Figure 4) and were able to feel by hand that the Cajun Coral structures supported oysters and barnacles.

Winter Evaluation: Golden Meadow Cajun Coral and Oyster Stakes.

We made the Winter site visit on 29 January 2022 to evaluate the structures, but the tides were extremely low and the majority of the Cajun Corals and Oyster Stakes were completely exposed (Figure 5). Although some Cajun Coral structures and Oyster Stakes were below the surface of the water, water levels were too shallow to approach by boat (Figures 6 through 8). Because we were not able to access the structures, we used photography to document the presence of oysters *Crassostrea virginica* and barnacles (Class Cirripedia) on the structures. We observed oysters and barnacles attached to all of the Cajun Corals (Figures 6 and 8 through 11). Some Cajun Corals were heavily populated by oysters (Figure 10). We observed oysters and barnacles attached to the overwhelming majority of Oyster Stakes (Figures 7, 12 and 13). However, the density of oysters appeared to be lower on the Oyster Stakes than on the Cajun Coral.

Summer Evaluation: Golden Meadow Cajun Coral and Oyster Stakes.

We made the Summer site visit on 1 June 2022 to evaluate oyster and barnacle growth on the Cajun Corals and Oyster Stakes. The tide was relatively high and all of the Cajun Corals were submerged (Figures 14 and 15). We measured the submerged depth of 12 Cajun Corals and the mean (\pm SE) was 25 ± 1.3 cm below the water surface. We also confirmed by touch the presence of oysters and barnacles on all 12 Cajun Corals that were evaluated.

The tops of the poles of all Oyster Stakes were above the water surface, but the settlement substrates designed to attract oysters were all submerged (Figures 16 and 17). All 45 Oyster Stakes evaluated had oysters and barnacles attached (Figure 18), and several Oyster Stakes had large oysters attached (Figure 19). We observed an oyster settlement pattern related to the amount of the lower end of the settlement substrate that subsided into the sediment or was buried by sediment and the amount of the upper end of the settlement substrate that was exposed at low tide. For example, some settlement substrates had dead oysters or empty shells attached to the lower end and live oysters attached to the upper end (Figure 20) or middle region of the settlement substrates (Figure 21). It appears that oysters

had settled onto the lower end, but the settlement substrate sunk into or was buried by sediment over time thus killing the oysters. Some settlement substrates only had oysters in the middle region (Figure 22) suggesting that the lower end had subsided or was buried by sediment and the upper end was exposed at low tide thus preventing the recruitment or survival of oysters and barnacles.

Summer Evaluation: Pointe aux Chenes Cajun Coral and Oyster Stakes.

We made the Summer visit on 3 June 2022 to evaluate oyster and barnacle growth on the Cajun Corals and Oyster Stakes. The tide was relatively high and all of the Cajun Corals were submerged. It was difficult to locate the structures and used a paddle to identify the locations of the Cajun Corals. The Cajun Corals were too deep to feel with our hands therefore we could not identify if oysters and/or barnacles had colonized the Cajun Corals.

The poles for the Oyster Stakes were above the water line, but all of the settlement substrates were submerged (Figure 24). We evaluated 30 Oyster Stakes and did not observe any oysters, but all Oyster Stakes had solid coverage of barnacles (Figure 25). Some of the Oyster Stake settlement substrates had large cracks (Figure 26), with some cracks extending the entire length of the settlement substrate (Figure 27). We observed three units that had broken in half and fell from the pole while we were extracting the Oyster Stakes. Oyster Stakes at Pointe aux Chene may recruit oysters in the future although the time between installation of the Oyster Stakes and our evaluation may not have been sufficient for oyster spat recruitment to the settlement substrates.



Figure 1. Vertical PVC poles mark the bank where the Cajun Corals were placed. All structures were completely submerged on 7 October 2021, Golden Meadow site.



Figure 2. A single Cajun Coral submerged below the water surface on 7 October 2021, Golden Meadow site.



Figure 3. The tops of poles of Oyster Stakes just above the water surface on 7 October 2021, Golden Meadow site.



Figure 4. Newly removed Oyster Stake with visible oysters and barnacles on 7 October 2021, Golden Meadow site.



Figure 5. Cajun Corals and Oyster Stakes were completely exposed on 29 January 2022, Golden Meadow site.



Figure 6. Cajun Corals in shallow water on 29 January 2022, Golden Meadow site.



Figure 7. Oyster Stakes in shallow water on 29 January 2022, Golden Meadow site.



Figure 8. Cajun Corals in water too shallow to approach with a boat on 29 January 2022, Golden Meadow site.



Figure 9. Dense growth of oysters and barnacles on a single Cajun Coral on 29 January 2022, Golden Meadow site.



Figure 10. Dense oyster and barnacle growth on Cajun Corals on 29 January 2022, Golden Meadow site.



Figure 11. Oyster and barnacle growth on Cajun Corals on 29 January 2022, Golden Meadow site.



Figure 12. Oyster and barnacle growth on Oyster Stakes on 29 January 2022, Golden Meadow site.



Figure 13. Oyster and barnacle growth on Oyster Stakes on 29 January 2022, Golden Meadow site.



Figure 14. Vertical PVC poles mark the bank where Cajun Corals were placed. All structures were completely submerged on 1 June 2022, Golden Meadow site.



Figure 15. Vertical PVC poles mark the bank where Cajun Corals were placed. All structures were completely submerged on 1 June 2022, Golden Meadow site.



Figure 16. Oyster stakes with only the tops of the poles exposed above the water on 1 June 2022, Golden Meadow site.



Figure 17. Oyster stakes with only the tops of the poles exposed above the water on 1 June 2022, Golden Meadow site.



Figure 18. An Oyster Stake with attached oysters and barnacles on 1 June 2022, Golden Meadow site.



Figure 19. Large oysters on an Oyster Stake on 1 June 2022, Golden Meadow site.



Figure 20. An Oyster Stake with dead oysters on the lower end of the settlement substrate on 1 June 2022, Golden Meadow site. It appears that the settlement substrate had submerged into or was buried by sediment as indicated by the dark (anoxic) sediment and empty oyster shells.



Figure 21. An Oyster Stake with live oysters in the middle region of the settlement substrate and dead oysters on the bottom end of the settlement substrate on 1 June 2022, Golden Meadow site.



Figure 22. An Oyster Stake with oysters only growing on the middle region of the settlement substrate on 1 June 2022, Golden Meadow site. The lower end of the settlement substrate had submerged or was buried by sediment and the upper end of the settlement substrate may have been exposed at low tide thus preventing oyster and barnacle settlement and growth.



Figure 23. Vertical PVC poles mark the locations of Cajun Corals that were too submerged for evaluation on 3 June 2022, Pointe aux Chenes site.



Figure 24. Oyster Stake poles were above the water surface, but the settlement substrates were submerged on 3 June 2022, Pointe aux Chenes site.



Figure 25. An Oyster Stake with barnacles on the settlement substrate, but no oysters on 3 June 2022, Pointe aux Chenes site.



Figure 26. An oyster stake with a crack starting on the top of the settlement substrate on 3 June 2022, Pointe aux Chenes site.



Figure 27. An Oyster Stake with a crack extending the entire length of the settlement substrate on 3 June 2022, Pointe aux Chenes site.

Section 2. Coverage: Golden Meadow and Pointe aux Chenes Summer Marsh Vegetation Evaluation

Immediately subsequent to the oyster and barnacle evaluation on 1 June 2022, visual estimation of marsh vegetation coverage at 20 different 1-m² plots was performed at two nearby marsh fill areas at the Golden Meadow site. Polygons of marsh fill areas that had previously been provided were used to select areas for sampling, along with visual representativeness of the greater marsh area. Within the two fill areas, each 1-m² sampling plot was separated by approximately 20 m and both total and live coverage, as well as species composition was visually estimated in 5% increments. Overall, live vegetation cover at the Golden Meadow marsh site (46.5%) was lower than reported in 2020 at a nearby Coast-Wide Reference Monitoring Site (CRMS 0387; 72.5%) as compared by a one-sample t test ($t_{1,19}=5.31$, $p<0.001$). Live vegetation cover ranged from 5 to 80% at the Golden Meadow site (see figures 28 and 29 for examples of a low-coverage, unhealthy and high coverage, healthy plot, respectively). However, it should be noted that in addition to being collected in different years, vegetation cover was also estimated by different personnel and with different plot sizes (1-m² versus 4-m²), all of which may affect comparisons. Notably, species composition was similar between the CRMS and Golden Meadow sites, with *Spartina alterniflora*, *Spartina patens*, and *Distichlis spicata* being the primary species occurring at both. The CRMS site also had minimal cover (0.5%) reported for the salt marsh aster, *Symphyotrichum tenuifolium*. Although this species was not found with the cover plots at Golden Meadow in the summer sampling, its presence was anecdotally noted outside the plots in the area.

After the oyster and barnacle evaluation on 3 June 2022, visual estimation of marsh vegetation coverage was performed at 20 different 1-m² sampling plots at shorelines of recently established marsh terraces immediately outside the Pointe aux Chenes WMA. Coordinates of potential sampling points were provided by Ducks Unlimited and 20 were navigated to for vegetation sampling. At each 1-m² plot both total and live coverage, as well as species composition was visually estimated in 5% increments. Overall, live vegetation cover at the Pointe aux Chenes site (52.5%) was lower than reported in 2021 at a nearby Coast-Wide Reference Monitoring Site (CRMS 3296; 71.3%) as compared by a one-sample t test ($t_{1,19}=4.95$, $p<0.001$). Live vegetation cover ranged from 15 to 85% at the Pointe aux Chenes site. As noted above for the Golden Meadow site, cover was collected in different years, by different personnel, and with different plot sizes (1-m² versus 4-m²), and thus conclusions based on this comparison should be appropriately caveated. Species composition was consistent between the two sites, with cover dominated by *Spartina alterniflora* and *Spartina patens*, although *Distichlis spicata* was also found at the Pointe aux Chenes site. Importantly, the cover values reported for the Point aux Chenes terraces reflect coverage at the terrace shorelines, which generally exhibited robust healthy growth (Figures 30 - 32). Terrace center lines were typically bare (Figure 33), but are anticipated to fill in as the established clonal grasses at the edge continue to expand to the interior.

Overall, most plots at both the Golden Meadow marsh fill and Pointe aux Chenes terrace sites exhibited coverage and visual coloration consistent with a relatively healthy coastal marsh in Louisiana. However, several plots at the second marsh fill area in Golden Meadow exhibited comparatively low live coverage and a relatively large amount of standing dead. This area was also characterized by low density, almost fluid soils overlaying a stable substrate and a visual abundance of salt marsh chinch bug *Ischnodemus folicus*. However, both of these phenomena can either be direct stressors to salt marsh grasses, or be associated with areas of stressed salt marsh grass. Notably, the less healthy fill site of Golden Meadow exists as a mosaic of unconsolidated soils with unhealthy vegetation mixed with higher elevation dense

soils colonized by health vegetation (Figure 34). This suggests that if the stressor affecting this less health marsh is ameliorated, there is an abundance of proximity coastal marsh vegetation that would rapidly expand into these areas.



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Figure 28. An unhealthy, low coverage plot at the Golden Meadow site (second fill area).

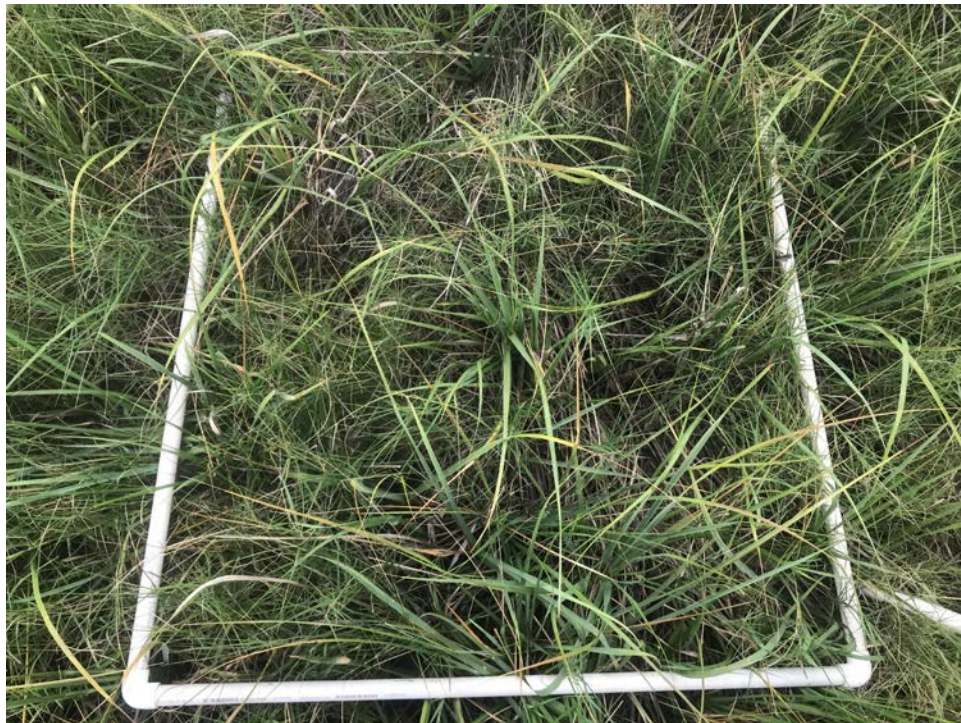


Figure 29. A healthy, high coverage plot at the Golden Meadow site (first fill area).



Figure 30. Terrace at the Pointe aux Chene site illustrating high edge vegetation cover, but minimal vegetation at terrace crest.



Figure 31. Sampling plot at a Pointe aux Chene terrace illustrating high *Spartina alterniflora* edge cover.



Figure 32. Sampling plot at a Pointe aux Chene terrace illustrating high *Distichlis spicata* cover on the slope to the terrace crest.



Figure 33. Sampling plot at a Pointe aux Chene terrace illustrating lack of vegetation establishment at the terrace crest.



Figure 34. Landscape view of the mosaic of healthy and unhealthy marsh portions of the second marsh fill area of the Golden Meadow site.