# Large-Scale Marsh Creation - Upper Barataria Component Marsh Restoration Project (BA-207)


## Monitoring and Adaptive Management Interim Synthesis Report:

*Preconstruction Through Project Year 1 (2024)*

DIVER Project ID 124
Upper Barataria, Jefferson Parish, Louisiana USA

March 16, 2026

Developed in collaboration between the Water Institute and the National Oceanic and Atmospheric Administration (NOAA)

Large-Scale Marsh Creation – Upper Barataria Component Marsh Restoration Project

**MONITORING AND ADAPTIVE MANAGEMENT (MAM) INTERIM SYNTHESIS REPORT PRECONSTRUCTION THROUGH PROJECT YEAR 1 (2024)**


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## SUGGESTED CITATION

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| Acronym | Term |
|---|---|
| ANOVA | Analysis of variance |
| CF | Confined edges along a flow pathway |
| CI | Confidence interval |
| CIMS | Coastal Information Management System |
| CO | Confined edges along an open bayou |
| CPRA | Coastal Protection and Restoration Authority |
| CPUE | Catch per unit effort |
| CRMS | Coastwide Reference Monitoring System |
| CW | Carapace width |
| DEM | Digital elevation model |
| DWH | *Deepwater Horizon* |
| FIMP | Fisheries Independent Monitoring Program |
| FQI | Floristic Quality Index |
| GF | Gaps along flow pathway |
| GO | Gaps along an open bayou |
| GPS | Global position system |
| HRI | Habitat Resource Index |
| I | Interior |
| IEI | Index of Energetic Importance |
| IQR | Interquartile range |
| LA TIG | Louisiana Trustee Implementation Group |
| LDWF | Louisiana Department of Wildlife and Fisheries |
| LSU | Louisiana State University |
| MAM | Monitoring and Adaptive Management |
| MCA | Marsh creation area |
| ME | Marsh edge |

| Acronym | Term |
| --- | --- |
| NAVD | North American Vertical Datum |
| NOAA | National Oceanic and Atmospheric Administration |
| NRDA | Natural Resource Damage Assessment |
| OW | Open water |
| P | Pond |
| PA | Project Area |
| PERMANOVA | Permutational multivariate analysis of variance |
| PCoA | Principal coordinates analysis |
| RA | Reference Area |
| RTK | Real time kinematic |
| SAV | Submerged aquatic vegetation |
| SD | Standard deviation |
| SEFSC | Southeast Fisheries Science Center |
| TL | Total length |
| U | Unconfined edges |
| USGS | United States Geological Survey |
| VVI | Vegetation Volume Index |

# ACKNOWLEDGEMENTS

This report was prepared by the Water Institute of the Gulf (the Institute) using Federal funds under award number NA24NMFX463C0001-T1-01 from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Several team members of the Institute collaboratively developed this report including Erin Kiskaddon, Shawn Doyle, Emelia Marshall, Maricel Beltran Burgos, Tim Carruthers, Jessica Henkel, and Mike Miner. David Reeves, Gabrielle Armin, Melissa Carle, and Ian Zink of the National Oceanic and Atmospheric Administration (NOAA) provided review and guidance. Camille Stagg and Brett Batton of the U.S. Geological Survey (USGS) collected vegetation and soil data and provided review and guidance during the development of this report. Lastly, we wish to thank the tireless efforts of Rissa Inselman at Nicholls State University for her commitment to providing hands-on research experience to undergraduate students while processing nekton samples for this project. Technical editing of this report was completed by Charley Cameron of the Institute.

# EXECUTIVE SUMMARY

The *Deepwater Horizon* (DWH) oil spill released historic amounts of oil and contaminants into marine and coastal environments situated along the northern Gulf Coast. Response activities at times caused additional damage while remediating the spill. Of the five Gulf States, Louisiana's shores were significantly impacted and experienced the most severe oiling (Nixon et al., 2016). In particular, the Barataria Basin of coastal Louisiana was subjected to heavy and persistent oiling, injuring both natural resources and ecosystem services provided by wetland habitats. Decreased plant cover, decreased production of important species stocks, and increased marsh edge erosion were some of the injuries observed in the Basin (DWH Natural Resource Damage Assessment [NRDA] Trustees, 2016a). Typically, wetlands provide a wealth of ecosystem services which directly benefit humans living in this region, including storm surge protection, enhanced water quality, recreational opportunities, and production of commercially important species. However, due to injuries from the DWH spill, many of these natural resources and the ecosystem services they provide, particularly habitat provisioning as a supporting ecosystem service, were severely and negatively impacted in Barataria Basin.

As part of a large-scale effort to restore and conserve injured wetland habitats and their habitat provisioning support services in Barataria Basin, the Louisiana Trustee Implementation Group implemented the Large-Scale Barataria Marsh Creation: Upper Barataria Component (BA-207) restoration project (termed the Upper Barataria Project). The Upper Barataria Project was designed to build a large area of intertidal marsh and constructed water features which include flow pathways, a large pond, unconfined fill areas, and containment dike gaps to promote ecological function. This restoration project also includes 20 years of post-construction monitoring to assess the following objectives:

- **Objective 1- Marsh Creation:** Create approximately 1,183 acres of intertidal marshes and water features.
- **Objective 2- Basin Connectivity:** Create and/or restore interspersed and ecologically connected marshes.
- **Objective 3- Productivity:** Increase vegetation and nekton productivity in the project area.

Upper Barataria Project construction concluded in April 2023 and the final site inspection occurred in November 2023. Following construction, the monitoring period began for which a variety of performance criteria were established to assess progress towards these project objectives (see Table 1 below for summarized performance criteria). Additional monitoring and/or analyses were conducted to provide additional context with regards to the ecological function and the services the Upper Barataria Project provides, though these were not intended to reflect an assessment of project performance. This report outlines the first year of post-construction monitoring results and corresponding analyses aligned with the above objectives and additional learning goals.

As of 2023, an immense step towards **Objective 1** was achieved; 1,259 acres of marsh and created water features were built within the Upper Barataria Project footprint (also referred to as the Project Area), with a total of 1,170 acres of emergent wetland habitat. The constructed marsh is comprised of five large areas, known as marsh creation areas (MCAs). Immediate post-construction surveys across the Project Area indicate mean elevations of +1.22 ft to +1.88 ft NAVD88. This falls short of the +2.5 ft minimum as-built target for all MCAs but remains above the +1 ft project life target. As monitoring continues, the spatial extent, project elevation, and marsh fragmentation will be assessed to determine the success and resilience of the restored marsh. A sustained, healthy marsh will create habitat for many species, aid in stabilizing the shoreline, and reduce surge risk from future tropical storms over an extended period of time.

As a transitional habitat, wetlands require connectivity to surrounding areas in the Basin to act as functional parts of the ecosystem. Water levels, marsh platform inundation, and the presence of target fish and mobile invertebrate species (also termed "nekton") were parameters used to track progress towards **Objective 2**. In the first year of monitoring, MCAs 1B and 2B met inundation targets, while MCAs 1A, 2A, and 3A were inundated less than 10% of the time and did not meet the performance target. The lower inundation may be attributed to higher constructed average elevation and/or slower settling rates associated with those MCAs. However, over time, all MCAs are expected to meet the inundation goal.

Despite not yet fully achieving the inundation target, most target nekton species (discussed further under Objective 3 for secondary productivity) were observed within seine and trawl nets deployed adjacent to the Project Area as well as within drop samplers deployed directly within the Project Area. Only Red Drum, *Sciaenops ocellatus*, were not observed; however, these organisms may have been missed due to the timing of sample collection. Presence of target nekton species suggests connectivity with the broader Basin. As connectivity is maintained over time, nekton access to the marsh interior should increase as the elevation of MCAs settles further and water passes readily into the constructed marsh. These connections allow transient nekton species to move in and out of the constructed marsh for use as nursery and forage habitats during different life stages. Greater basin connectivity also supports the transportation of nutrients, food, and energy to adjacent inshore open waters and ultimately to the open ocean to sustain broader nearshore and offshore marine food webs.

To address **Objective 3**, both primary and secondary productivity were analyzed using a wide variety of parameters. For primary production, the Project Area has room to grow until formal project performance assessment in Years 3 and 6. Overall vegetation cover, species cover, height, and diversity are all guiding factors. Vegetation and soils monitoring was conducted by the United States Geological Survey within the Project Area and Reference Area following methods that align with the Coastwide Reference Monitoring System. In Year 1, the overall vegetation cover in the Project Area was significantly lower than in the Reference Area (located ~1 km south of the Project Area), and the vegetation communities were significantly different in terms of the number of different species and the evenness of the community. The differences observed in primary production in the early stages of the Project's lifetime are aligned with plant community succession patterns mediated by elevation as observed in other marsh restoration projects in Louisiana (Edwards & Proffitt, 2003). Furthermore, early establishment of the invasive plant species *Phragmites australis*—a species highly tolerant of a wide range in environmental conditions—within the Project Area may have been exacerbated by storms and drought during the period of project construction. Further establishment of resilient native species and increased overall vegetation cover will provide a variety of habitats, food sources, and refuge for faunal species as well as support efficient nutrient cycling, decrease erosion, and increase storm protection. Ultimately, enhanced primary production in the constructed marsh will support secondary production of primary consumers and higher trophic level consumers that prey upon them.

For secondary production, a number of nekton species were identified as "target nekton" due to their vital role in the ecosystem and their importance to commercial and recreational fisheries. Some of these valuable target species include the Blue Crab (*Callinectes sapidus)* and White Shrimp (*Penaeus setiferus*), whose landings combined generated over $120 million USD in Louisiana in 2024 (NOAA, 2025a). Nekton monitoring data for this project were obtained using trawls and seines within the Fisheries Independent Monitoring Program (FIMP) conducted by Louisiana Department of Wildlife and Fisheries, and fixed-area gear types (i.e., drop sampler and throw trap), otherwise known as "enclosure traps," collected by The Water Institute in collaboration with Nicholls State University.

In the first year of monitoring, the FIMP data pointed to a significantly higher relative abundance (catch per unit effort, CPUE) of Blue Crab collected by trawls, as well as higher biomass and individual sizes of White and Brown Shrimp (*Penaeus aztecus*) collected by seines adjacent to the Project Area. There were no other significant differences observed in CPUE for the other target species between the Project and Reference areas. Fixed-area gear types collected significantly larger individuals of Blue Crab, Killifish[1] species, and White Shrimp in open water habitats located near the marsh edge within the Project Area. Additionally, significantly larger sized White Shrimp were observed in the marsh edge habitats of the Project Area, but significantly fewer individuals were observed. The presence of larger individuals in the Project Area may point to the initial lack of appropriate marsh vegetation that serves as refuge habitat for smaller individuals. Importantly, the number of monitoring events captured in this report may not be sufficient to determine restoration impacts to specific target species at this time. As habitat types in the constructed marsh area start to more closely resemble the Reference Area, target nekton in these areas will most likely start to converge. Formal assessment of the Project by these secondary productivity metrics is expected in Year 8.

One year post-construction, the major takeaways from monitoring associated with the Upper Barataria Project objectives suggest:

- **Objective 1:** Expansive marsh habitat, including marsh platform and water features, has been established.
- **Objective 2:** Signs of basin connectivity were detected, and marsh access will likely improve with increased marsh settlement and inundation.

[1] As defined in the Monitoring and Adaptive Management plan (LA TIG, 2024), this guild comprises multiple species including: Rainwater killifish (*Lucania parva*); Gulf (*Fundulus grandis*), Longnose (*F. similis*), Diamond (*F. xenicus*), Bayou (*F. pulvereus*), and Saltmarsh (*F. jenkinsi*) killifish; Golden topminnow (*F. chrysotus*); Least killifish (*Heterandria formosa*); Sailfin molly (*Poecilia latipinna*); and Sheepshead minnow (*Cyprinodon variegatus*).

- **<u>Objective 3:</u>** Differences in sizes and abundances/densities of some target nekton species between the Project and Reference areas were noted but may change in coming years as the habitat quality in Project Area continues to evolve.

Thus far, the created marsh and water features have built habitat spanning over 1,200 acres for many important species even at this early post-construction stage. Similarly, this project has initiated the restoration of ecosystem services like nutrient cycling, production of ecologically and commercially relevant species, and storm protection. Ecological function may take more time to develop in the Project Area as inundation, vegetation coverage, and vegetation communities evolve. Looking ahead, the marsh platform is expected to continue settling which will lead to increased inundation, progressing all MCAs towards achieving relevant performance criteria. Additionally, further colonization of vegetation and community succession in subsequent years may lead to the creation of an environment more suitable for typical marsh nekton. The Upper Barataria Project has set a foundation for a healthy marsh which has great potential to restore natural resources and ecosystem services in the Barataria Basin that were degraded by the DWH oil spill.

*Table 1. Summary of performance criteria and status after project construction completion and the first year of monitoring (2024). Criteria not assessed in this report are indicated by "–".*

| Objective Addressed | Performance Criteria | On Target? |
|---|---|---|
| **1 – Marsh Creation** | 1,183 acres of wetland created as-built | Yes |
| | Land loss is not faster than reference at Year 20 | – |
| | Marsh elevation of +2.5-3.0 ft as-built | No |
| | Marsh elevation maintained at +1 ft | – |
| **2 – Basin Connectivity** | Inundation of 10–90% exceedance for all MCAs | No |
| | Presence of target nekton in seines and trawls | Yes |
| | Presence of target nekton in fixed-area gears | Partially |
| **3 - Productivity** | Vegetation cover is not less than reference by Year 6 | Not yet |
| | Vegetation composition and vigor are not different than reference by Year 3 | Not yet |
| | Relative abundance, size, and biomass of target nekton in seines and trawls are not less than reference by Year 8 | Not yet |
| | Density, size, and biomass of target nekton in fixed-area gears are not less than reference by Year 8 | Not yet |
| | Secondary productivity is enhanced by Year 20 | – |
| | Habitat value for target species is improved | – |

# 1.0 INTRODUCTION

The Large-Scale Barataria Marsh Creation: Upper Barataria Component (BA-207) restoration project referred to as the Upper Barataria Project (Figure 1) was approved by the *Deepwater Horizon* (DWH) Oil Spill Louisiana Trustee Implementation Group (LA TIG) in their Final Phase II Restoration Plan and Environmental Assessment #3.3 Restoration Plan (DWH Trustees, 2020). The project was specifically designed to offset injuries to coastal wetlands and associated wildlife caused by the DWH oil spill. It directly addresses the programmatic goal of "Restoring and Conserving Habitat," explicitly "Wetlands, Coastal, and Nearshore Habitats" within the Barataria Basin. The Upper Barataria Project also incorporates targeted design factors such as hydrologic connectivity, shallow water features, and unconfined edge habitat to address injuries to associated living coastal and marine resources by restoring the ecological functions provided by these habitats.


*Figure 1. The Upper Barataria Marsh Creation Project. Aerial photo collected in July 2023, 2 months after the marsh creation areas were filled. Photo credit: Patrick M. Quigley.*

The wetlands of Barataria Basin support many ecologically important species—including shrimps, crabs, and fishes—throughout various stages of their life cycles (DWH Natural Resource Damage Assessment [NRDA] Trustees, 2016). The DWH oil spill inflicted significant damage on natural resources, ranging from a threefold increase in coastal erosion in heavily oiled marshes to decreased growth rates and mortality in some species (LA TIG, 2024).

Beyond addressing the primary objective of restoring natural resource damages associated with the DWH oil spill, the Upper Barataria Project also addresses severe ongoing shoreline erosion and the loss of intertidal and brackish marshes along the degraded Barataria Landbridge (Coastal Protection and Restoration Authority [CPRA], 2023). The Upper Barataria Project is one of a handful of previously constructed marsh creation areas (MCAs) positioned closely together in an area south of The Pen in Jefferson Parsh, Louisiana (Figure 2). Together, these projects serve to restore the Barataria Landbridge, a critical hydrologic barrier that separates freshwater marshes in the upper basin from more saline marshes in the lower basin, and also served to dampen hurricane storm surges. Its deterioration has led to further saltwater intrusion and widespread marsh degradation (Hymel, 2017; Lindquist, 2007).

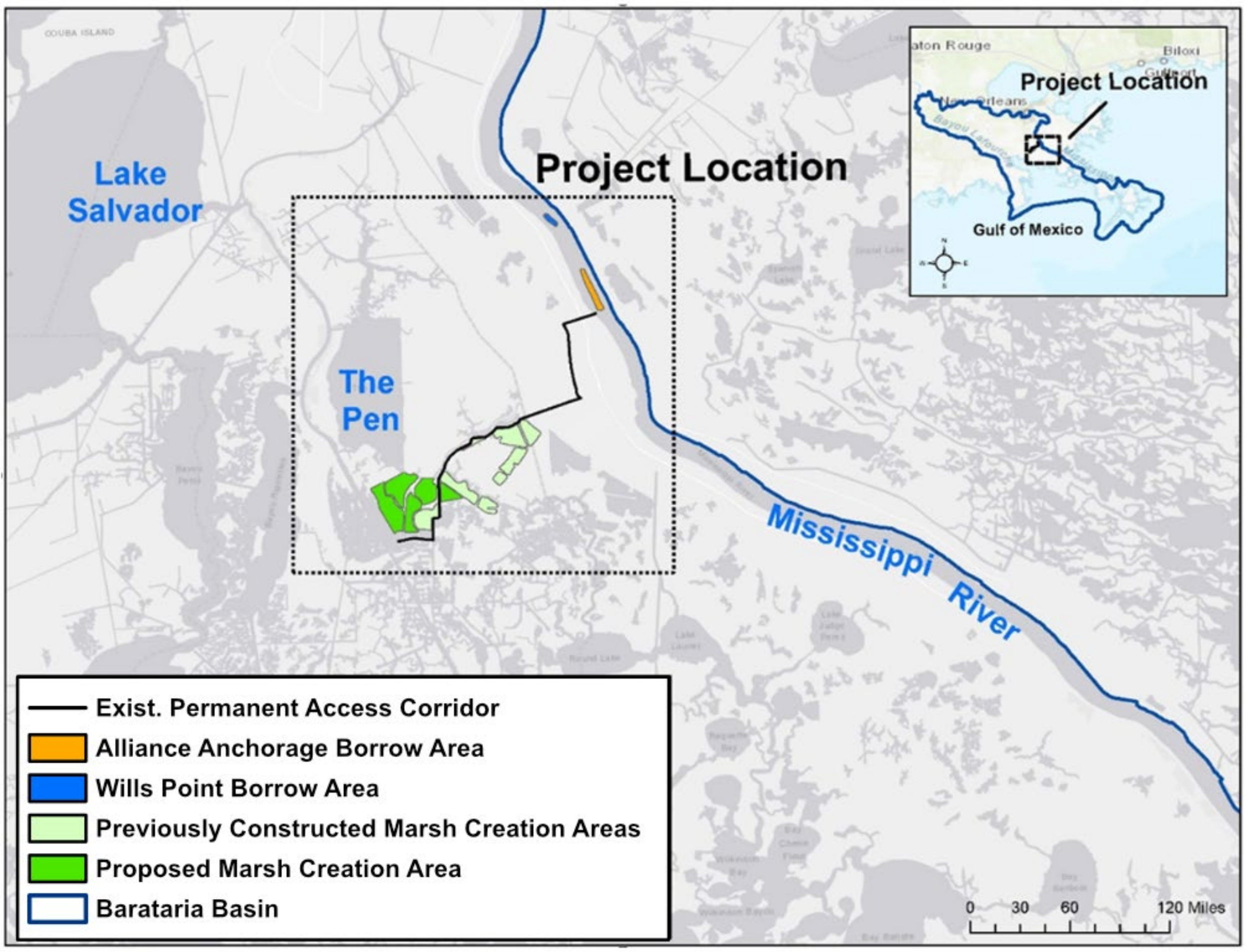


*Figure 2. Location of the Upper Barataria Project Area (darker green, “Proposed Marsh Creation Area”) in the Barataria Basin. Modified from Figure 1-1 in the Louisiana Trustee Implementation Group Final Phase II Restoration Plan/Environmental Assessment #3.3: Large-Scale Barataria Marsh Creation: Upper Barataria Component (BA-207) (DWH, 2020).*

## 1.1 PROJECT OVERVIEW

The Upper Barataria Project, implemented by the National Oceanic and Atmospheric Administration (NOAA) aims to restore interconnected coastal wetland habitats in the Upper Barataria Basin in coordination with other restoration projects in the same area (e.g., BA-164 Bayou Dupont Sediment Delivery – Marsh Creation and Terracing #3 project [funded by Coastal Wetlands Planning, Protection, and Restoration Act]). The project site is located approximately 15 miles south of New Orleans, spanning both Jefferson and Plaquemines parishes, Louisiana (Figure 2).

This restoration effort involved creating approximately 1,200 acres of intertidal marsh habitat within the Upper Barataria Project footprint (also referred to as the Project Area). The project utilized borrow material from the Mississippi River to fill five MCAs following methods used to construct other successful restoration projects. MCAs for the Upper Barataria Project ranged from fully confined (e.g., MCA 1A), partially confined (e.g., MCA 1B, 2B, and 2A), and fully unconfined (e.g., MCA 3A) by earthen containment dikes (Figure 3). After fill placement was complete, excavators were used to degrade 50-foot sections of the containment dike throughout the Project Area to facilitate dewatering and nekton access to the interior area of the MCAs. Flow ways were constructed through the containment dikes and between sections of diked MCAs to ensure tidal exchange and connectivity between and among MCAs and the larger Barataria Basin (DWH, 2020).


*Figure 3. Locations of elevated containment dikes of the Upper Barataria Project. Reproduced from Figure 3-4 in the Louisiana Trustee Implementation Group Final Phase II Restoration Plan/Environmental Assessment #3.3: Large-Scale Barataria Marsh Creation: Upper Barataria Component (BA-207) (DWH, 2020). Acronyms: UBMC = Upper Barataria Marsh Creation; ECD = earthen containment dike; MCA = marsh containment area.*

Construction took place from May 2022 through April 2023 and experienced delays due to Hurricane Ida, which impacted the area in August 2021. Upon completion, the total constructed area was 1,259 acres, comprising 1,170 acres of marsh platform and 89 acres of water features (68.5 acres of tidal pond and 20.5 acres of flow pathways emulating tidal creeks). A total of 18,815 linear feet of flow pathways were constructed within the Project Area.

The marshes created by the Upper Barataria Project are expected to persist for at least a 20-year project life, accounting for sea-level rise and subsidence (DWH, 2020). To evaluate the performance of the restored intermediate and brackish marsh habitat for the life of the project, the NOAA Restoration Center established a 20-year Monitoring and Adaptive Management (MAM) plan which describes the ecological setting of the project, defines the major objectives of project monitoring, and identifies performance parameters and targets to assess project performance (LA TIG, 2024). The identified restoration objectives include:

- **Objective #1 – Marsh creation:** Create and restore approximately 1,183 aces of intertidal marsh and water features. Monitoring for this objective assesses the spatial extent and fragmentation of the project site over time.
- **Objective #2 – Basin connectivity:** Create and restore interspersed and ecologically connected marshes in the Upper Barataria Basin by constructing flow pathways that ensure hydrologic and biologic connections among MCAs. Monitoring for this objective tracks hydrology and biologic connectivity over time.
- **Objective #3 – Productivity:** Increase vegetation and nekton productivity within the Project Area. This objective's monitoring evaluates primary productivity (via vegetation community composition and vigor) and secondary productivity (via target nekton species standing stock density and biomass) at the project site compared to a nearby Reference Area over time.

A suite of monitoring parameters was identified for assessing each objective. Some parameters are used to directly assess project performance, whereas others are included for context purposes. Contextual parameters were defined to support interpretation and assessment of performance parameters. Many of the monitoring parameters were also used to evaluate the learning goals described in Section 3.1.

## 1.2 REPORT STRUCTURE

This synthesis report documents the objectives, methods, data, and results of the Upper Barataria Project MAM program from the start of construction in 2021 through the most recent post-construction monitoring in 2024 (Project Year 1). **Section 2.0** reports the detailed analytical methods and findings for performance- and context-related monitoring parameters organized by objective: (1) marsh creation; (2) basin connectivity; and (3) productivity. **Section 3.0** provides a synthesis and discussion of the analytical findings from Section 2.0, including evaluation of whether the Upper Barataria Project monitoring contributes to broader marsh restoration learning goals, specifically investigating whether ecosystem services are enhanced by hydrologic and biological connectivity and by various marsh edge types (e.g., unconfined and diked marsh edges) created by the targeted water features (e.g., gaps and flow pathways). Lastly, **Section 4.0** identifies recommendations and lessons learned relevant to project monitoring.

Some monitoring activities described in the project MAM Plan (LA TIG, 2024) will not be completed until future monitoring cycles and such instances are clearly noted. Further, some monitoring activities have not yet accumulated sufficient data to facilitate more detailed analyses and thus some data may be summarized but not analyzed for statistical significance in this report. It is anticipated that future synthesis reports for the Upper Barataria Project will include analyses and results as warranted by the availability of data and/or the completion of specific monitoring activities.

# 2.0 MONITORING

The Upper Barataria Project MAM Plan describes the monitoring parameters used to assess project outcomes across three main objectives: (1) marsh creation; (2) basin connectivity; and (3) productivity (LA TIG, 2024). This section is organized by objective and describes the analysis of each parameter across individual years of monitoring and against multi-year trends as relevant and available. For ease of navigation, Table 2 outlines the parameters and metrics nested under each monitoring objective.

*Table 2. Structure of Section 2.0 provided to define which parameters (headers) and metrics (bullets) were evaluated for each objective. Text differentiates between performance and context parameters. Performance parameters are used to directly assess project performance, whereas context parameters are included to help with interpretation of the performance parameters.*

| Objective | Parameters & Metrics |
|---|---|
| Objective #1: Marsh creation | Parameter #1: Spatial extent (acres) of created tidal marsh platform.<br>• Total Land Area and Land Area Change (Performance).<br>• Marsh Area Elevation and Settlement (Performance).<br>Parameter #2: Marsh fragmentation (Context). |
| Objective #2: Basin connectivity | Parameter #3: Water levels & salinity.<br>• Tidal signal (Context).<br>• Inundation (Performance).<br>• Salinity (Context).<br>Parameter #4: Presence of target nekton species.<br>• Presence of target nekton: 50 ft seine and 6 ft trawl (Performance).<br>• Presence of target nekton: fixed-area gear types (Performance).<br>• Assemblage composition of nekton: 50 ft seine, 6 ft trawl, and fixed-area gear types (Context).<br>• Red drum utilization of the Project Area by acoustic telemetry (Performance). |
| Objective #3: Productivity | Parameter #5: Primary productivity.<br>• Primary Productivity: Vegetation Height, Cover, and Indices of Community Composition and Vegetation Vigor (Performance).<br>• Soil Porewater Characteristics (Context).<br>• Soil Properties (Context).<br>• Jefferson Parish Cypress Plantings (Context).<br>Parameter #6: Secondary productivity.<br>• Abundance, size distribution, and biomass of target nekton collected by multiple gear types: 50 ft seine and 6 ft trawl (Performance).<br>• Density, size distribution, and biomass of target nekton collected by multiple gear types: Fixed-area gear types (Performance).<br>• Secondary productivity by overall production (Performance).<br>• Secondary productivity by habitat resource index (Performance). |

For all objectives, the Coastwide Reference Monitoring System (CRMS) site 0248 and surrounding area is the primary Reference Area for comparison against the Project Area over time (Figure 4).

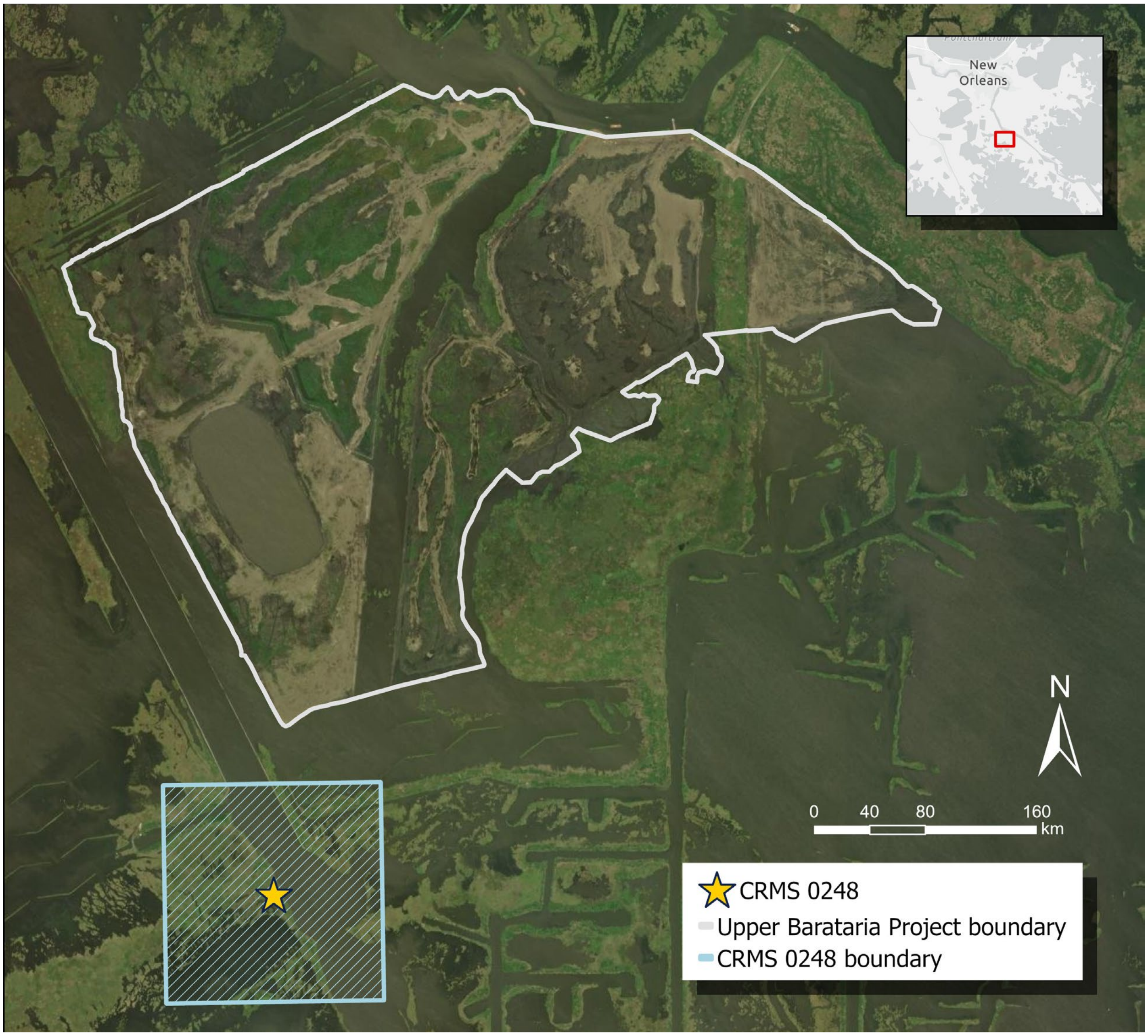


*Figure 4. The Upper Barataria Project Area boundary and Reference Area location. The Project Area boundary is delineated by the solid white line, whereas the Reference Area (CRMS0248) boundary is shown in light blue hatched with a star representing the station centroid.*

## 2.1 OBJECTIVE #1: MARSH CREATION

### 2.1.1 Parameter #1: Spatial extent (acres) of created tidal marsh platform

This parameter is used to directly assess project performance by quantifying the acreage of created tidal marsh platform immediately post-restoration as well as the change in land area and its elevation over time. The metrics used to evaluate this parameter include:

- **Total land area (Purpose: Performance)**
- **Land area change (Purpose: Performance)**
- **Marsh area elevation (Purpose: Performance)**

- **Marsh area settlement (Purpose: Performance)**

### *2.1.1.1 Total Land Area and Land Area Change*

**Methods**: The areas of land and water within the 1 $km^2$ (247.1 acre) area of CRMS0248 Reference Area and the 6.66 $km^2$ (1,646 acre) Project Area footprint were delineated to serve as both geographic and quantitative assessments of landscape composition on the date of image acquisition (Beck et al., 2023). Using aerial orthophotographs, the perimeters of land area and water features within the Project Area were digitized following the same methods used for the CRMS datasets—protocols detailed in Rufe (2014). In brief, Digital Orthophoto Quarter Quadrangles flown in 2018 and subsequent years (coastwide aerials acquired by the state every 3 years during fall/winter) were classified into land and water categories using a threshold of the near-infrared band, followed by supervised and unsupervised classification. Initial unsupervised classification results were revised by multiple image analysts to identify and manually recode errors. The resulting datasets, in the form of raster image datasets with 1-m classified pixels, were published as a United States Geological Survey (USGS) data release following internal USGS review and creation of a map displaying the orthophotographs and the land:water dataset.

For monitoring of the Upper Barataria Project, USGS utilized the imagery from 2018 and 2021 to delineate land and water coverage within the Project Area footprint pre-construction (Beck & Dugas, 2021, 2024). Pre-construction data for the Reference Area (CRMS0248) accessed via the CRMS spatial viewer (https://www.lacoast.gov/crms_viewer/Map/CRMSViewer). Total land area (acres, % of total area) was summarized to provide additional insight of pre-construction land loss trends analyzed using simple linear regression to identify the rate of change (% land area change $year^{-1}$). At the time of writing, land:water delineation for the Upper Barataria Project footprint was only available at two timepoints pre-construction (2018 and 2021), with no available data post-construction. Due to insufficient sample size (not enough monitoring data yet to have a minimum of three data points for a trend line), no statistical comparisons were possible for comparing the rate of change between the Project Area and Reference Area. Simple summary statistics and rates of change were provided.

**Results – Long-Term Trends at Reference Site**: Available pre-construction data for the Reference Area spanned the years 2012, 2016, 2018, and 2021 (Figure 5, Table 3; Beck et al., 2023). Between 2012 and 2021, the long-term rate of land area change showed a loss of 0.71 % (~1.3 acres) of land area per year.

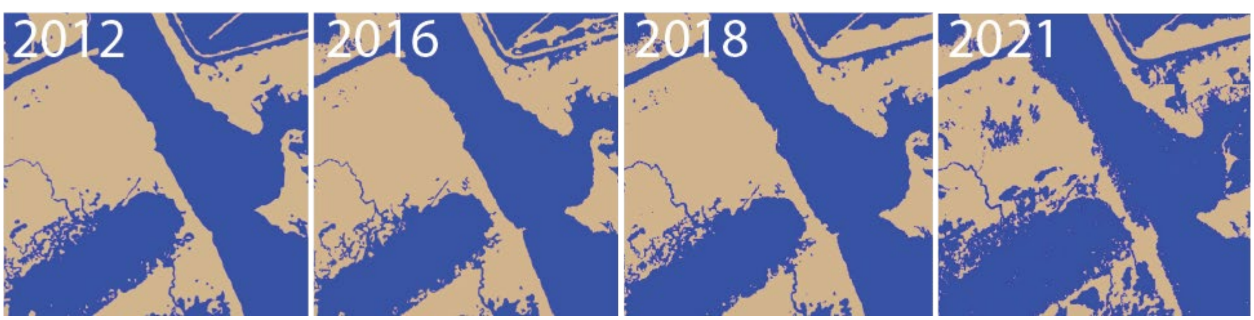


*Figure 5. Land:water delineation of the Reference Area (CRMS0248) through time. Imagery based on 2012, 2016, 2018, and 2021 aerial surveys (Beck et al., 2023).Data for the Reference Area was accessed in February 2025 via the CRMS Spatial Viewer.*

*Table 3. Total acreage and proportion (%) of land at the Reference Area (CRMS0248) for each year imagery was delineated by USGS (Beck et al., 2023). Data for the Reference Area was accessed in February 2025 via the CRMS Spatial Viewer.*

| Year | Size of Area Analyzed (acres) | Total Land (acres) | Total Land (%) |
|---|---|---|---|
| 2012 | 247.1 | 114.7 | 46.4 |
| 2016 | 247.1 | 121.4 | 49.1 |
| 2018 | 247.1 | 120.7 | 48.8 |
| 2021 | 247.1 | 103.2 | 40 |

**Results – Pre-Construction Reference and Project Area Comparisons**: The Upper Barataria Project created 1,259 acres of tidal wetland habitat, including 1,170 acres of tidal marsh, 68.5 acres of tidal pond, and 20.5 acres of tidal creeks. Delineated land:water data for the Upper Barataria Project footprint were available for pre-construction years 2018 (Figure 6) and 2021 (Figure 7), with data values provided therein (Table 4).

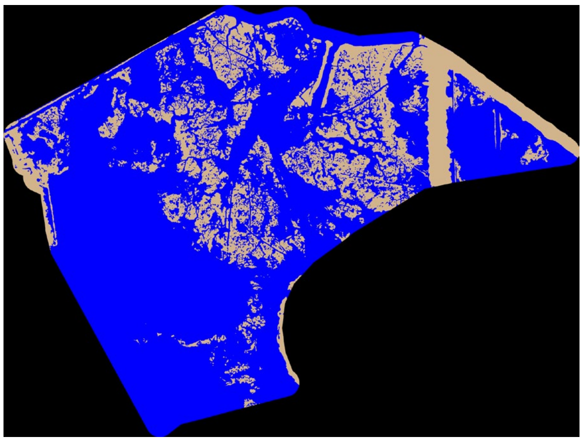

*Figure 6. 2018 land:water delineation of the Project Area. Data for the Project Area was provided by USGS (Beck & Dugas, 2021).*

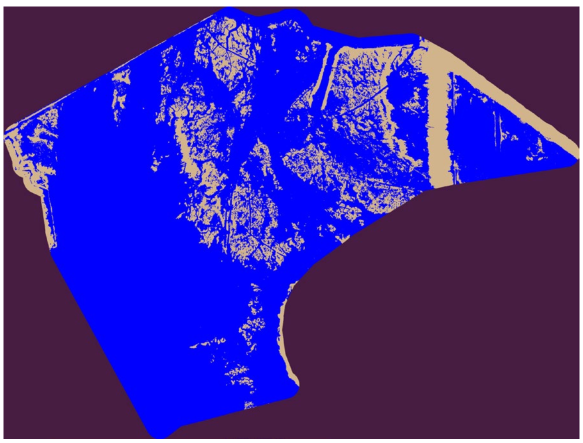

*Figure 7. 2021 land:water delineation of the Project Area. Data for the Project Area was provided by USGS (Beck & Dugas, 2024).*

*Table 4. Total acreage and proportion (%) of land in the Project Area. Data provided for each year that imagery was delineated by USGS (Beck & Dugas, 2021, 2024).*

| Year | Size of Area Analyzed (acres) | Total Land (acres) | Total Land (%) |
|---|---|---|---|
| 2018 | 1,646 | 415 | 25 |
| 2021 | 1,646 | 317 | 19 |

Data were only available for both the Project and Reference areas for years 2018 and 2021. In that period, the interpolated rate of total land area change was greater at the Reference Area (-2.93 % $year^{-1}$) compared to the Project Area (-2.00 % $year^{-1}$; Figure 8).

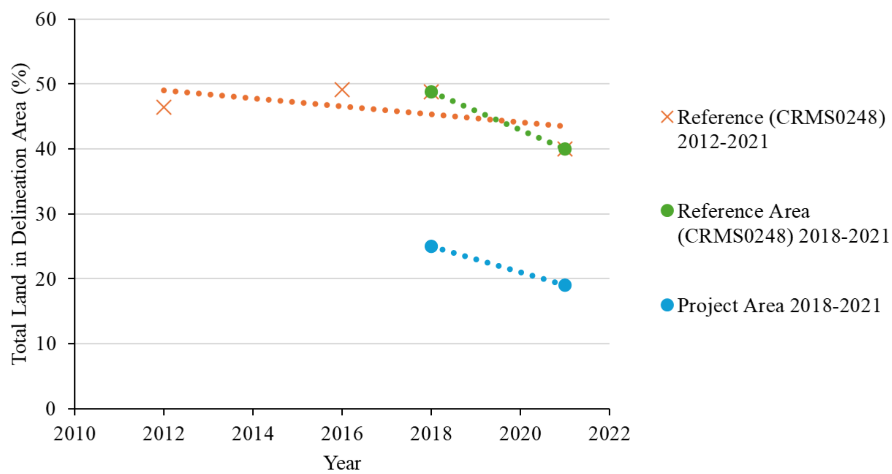


*Figure 8. Plot of land area (%) at the Project and Reference areas over time. Data for the Reference Area CRMS0248 was accessed in February 2025 via the CRMS Spatial Viewer and data for the Project Area was provided by USGS (Beck & Dugas, 2024).*

**Results – Post-Construction Comparisons**: The limited number of observations for both the Project and Reference areas prevented the use of statistical analyses to investigate if the rate of land cover change differed between them. Future Upper Barataria Project MAM Synthesis Interim reports will include this analysis once sufficient data has been collected.

**Project Performance Assessment:**

- ***Performance Criteria:*** *The total created wetland (marsh, created water features) built in the Project Area is <u>equal to or greater than 1,183 acres</u> (per final approved construction design).*
    - **Pre-Construction (< 2023)/As-Built (2023):** ***Performance Criteria Met*** – The total as-built constructed area was 1,259 acres inclusive of marsh and created water features. A total of 1,170 acres of emergent wetland habitat was constructed.
    - **Project Year 1 (2024):** Not assessed.

- ***Performance Criteria:*** *The total marsh platform area within the Project Area 20 years post-construction does* *<u>not exhibit a higher rate</u>* *of proportional land loss than the reference marsh at CRMS0248.*
    - **Pre-Construction (< 2023)/As-Built (2023):** ***Insufficient Data*** – Interpolated rate of land loss in the Project Area (-2.00 % $year^{-1}$) was less than the Reference Area (-2.93 % $year^{-1}$) between 2018 and 2021 pre-construction, however insufficient data were available to determine statistical significance of trends.
    - **Project Year 1 (2024):** Not assessed. Surveys planned, but data were not available at the time of writing.

#### *2.1.1.2 Marsh Area Elevation and Settlement*

**Methods:** Pre-construction (2022) and post-construction as-built (2023, Year 0) topographic elevation surveys of the Project Area were collected by the Upper Barataria Project's construction contractor using Real Time Kinematic (RTK) Global Position System (GPS) methods (Moffatt & Nichol, 2021). Surveys within each MCA footprint were organized along transects spaced approximately every 500 ft arranged in a grid pattern with survey points collected at a minimum every 50 ft. In total, 43 transect lines and 7,127 datapoints were surveyed in 2022, and 41 transect lines and 6,313 datapoints in 2023.[2] Subsequent surveys occurring over the life of the Project will use similar methods but may deviate from original spatial transect alignment in order to target features of interest.

Average (± SD) ground elevation of each MCA and the Project Area overall was evaluated using one-sided (meaning a "greater than" alternative) one-sample t-tests to determine if the observed average elevations (based on the manual RTK survey data) were as high or higher than the minimum post-construction target of +2.5 ft (North American Vertical Datum 1988 [NAVD88]) as-built. The null hypothesis was that the mean elevation was less than or equal to +2.5 ft, and the alternative hypothesis was that the mean elevation was greater than +2.5 ft. Future years of monitoring will evaluate whether the Project Area remains at the target elevation (average +1 ft NAVD88) throughout the 20-year Project life.

Ground surface elevation was visualized using digital elevation models (DEMs) created for each MCA footprint using the pre-construction and as-built RTK transect surveys. The point data from the transect surveys were interpolated using the Spatial Analyst tool in ESRI ArcPro and kriging interpolation, with a cell size of 50 ft. For each MCA, DEMs were created with the corresponding MCA footprint spatial delineations (polygons) and DEMs of elevation change were created by subtracting the as-built from the pre-construction DEMs using the Minus tool within the ArcPro software.

Lastly, a total of 33 settlement plates were embedded within the marsh platforms of each MCA and were surveyed alongside RTK elevation transects. The number of plates per MCA were as follows: MCA1A (n

[2] Datapoints collected outside the boundaries of the MCAs were excluded from elevation analyses.

= 7 plates), MCA1B (n = 12 plates), MCA2A (n = 5 plates), MCA2B (n = 6 plates), MCA3A (n = 3 plates). Surveys of settlement plates were conducted by the Upper Barataria Project construction contractor in 2022 and 2023 (Moffat & Nichol, 2024).

**Results:** Pre-construction, the DEM of the Project Area indicated that elevation was predominantly below +1.5 ft in 2022, with significant portions (83 %) at or below 0 ft (subtidal; Figure 9). Post-construction in 2023, the mean ground surface elevation across MCA footprints was variable, ranging from +1.22 ft (MCA1B) to +1.88 ft (MCA1A; Table 5). The highest measured elevation post-construction was +3.84 ft in MCA1A, while the lowest (-2.84 ft) was recorded in MCA1B. Results of the one-sided t-test indicate that the mean elevation of each MCA was significantly lower than the minimum project performance elevation target of +2.5 ft (Table 5). Therefore, the mean elevations observed immediately post-construction did not meet the performance goal of having a minimum average elevation of +2.5 ft NAVD88.

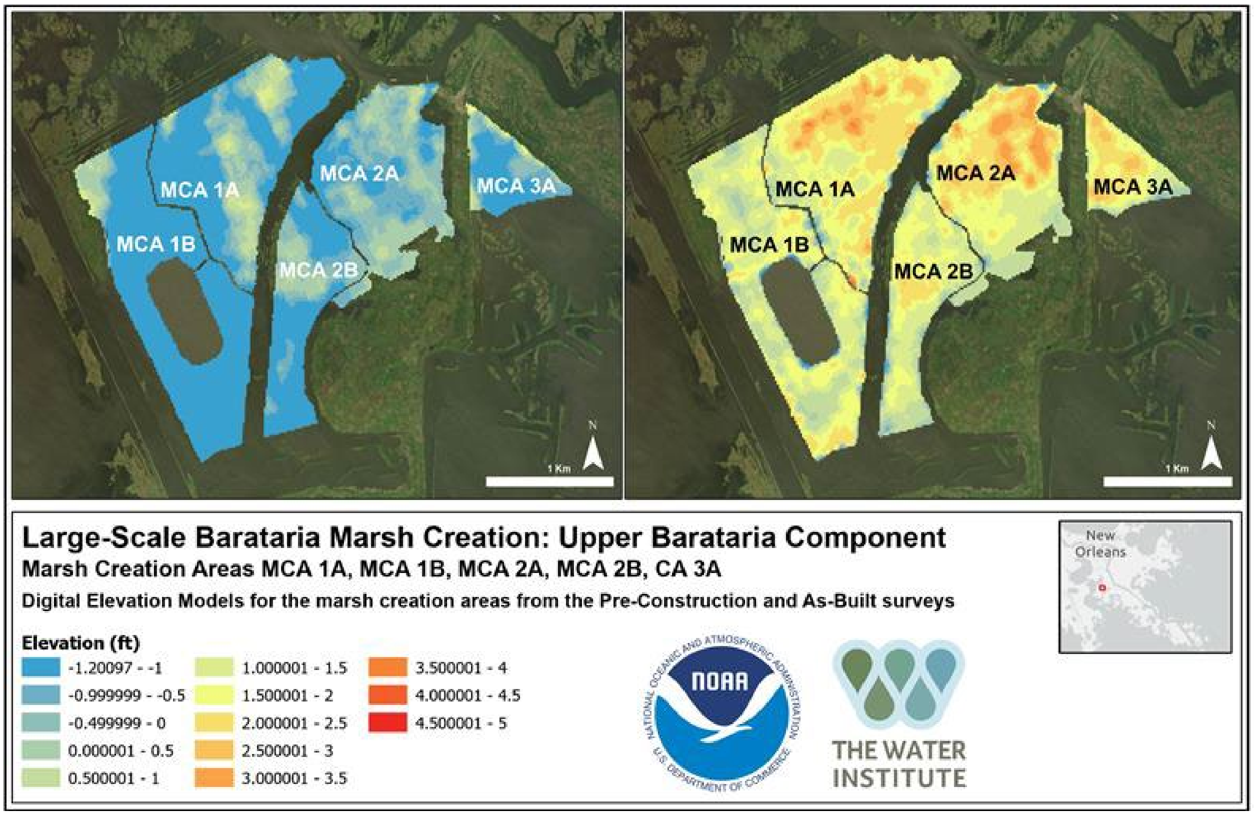


*Figure 9. Ground surface elevation of the Project Area in 2022 and 2023. Maps show digital elevation models for the Project Area based on pre-construction (2022) and as-built (2023) survey data. Identities of each MCA are provided. Elevation is given in ft NAVD88.*

*Table 5. Summary statistics of marsh fill elevations measured pre-construction and as-built in the Project Area. Marsh fill elevations (ft NAVD88) are based on RTK elevation transect surveys. Results of a one-sided t-test are provided to compare as-built mean elevations to the project performance criteria of a minimum target elevation of +2.5 ft at year 0 (2023). A p-value of 1 indicates that the observed sample means fall in the opposite direction of the alternative hypothesis; therefore, even accounting for the variability of elevation within each MCA, the mean as-built marsh elevations statistically did not meet the minimum project performance target of +2.5 ft NAVD88.*

| **Area** | **Pre-Construction (2022)** | | **As-Built (2023)** | | | | |
|---|---|---|---|---|---|---|---|
| | **Mean Elevation** (mean ± SD) | **Elevation Range** (min, max) | **Mean Elevation** (mean ± SD) | **Elevation Range** (min, max) | **n** | **t-stat** | ***p*-value** |
| MCA1A | -1.05 ± 1.1 | -4.43, +1.21 | +1.88 ± 0.64 | -1.89, +3.84 | 1,349 | -35.58 | 1.00 |
| MCA1B | -2.36 ± 0.91 | -4.25, +1.18 | +1.22 ± 0.55 | -2.84, +3.17 | 1,559 | -91.89 | 1.00 |
| MCA2A | -0.43 ± 0.63 | -3.2, +1.15 | +1.86 ± 0.78 | -1.63, +3.54 | 951 | -25.30 | 1.00 |
| MCA2B | -1.14 ± 0.93 | -3.88, +0.59 | +1.28 ± 0.57 | -2.10, +2.55 | 645 | -54.36 | 1.00 |
| MCA3A | -0.85 ± 0.82 | -2.22, +2.19 | +1.80 ± 0.64 | -0.69, +2.87 | 313 | -19.35 | 1.00 |
| Project Area | -1.27 ± 1.16 | -4.43, +2.19 | +1.60 ± 0.71 | -2.84, +3.84 | 4,817 | -87.98 | 1.00 |

The elevation change from pre-construction to as-built was notable across all MCAs of the Project Area (Figure 10), with the greatest changes observed in MCAs that were converted from mostly subtidal to emergent land (e.g., MCAs 1A, 1B, and 3A) between 2022 and 2023.

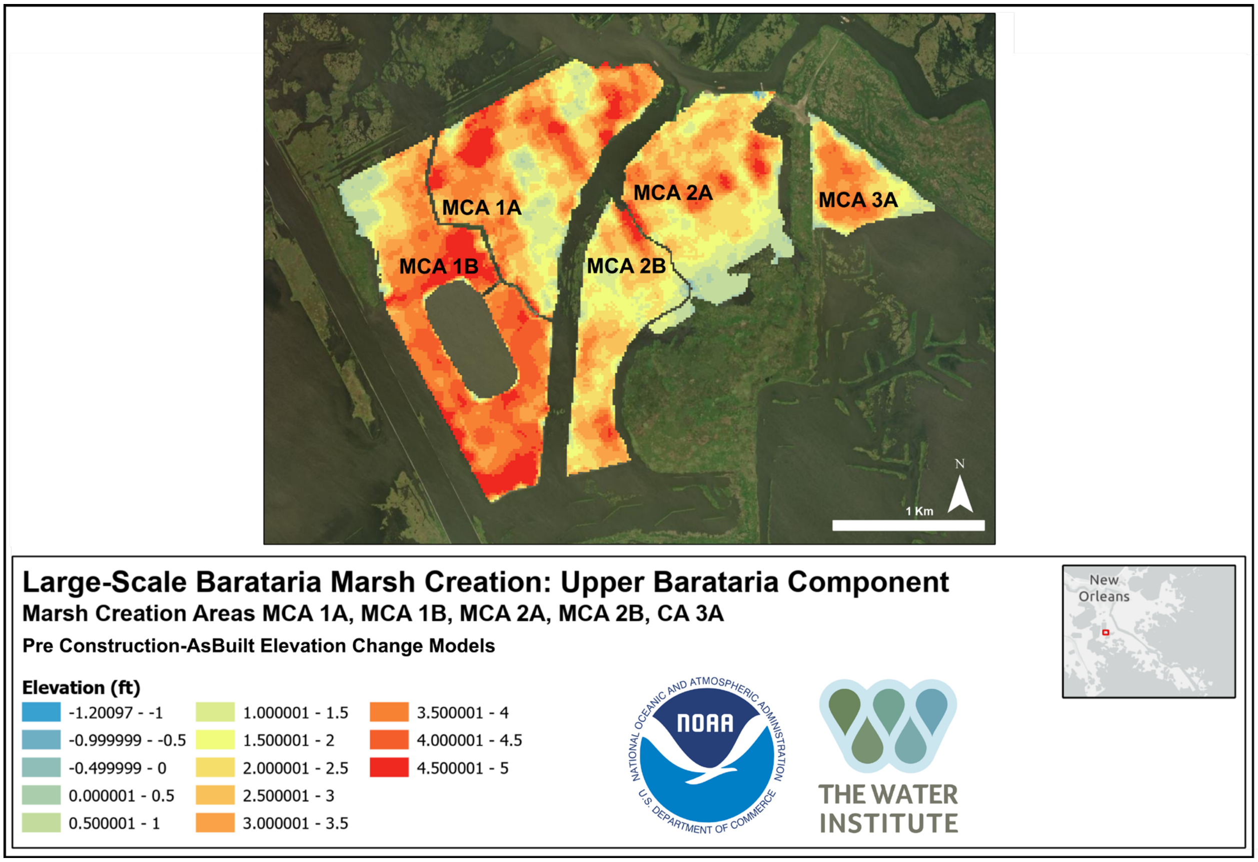


*Figure 10. Elevation change of the Project Area between 2022 and 2023. Map shows the digital elevation change model for the Project Area between pre-construction (2022) and as-built (2023). Identities of each MCA are provided. Elevation is given in ft NAVD88.*

Settlement data (of top and ground measurements) are presented in Table 6. Because settlement is a non-linear process, influenced by the time interval between measurements, calculating a settlement rate and making comparisons across MCAs at this time could be misleading considering the short time span of data collection. Therefore, data are presented in Table 6 as the difference between the most recent (2023) and first (2022) elevation measurement at each plate rather than as a rate. Settlement showed initial compaction and dewatering following construction and is aligned with what is expected based on other marsh creation projects in the area. Settlement plates set before October 2022 were displaced during the hydraulic fill placement and had to be reset post-construction (Moffat & Nichol, 2024). The data presented in Table 6 will serve as baseline for measurements and rate calculations obtained from future monitoring surveys and will be compared to the settlement curve presented in Figure 11 in future synthesis reports.

*Table 6. Settlement of the Project Area based on post-construction surveys. Top and ground settlement values measured at each settlement plate placed within the MCAs of the project area are provided based on surveys conducted between 2022 and 2023.*

| Area | Plate ID | First - Last Measurements | Top Elev-Settlement (ft) | Ground Elev-Settlement (ft) |
|---|---|---|---|---|
| MCA1A | 817 | 04/18/22–04/01/23 | -2.434 | 5.874 |
| | 812 | 03/17/22–05/12/23 | -0.264 | 0.876 |
| | 813 | 08/30/22–11/21/23 | 0.085 | 3.94 |
| | 814 | 08/14/22–11/21/23 | 0.248 | 1.011 |
| | 818 | 08/25/22–11/21/23 | 1.143 | 4.377 |
| | 816 | 08/30/22–11/21/23 | -0.123 | 2.031 |
| | 815 | 08/30/22–11/21/23 | 1.633 | 3.752 |
| MCA1B | 811 | 12/13/22–11/21/23 | -1.278 | -1.497 |
| | 809 | 12/13/22–11/21/23 | -1.995 | -2.653 |
| | 810 | 10/30/22–11/21/23 | 3.462 | 5.134 |
| | 806 | 12/13/22–11/21/23 | -1.956 | -1.99 |
| | 807 | 10/26/22–11/21/23 | -2.338 | 4.253 |
| | 808A | 10/26/22–11/21/23 | -1.649 | 2.131 |
| | 804 | 01/02/23–11/21/23 | -2.14 | -2.277 |
| | 805 | 11/09/22–11/21/23 | -1.694 | 0.174 |
| | 803 | 01/14/23–06/02/23 | -0.85 | -1.27 |
| | 802 | 01/18/23–09/22/23 | -1.339 | 1.405 |
| | 800 | 01/18/23–09/22/23 | -1.21 | 1.004 |
| | 801 | 05/01/22–04/01/23 | 1.991 | 6.891 |
| MCA2A | 823 | 03/30/23–11/21/23 | -0.388 | 4.618 |
| | 824 | 03/16/23–04/13/23 | 0.046 | 3.344 |
| | 820 | 03/16/23–04/22/23 | 4.26 | 2.717 |
| | 821 | 03/12/23–11/21/23 | -1.299 | 0.63 |
| | 822 | 04/10/22–11/21/23 | -2.08 | 1.489 |
| MCA2B | 830 | 03/08/23–11/21/23 | -0.818 | 1.874 |
| | 828 | 03/06/23–11/21/23 | -1.41 | -1.434 |
| | 829 | 03/08/23–11/21/23 | -0.497 | 2.192 |
| | 827 | 03/06/23–11/21/23 | -1.135 | -1.381 |
| | 826 | 02/07/23–02/14-23 | 0.183 | -0.021 |
| | 825 | 02/07/23–11/21/23 | -0.996 | -1.012 |
| MCA3A | 832 | 02/22/23–11/21/23 | -1.159 | 0.954 |
| | 833 | 02/19/23–11/21/23 | -1.579 | 0.533 |
| | 831 | 02/19/23–11/21/23 | -0.713 | 1.217 |

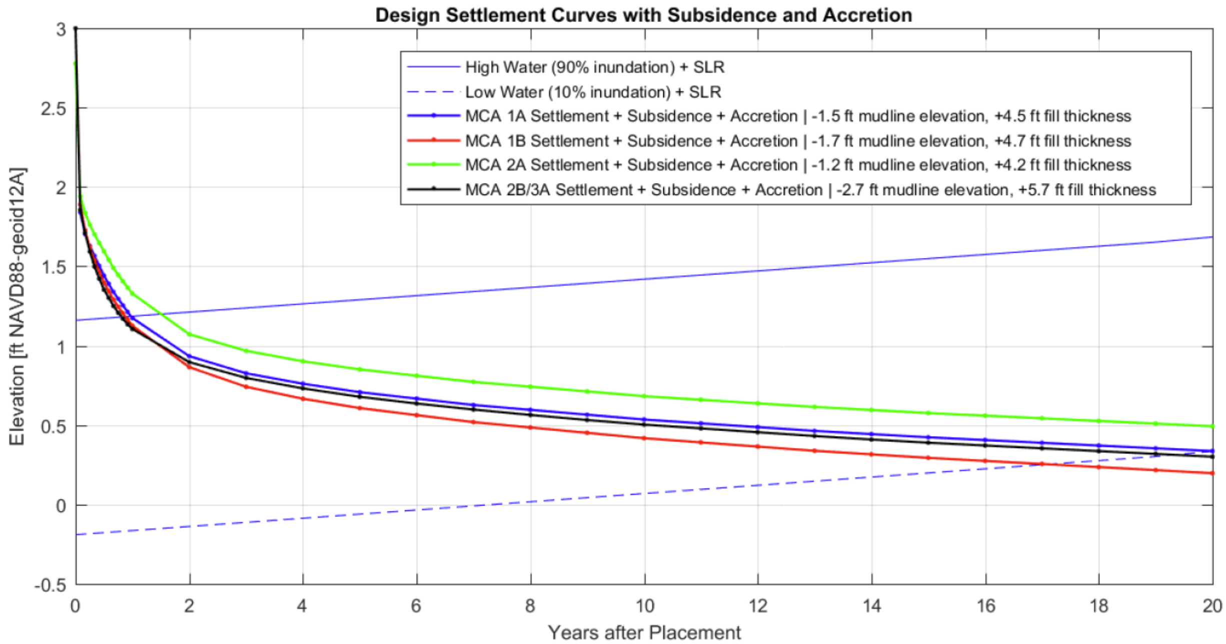


*Figure 11. 20-year settlement curves. Calculated settlement curves used for project design are provided for all marsh creation areas (MCAs) 1A, 1B, 2A, 2B, and 3A of the Upper Barataria Project. MCAs 2B and 3A show the same mudline elevation and therefore the settlement curves are equivalent. Figure reproduced from Figure 9 of the final construction completion report by Moffat & Nichol (2024).*

**Project Performance Assessment:**

- ***Performance Criteria:*** *The mean constructed marsh elevation for each MCA is* <u>*+2.5–3.0 ft NAVD88*</u> *immediately following construction (as-built surveys).*
  - **Pre-Construction (< 2023)/ As-Built (2023):** ***Performance Criteria Met*** – The mean as-built marsh elevation of all MCAs statistically did not meet the minimum project performance target of +2.5 ft NAVD88.
  - **Project Year 1 (2024):** Not assessed.
- ***Performance Criteria:*** *The constructed marsh for each MCA* <u>*maintains a mean elevation of +1 ft NAVD88*</u> *at the end of the Project life.*
  - **Pre-Construction (< 2023)/ As-Built (2023):** Not assessed.
  - **Project Year 1 (2024):** Not assessed.

### 2.1.2 Parameter #2: Marsh fragmentation

Fragmentation of the marsh platform over time will provide context for evaluating the sustainability of the project through its 20-year life. The metric used to evaluate this parameter is:

- **Marsh fragmentation (Purpose: Context)**

No monitoring activities were conducted to inform this parameter pre-construction or during Year 1 (2024). Fragmentation analyses are anticipated to be completed for both pre-construction and post-construction aerial imagery for future Upper Barataria Project MAM Synthesis reports.

## 2.2 OBJECTIVE #2: BASIN CONNECTIVITY

### 2.2.1 Parameter #3: Water levels & salinity

This parameter utilizes water level measurements to assess water depth and tidal influence in the MCAs to provide context for comparison of the Project and Reference Area marshes. Salinity as a contextual measurement is used to interpret all biological metrics. Direct assessment of project performance is based on modeled inundation of the constructed marsh. The metrics used to evaluate this parameter include:

- **Tidal signal (Purpose: Context)**
- **Inundation (Purpose: Performance)**
- **Salinity (Purpose: Context)**

#### *2.2.1.1 Tidal signal*

**Methods:** Continuously collected hourly water level data collected at the Reference Area (CRMS0248) by CRMS protocols (Folse et al., 2020) was used to describe water level variation for the Project Area. Hourly water level data (ft; converted to the NAVD88) were accessed via the Coastal Information Management System (CIMS; https://cims.coastal.louisiana.gov/monitoring-data/). Data were examined across three project phases: pre-construction (2018–2021), during construction (2022–2023), and Project Year 1 (2024). For each year of monitoring, the tidal range (i.e., amplitude; ft year$^{-1}$), maximum and minimum water level observed (ft) per season, and annual average water level (ft) were quantified. Each season is defined by the following months: fall = September through November, winter = December through February, spring = March through May, and summer = June through August. Data were converted to meters (m = ft × 0.3048) and analyzed using a harmonic regression analysis within the *tidem* function of the R package *oce* to extract the amplitude and frequency of tidal constituents: M2 (Principal lunar semidiurnal), S2 (Principal solar semidiurnal), N2 (Lunar elliptical semidiurnal), K2 (Lunar-solar declinational semidiurnal), K1 (Lunar-solar declinational diurnal, O1 (Principal lunar diurnal), P1 (Principal solar diurnal), and Q1 (Lunar elliptical diurnal). These elements were used to characterize the tidal regime of the Project Area.

**Results – Long-Term Trends and Project Year 1 (2024):** Seasonal and annual mean water levels exhibited variations across the periods examined (Table 7). The highest water levels were typically observed in the fall season, whereas winter consistently showed the lowest water levels. Annual average water levels at the Reference Area ranged from 0.73 to 0.84 ft NAVD88 throughout the monitoring timeframes.

*Table 7. Summary of water level data collected at the Reference Area. Seasonal and annual mean water level (ft NAVD88) measured at the Reference Area between 2018 and 2024. Hourly water level data was collected at CRMS0248 and accessed in February 2025 via CIMS.*

| | **Pre-Construction (2018–2021)** | **During Construction (2022–2023)** | **Project Year 1 (2024)** |
|---|---|---|---|
| **Seasonal Averages (mean ± SD)** | | | |
| • Fall | 1.08 ± 0.47 | 0.80 ± 0.37 | 1.21 ± 0.41 |
| • Winter | 0.29 ± 0.43 | 0.53 ± 0.44 | 0.25 ± 0.42 |
| • Spring | 0.82 ± 0.47 | 0.83 ± 0.43 | 0.85 ± 0.44 |
| • Summer | 0.87 ± 0.45 | 0.82 ± 0.33 | 0.93 ± 0.43 |
| **Annual Average (mean ± SD)** | 0.76 ± 0.54 | 0.73 ± 0.43 | 0.84 ± 0.53 |
| **Annual Range (min to max)** | -0.75 to 5.16 | -0.59 to 2.01 | -0.55 to 3.45 |

Tidal analysis revealed that the Reference Area experienced a predominantly diurnal tidal regime pre-construction (Figure 12). The K1 (diurnal lunar-solar declinational) and O1 (diurnal principal lunar) tidal constituents were the greatest contributors to total tidal regime, each exhibiting relative amplitudes of approximately 3 cm. In contrast, semidiurnal components had small amplitudes (<0.2 cm). This pattern aligns with general micro-tidal systems characteristics of the Louisiana Gulf Coast, which are dominated by diurnal tides with negligible semidiurnal influence.

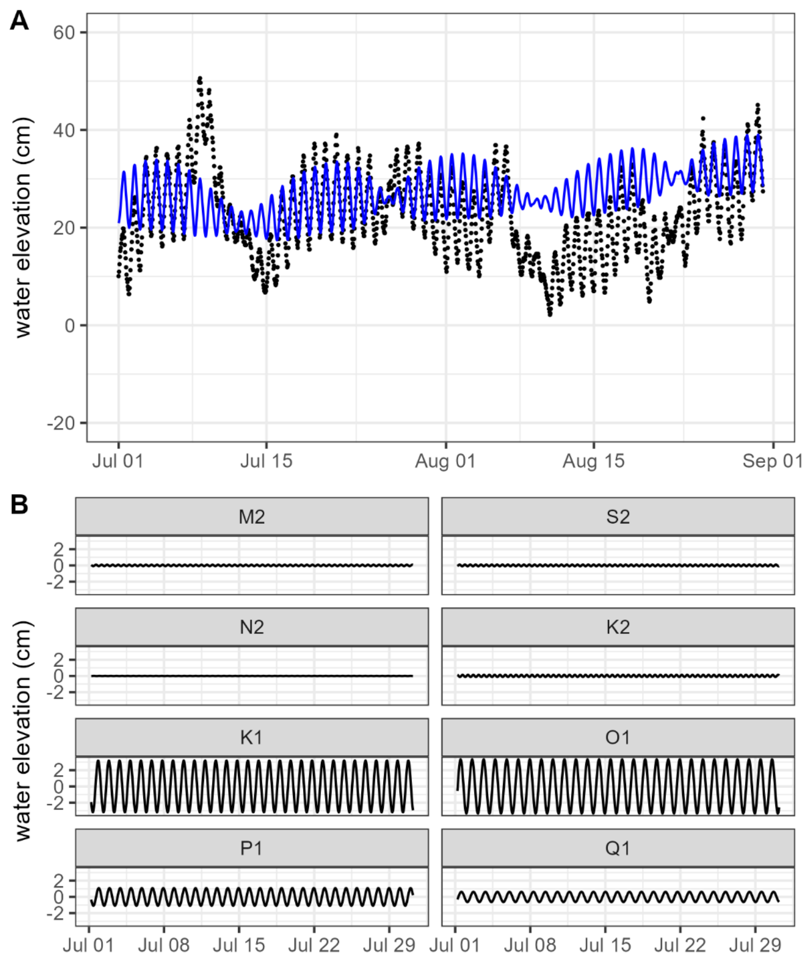


*Figure 12. Snapshot of the tidal analysis of adjusted water level data at the Reference Area. As an example of daily tidal signal, observed water elevation (black dots) and the tidal model prediction (blue line) from July through August 2024. The average daily range during this period was 16.1 ± 4.8 cm. The blue line represents the harmonic regression tidal model, which captures only the tidal components of water level variation. Differences between the observed data (black dots) and model predictions (blue line) represent non-tidal influences on water levels, such as meteorological forcing, freshwater input, or other oceanographic processes that the tidal model does not attempt to capture. (B) Individual tidal constituents identified in the model. Eight tidal components are displayed (M2, S2, N2, K2, K1, O1, P1, and Q1), showing their respective amplitudes and patterns. The principal lunar semidiurnal (M2) and principal solar semidiurnal (S2) tides show minimal variation at this location, while the lunar-solar declinational diurnal (K1) and principal lunar diurnal (O1) constituents exhibit stronger oscillatory patterns. Note differing temporal scales for figures (A) and (B). Hourly water level data was collected at CRMS0248 and accessed in February 2025 via CIMS.*

**Project Performance Assessment:** Tidal regime is monitored as a context variable, thus there are no defined performance targets for this monitoring parameter.

### *2.2.1.2 Inundation*

**Methods:** It is expected that the created marsh platforms of the Project Area will be inundated more than 10 % but less than 90 % per year of the project's 20-year life. Initial assessments of inundation for this report employed a relatively simple approach that compared continuously recorded hourly water level data collected at the Reference Area to a single elevation value from each MCA (the *mean* elevation, see Section 2.1.1). Inundation was calculated as the amount of time (hours per year) that water levels exceeded the mean elevation of each MCA. Inundation was assessed pre-construction (2022) and immediately after construction completion (2023–2024). Data from 2024 were used to identify whether the MCAs of the Project Area met the desired inundation frequency described in the performance criteria (10–90 % hours inundation per year).

**Results – Long-Term Trends and Project Year 1:** Figure 13 illustrates the relationship between historical high-water elevations (2007–2024) and the marsh platform elevations for both pre- and post-construction conditions. Prior to construction, low elevations of existing emergent wetland fragments and the open water nature within the MCA footprints led to frequent and prolonged inundation by high water throughout the year. Following construction, the elevations of all MCA footprints were raised notably, positioning them above the annual median daily high-water level (~1.1 ft NAVD88). Consequently, these newly created higher-elevation marsh platforms were inundated much less frequently post-construction, primarily during seasonal peaks in water levels that typically occur in late summer and early fall in this region of the Barataria Basin.

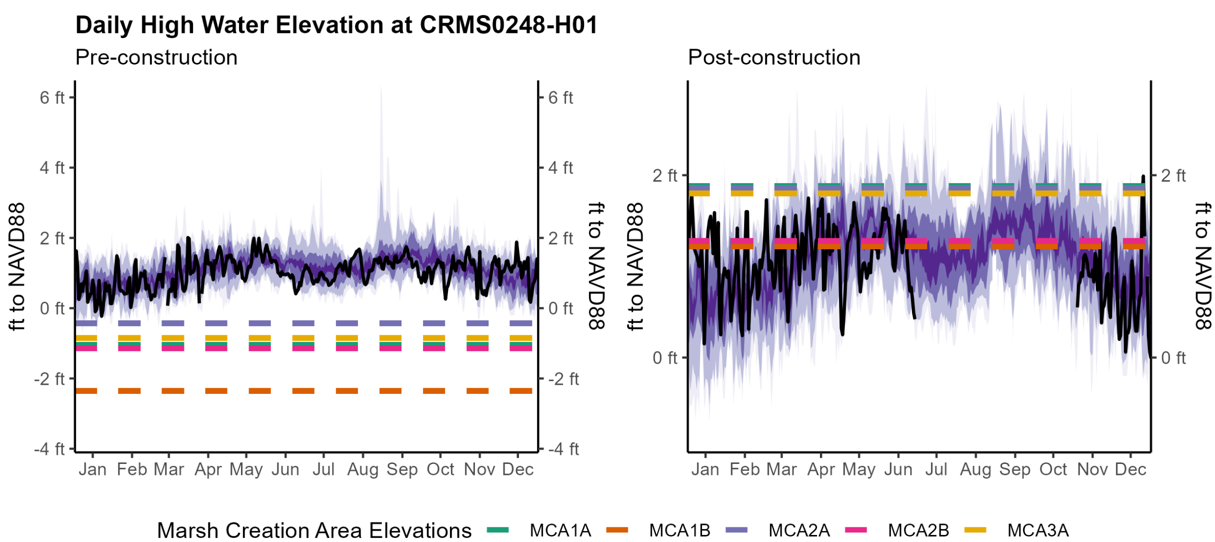


*Figure 13. Hourly water level data collected at the Reference Area between 2007 and 2024. The purple shaded ribbons denote the historical range of daily high-water elevations, where the lightest shade represents the minimum to maximum values and the progressively darker shades represent the ranges for the 5th–95th, 20th–80th, and 40th–60th percentiles. The black line denotes daily high-water elevations for 2022 (pre-construction; left panel) and 2023 (post-construction; right panel). The horizontal dashed lines indicate the average marsh surface elevation of the MCA footprints prior to construction completion (2022) and at construction completion (Project Year 0, 2023) based on topographic surveys described in Section 2.1.1. Note the difference in y axis scale between panels is deliberate to highlight the post-construction variation.*

Each MCA footprint (Table 8) as well as the Project Area in its entirety (Table 9) was found to be constantly inundated in 2022, the year prior to construction. After the project was completed, the mean elevation of each MCA and the Project Area overall suggest considerably reduced inundation in 2024. Inundation of the Project Area was lowest during the winter season in both pre- and post-construction periods.

*Table 8. Summary of annual inundation of the Project Area between 2022 and 2024. Data provided as an annual mean % inundation of the marsh platform in each MCA of the Project Area. Calculations were based on average ground surface elevation pre-construction (2022) and upon project completion (2024). Values calculated from NAVD88-adjusted water elevation data shifted relative to average marsh elevation in the immediate vicinity of the data recorder (CRMS0248). Hourly water level data was collected at CRMS0248 and accessed in February 2025 via CIMS. Elevation data were collected by project construction contractors and provided by NOAA for analysis.*

| | **Pre-Construction Inundation (2022)** (% mean ± SD) | **Project Year 1 Inundation (2024)** (% mean ± SD) |
|---|---|---|
| MCA1A | 100 ± 0 | 2.68 ± 16.1 |
| MCA1B | 100 ± 0 | 22.2 ± 41.5 |
| MCA2A | 99.6 ± 6.0 | 2.8 ± 16.6 |
| MCA2B | 100 ± 0 | 19.4 ± 39.5 |
| MCA3A | 100 ± 0 | 3.5 ± 18.4 |

*Table 9. Summary of annual and seasonal inundation of the Project Area between 2022 and 2024. Data provided as seasonal and annual mean % inundation (daily) of the overall Project Area marsh platform pre-construction (2022) and upon project completion (2024). Values calculated from NAVD88-adjusted water elevation data shifted relative to average marsh elevation in the immediate vicinity of the data recorder at the Reference Area. Hourly water level data was collected at CRMS0248 and accessed in February 2025 via CIMS. Elevation data were collected by project construction contractors and provided by NOAA for analysis.*

| | **Pre-Construction Inundation (2022)** (% mean ± SD) | **Project Year 1 Inundation (2024)** (% mean ± SD) |
|---|---|---|
| Seasonal Averages (mean ± SD) | | |
| • Fall | 100 ± 0.0 | 15.6 ± 36.3 |
| • Winter | 100 ± 0.0 | 0.1 ± 3.28 |
| • Spring | 100 ± 0.0 | 4.1 ± 19.7 |
| • Summer | 100 ± 0.0 | 7.9 ± 27.0 |
| Annual Average (mean ± SD) | 100 ± 0.0 | 7.3 ± 26.0 |
| Annual Range (min-max) | 100 to 100 | 0.0 to 100.0 |

**Project Performance Assessment:**

- ***Performance Criteria:*** *The modeled post-settlement marsh surface inundation in each MCA will have a* <u>*10 to 90 % exceedance frequency*</u> *for the 20-year project life.*
    - **Project Year 1 (2024):** ***Performance Criteria Not Met*** – Annual mean inundation was below 10 % for MCAs 1A, 2A, and 3A. Only annual mean inundation of MCA1B and 2B met the target threshold.

*2.2.1.3 Salinity*

**Methods:** Salinity within the Project Area was evaluated using hourly hydrographic data collected at the Reference Area (CRMS0248). Salinity was summarized (mean ± SD) using all salinity records available for the three project phases: pre-construction (2018–2021), during construction (2022–2023), and Project Year 1 (2024).

**Results – Long-Term Trends and Project Year 1:** Table 10 presents the seasonal and annual mean salinities recorded at the Reference Area for each period. Salinity measurements show variations across seasons and project phases. Fall typically exhibited the highest salinities between the pre-construction and during construction phases (2018–2023). However, in Project Year 1 (2024), the highest salinity was observed in winter. Annual average salinities ranged from 3.37 to 7.23 ppt across the monitoring timeframes.

*Table 10. Summary of salinity measured at the Reference Area. Data provided as seasonal and annual mean water salinity (ppt) measured at the Reference Area between 2018 and 2024. The number of datapoints for each period of data summary are provided. Salinity data (ppt) was collected at CRMS0248 and accessed in February 2025 via CIMS.*

| | **Pre-Construction 2018–2021 (n = 34,631)** | **During Construction 2022–2023 (n = 17,708)** | **Project Year 1 2024 (n = 7,133)** |
|---|---|---|---|
| **Seasonal Averages (mean ± SD)** | | | |
| • Fall | 5.01 ± 2.60 | 12.18 ± 6.84 | 4.38 ± 1.92 |
| • Winter | 4.40 ± 2.00 | 7.39 ± 4.78 | 8.77 ± 3.07 |
| • Spring | 2.05 ± 1.40 | 4.27 ± 1.73 | 3.14 ± 1.11 |
| • Summer | 2.13 ± 2.03 | 5.13 ± 2.27 | 3.01 ± 1.38 |
| **Annual Average (mean ± SD)** | 3.37 ± 2.44 | 7.23 ± 5.37 | 4.51 ± 2.92 |
| **Annual Range (min-max)** | 0.20 - 17.52 | 0.36 – 23.23 | 1.02 - 17.67 |

**Project Performance Assessment:** Salinity is monitored as a context variable, thus there are no defined performance targets for this monitoring parameter.

### 2.2.2 Parameter #4: Presence of target nekton species

The presence of target nekton is used to directly assess project performance in terms of biological connectivity between MCAs and the broader Barataria Basin via constructed tidal channels. Additional measurements of nekton community composition are used to provide context. The metrics used to evaluate this parameter include:

- **Presence of target nekton collected by three distinct gear types**: 50 ft seine, 6 ft trawl, and fixed-area sampling **(Purpose: Performance)**
- **Assemblage composition of nekton collected by these three gear types:** 50 ft seine, 6 ft trawl, and fixed-area sampling summarized as univariate Shannon-Wiener Diversity and raw Species Richness metrics, as well as multivariate community similarity **(Purpose: Context)**
- **Red drum utilization of Project Area, assessed via acoustic telemetry (Purpose: Performance).**

The target nekton taxa for Project monitoring include:

- Blue Crab (*Callinectes sapidus*)
- Brown Shrimp (*Penaeus aztecus*)
- Killifish spp. – e.g. Rainwater Killifish (*Lucania parva*), Gulf Killifish (*Fundulus grandis*), Longnose Killifish (*Fundulus similis*), Diamond Killifish (*Fundulus xenicus*), Bayou Killifish (*Fundulus pulvereus*), Least Killifish (*Heterandria formosa*), Golden Topminnow (*Fundulus chrysotus*), Saltmarsh Topminnow (*Fundulus jenkinsi*), Sailfin Molly (*Poecilia latipinna*), and Sheepshead Minnow (*Cyprinodon variegatus*)
- Other Shrimps (Grass Shrimps and other members of infraorder Caridea)
- Red Drum (*Sciaenops ocellatus*)
- White Shrimp (*Penaeus setiferus*).

#### *2.2.2.1 Presence of target nekton: 50 ft seine and 6 ft trawl*

**Methods:** LDWF routinely conducts 50 ft bag seine ("seine") surveys in close association with vegetated edge and adjacent, shallow (<6 ft), open water habitats as part of the Fisheries Independent Monitoring Program (FIMP; LDWF, 2022). The frequency of FIMP seine sampling has changed over time, but since 2014 seine sampling has occurred monthly across the Barataria Basin. Standard FIMP protocols dictate all organisms collected by seines are identified to lowest taxonomic level (often to species), counted, and weighed in aggregate (LDWF, 2022). All target nekton taxa relevant to the Upper Barataria Project are included in the list of "species of interested" maintained by LDWF and therefore up to 30 individuals per taxon are measured for total length (TL, mm) or carapace width (CW, mm) when collected by seines.

In addition, LDWF routinely conducts 6 ft balloon otter trawls ("trawl") to assess juvenile penaeid shrimp (White and Brown Shrimp) in shallow (<6 ft) open water habitats near vegetated marsh edges (LDWF, 2022). FIMP sampling activities with this gear type are conducted in two pulses: (1) sampling conducted in April through the first week of May is used to provide recommendations on opening the spring inshore shrimp season; and (2) sampling conducted in the second week of June through the first week of July is used to provide recommendations on shrimp season closure. During these pulses LDWF conducts sampling on a weekly basis, with up to nine samples potentially collected per station per year. LDWF dictates the total number of trawl stations sampled per basin per week based on power analysis of data from prior years; thus, not all stations are sampled each year. LDWF describes that this stratified sampling regime is employed to help ensure greater spatial coverage across the coastal area (LDWF, 2022). LDWF FIMP protocols dictate that only penaeid shrimp are identified, counted, and up to 50 individuals measured per species when collected using the trawl gear type.

In 2020, LDWF initiated new FIMP seine stations (2174, 2173, 2175) located adjacent to the Project Area specifically for monitoring of the Upper Barataria Project (Figure 14). Three existing FIMP trawl stations (1081, 1085, 1086) were also re-purposed for Upper Barataria Project monitoring. Trawl station 1081 was relocated by ~412 m in 2022 because the Project Area was built on top of it. Existing long-term FIMP stations located in the broader surrounding area were used as Reference FIMP stations for comparison to the Project Area, including six Reference FIMP seine stations (2008, 2002, 2011, 2177, 2004, 2007) and two Reference FIMP trawl stations (1080 and 1012). All FIMP sampling station locations are fixed and sampling will be repeated at those locations during each monitoring cycle.

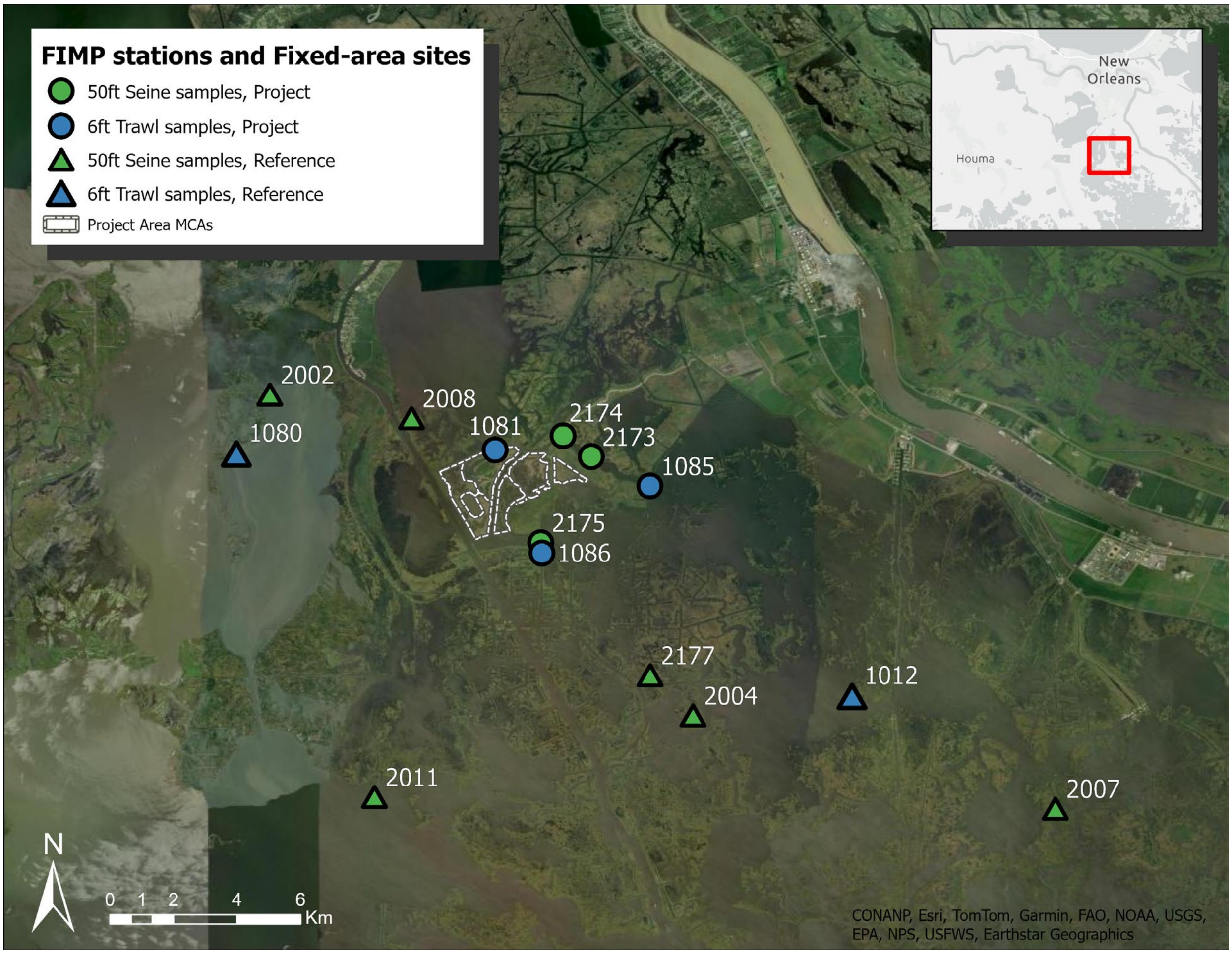


*Figure 14. Map of FIMP nekton monitoring stations in relation to the Project Area. Locations of Project FIMP stations (green circles = 50 ft seine; blue circles = 6 ft trawl) and Reference FIMP stations (green triangles = 50 ft seine; blue triangles = 6 ft trawl) are also shown. Each FIMP station is labelled with its unique ID number. The Project Area MCA footprints are denoted with dashed white lines.*

At the time of writing, LDWF sample processing for *Reference* FIMP trawl stations (1080 and 1012) has not deviated from standard LDWF protocols, meaning no other taxa aside from penaeid shrimp are counted, weighed, or identified. However, in 2023, LDWF sample processing protocols for all *Project* FIMP trawl stations (1081, 1085, 1086) were changed such that all organisms are identified, counted, and weighed. Unfortunately, the result of this mismatch prevents comparisons between Project and Reference FIMP trawl stations for all target nekton taxa post-construction until LDWF FIMP protocols are updated for the Reference FIMP trawl stations.

Target species relative abundance data (catch per unit effort, CPUE) was used to determine presence/absence of the target species at each Project Area and Reference FIMP station. Presence is defined as the observation of at least one individual in a sample within the calendar year. The presence of target nekton was assessed in three periods: pre-construction (January 1, 2012 through December 31, 2021), during construction (January 1, 2022 through December 31, 2023), and post-construction (January 1 through December 31, 2024). Note: between January 1, 2022 and December 31, 2023 sampling at Project FIMP seine stations only occurred in January 2022 due to construction.

**Results – Long-Term Trends and Project Year 1:** Sampling effort across FIMP stations is summarized in Table 11.

*Table 11. FIMP sample collection summary. Data summarize the total number of samples collected by Reference and Project FIMP seine and trawl stations across each summary time period based on the data acquired. Total numbers of samples may not match totals expected under LDWF described sampling frequencies due to irregularities in sampling over time. The rationale for any irregularities is not apparent from the dataset used for analysis.*

| FIMP Gear and Station Type | Pre-Construction (2012–2021) | During Construction (2022–2023) | Project Year 1 (2024) |
|---|---|---|---|
| Reference FIMP Seine Stations (n = 6 stations; 2008, 2002, 2011, 2177, 2004, 2007) | 490 | 120 | 44 |
| Project FIMP Seine Stations (n = 3 stations; 2173, 2174, 2175) | 54 | 3 | 27 |
| Reference FIMP Trawl Stations (n = 2 stations; 1080 and 1012) | 55 | 12 | 6 |
| Project FIMP Trawl Stations (n = 3 stations; 1081, 1085, 1086) | 58 | 7 | 25 |

All target nekton taxa (except Red Drum in 2013) were observed at least once at a Reference FIMP seine station between 2012 and 2024 (Table 12). All target species were also identified at Project FIMP seine stations between 2020 and 2024, although Brown Shrimp, Red Drum, and White Shrimp were not observed in 2022. In 2024, all target taxa were identified in at least one sample from both Project and Reference FIMP seine stations.

*Table 12. Presence/absence of target species between 2012 and 2024 at Project and Reference FIMP seine stations. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Note: sampling at Project FIMP seine stations was not initiated until 2020. Acronyms:Y1 = Project Year 1; Y (green cells) = the target taxa was observed in at least one sample collected within the indicated calendar year; N (red cells) = the target taxa was not observed in any sample collected within the indicated calendar year; "–" (light grey cells) = no samples were collected within the indicated calendar year. Raw data were collected as part of the FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| **Common Name** | **Type** | **Pre-Construction** | | | | | | | | | | **During-Construction** | | **Project Year 1** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **'12** | **'13** | **'14** | **'15** | **'16** | **'17** | **'18** | **'19** | **'20** | **'21** | **'22** | **'23** | **'24** |
| Blue Crab | Reference | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Blue Crab | Project | – | – | – | – | – | – | – | – | Y | Y | Y | – | Y |
| Brown Shrimp | Reference | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Brown Shrimp | Project | – | – | – | – | – | – | – | – | Y | Y | N | – | Y |
| Killifish spp. | Reference | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Killifish spp. | Project | – | – | – | – | – | – | – | – | Y | Y | Y | – | Y |
| Other Shrimps | Reference | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Other Shrimps | Project | – | – | – | – | – | – | – | – | Y | Y | Y | – | Y |
| Red Drum | Reference | Y | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Red Drum | Project | – | – | – | – | – | – | – | – | Y | Y | N | – | Y |
| White Shrimp | Reference | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| White Shrimp | Project | – | – | – | – | – | – | – | – | Y | Y | N | – | Y |

Presence/absence assessment for all target nekton at trawl stations was generally not possible, as prior to 2024 only White and Brown Shrimp were routinely evaluated per LDWF protocols for this gear type (LDWF, 2022). Beginning in 2024, Project FIMP trawl samples were evaluated for all species, though Reference FIMP trawl samples were not. Between 2012 and 2024, Brown Shrimp were consistently observed during nearly all Reference FIMP trawl sampling events, although 2013 was an exception (Table 13). Brown Shrimp were also observed at all Project FIMP trawl stations during this reporting cycle. The observed presence of White Shrimp at both Reference FIMP trawl stations was more variable than Brown Shrimp, with notable gaps prior to 2019. In 2024, at Project FIMP trawl stations, Blue Crab, Killifish spp., and Other Shrimps were observed, but Red Drum were not.

*Table 13. Presence/absence of target species between 2012 and 2024 at Project and Reference FIMP trawl stations. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. Acronyms: Y1 = Project Year 1; Y (green cells) = the target taxa was observed in at least one sample collected within the indicated calendar year; N (red cells) = the target taxa was not observed in any sample collected within the indicated calendar year; "–" (light grey cells) = no samples were collected within the indicated calendar year; "NA" (dark grey cells) = samples were collected at Reference trawl stations and were processed per standard LDWF FIMP protocols (LDWF, 2018) such that only Brown and White Shrimp were identified, therefore presence of organisms other than Brown and White shrimp could not be assessed (note: starting in 2024 samples collected at Project trawl stations deviated from the standard protocols and were processed to count and identify all organisms). Raw data were collected as part of the FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| **Common Name** | **Type** | **Pre-Construction** | | | | | | | | | | **During-Construction** | | **Project Year 1** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **'12** | **'13** | **'14** | **'15** | **'16** | **'17** | **'18** | **'19** | **'20** | **'21** | **'22** | **'23** | **'24** |
| Blue Crab | Reference | NA | – | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Blue Crab | Project | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y |
| Brown Shrimp | Reference | Y | – | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Brown Shrimp | Project | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Killifish spp. | Reference | NA | – | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Killifish spp. | Project | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y |
| Other Shrimps | Reference | NA | – | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other Shrimps | Project | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | Y |
| Red Drum | Reference | NA | – | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Red Drum | Project | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | N |
| White Shrimp | Reference | Y | – | Y | N | N | N | N | Y | Y | N | Y | Y | Y |
| White Shrimp | Project | N | Y | N | N | Y | N | N | Y | Y | Y | Y | Y | Y |

**Project Performance Assessment:**

- ***Performance Criteria:*** *Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab* *<u>are present</u>* *in the habitat types sampled by* ***50 ft seines*** *(marsh edge) at FIMP sites adjacent to the Project Area.*
    - **Project Year 1 (2024):** ***Performance Criteria Met*** – Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab were observed at Project FIMP seine stations in 2024.
- ***Performance Criteria:*** *Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab* *<u>are present</u>* *in the habitat types sampled by* ***6 ft trawls*** *(shallow open water adjacent to marsh edge) at FIMP sites adjacent to the Project Area.*
    - **Project Year 1 (2024):** ***Performance Criteria Met*** – Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab were observed at Project FIMP trawl stations in 2024.

#### *2.2.2.2 Presence of target nekton: fixed-area gear types*

**Methods:** This Project implemented fixed-area sampling following methods and protocols developed under the *Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates* MAM Activity Implementation Plan (DIVER ID# 299) and documented in Kiskaddon et al. (2024). Two types of enclosure samplers (square throw traps and cylindrical drop samplers) were used to sample nekton as part of fixed-area sampling (Figure 15). The drop sampler is a cylindrical fiberglass enclosure (119.4 cm tall, 127 cm diameter) which encloses approximately 1.27 $m^2$. A galvanized metal skirt attached to the bottom of the sampler is used for cutting through vegetation roots and ensuring complete contact between the bottom of the sampler and the substrate. A specifically modified vessel was used to release the drop sampler from a bow-mounted boom, whereas throw traps were deployed by hand.

When drop sampling, organisms were collected from the sampler by first using dip nets to collect larger organisms and then pumping enclosed water through a 1-mm mesh plankton net using an open impeller trash pump. Any remaining animals were collected via dipnets or by hand once the water had drained. The throw trap is a square aluminum enclosure (101.6 cm L, 101.6 cm W, 76 cm H). When throw trapping, organisms were removed using an aluminum bar seine with 1.6 mm mesh swept through the trap from alternating directions until three consecutive passes yielded no organisms or for a minimum of ten passes. Nekton samples were then placed on ice until they were preserved in a 10% buffered formalin/seawater solution at the end of each sampling day.

Site characteristics and water quality data, collected using a YSI ProSolo ODO/CT probe assembly (#62666), were collected directly after the sampler had been deployed but prior to dip netting and suction sampling. These measurements included time, location (latitude, longitude), water depth (cm; average of 5 measurements from within the sampler), distance from marsh edge (cm), dominant vegetation within the sampler, stem density (number of stems $0.25m^{-2}$), submerged aquatic vegetation (SAV) cover (%), and water quality metrics such as: water temperature (°C), dissolved oxygen (DO; mg $L^{-1}$, % saturation), salinity (ppt), and turbidity (cm, Secchi turbidity tube). One drop sample was collected from vegetated edge habitat (within 1 m of the land:water interface) and one from adjacent open water habitat (within 1 m seaward of the land:water edge) at each station, whereas throw trap samples were only collected from shallow open water habitats located within the marsh platform interior.

*Figure 15. Deployment photographs of fixed-area gear types. Fixed-area gears were employed to sample nekton for the Upper Barataria Project in August 2024. Left: field staff quietly pushing the boat into position for drop sampling the marsh edge; Right: field staff deploy a throw trap. Photo credit: Erin Kiskaddon (The Water Institute).*

Figure 16 provides the locations of 6 fixed-area nekton stations in the Reference Area and 16 stations within the Project Area for drop sampling. All stations were sampled by drop sampler except for three **Interior (I)** stations (defined as being located more than 3 m landward from the marsh edge/open water interface) within the Project Area which were only sampled by throw trap.

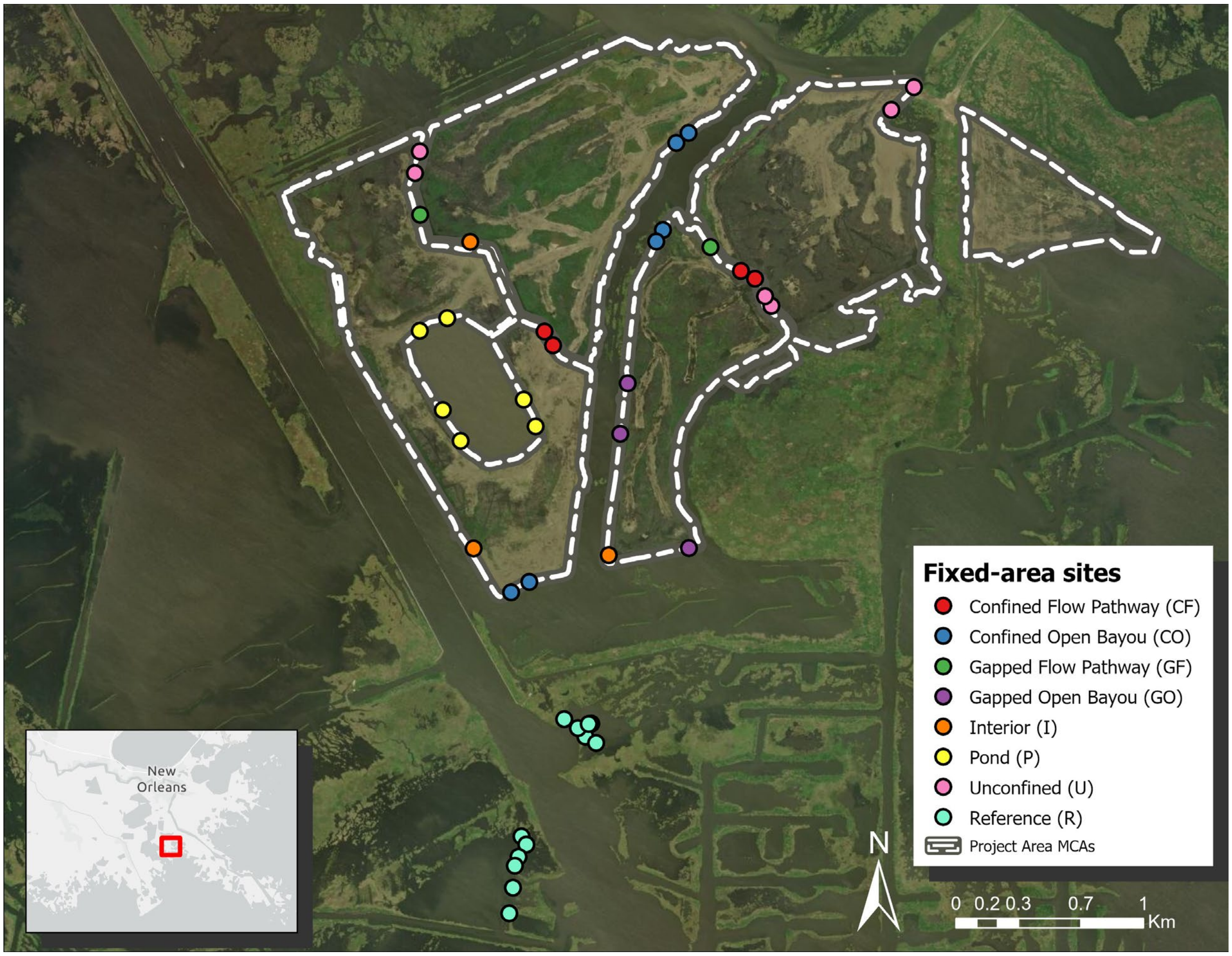


*Figure 16. Map of the Project Area MCAs and sampling locations of fixed-area nekton monitoring. Locations of Project site (yellow circles) and Reference sites (light blue circles). Inset map: General vicinity of the Project Area (red box) in Barataria Bay, Louisiana.*

Project Area fixed-area nekton sampling targeted specific construction design features described below and illustrated in Figure 17:

- **Confined edges along a flow pathway (CF; 2 stations):** Areas along non-gapped sections of containment dikes within a constructed flow pathway (a mechanically cut channel promoting water exchange between MCAs).
- **Confined edges along an open bayou (CO; 3 stations):** Areas along non-gapped sections of containment dikes adjacent to an open-water bayou.
- **Unconfined edges (U; 3 stations total):** Areas where piped dredge sediment flowed freely without containment dikes.
- **Gaps:** Gaps were generally located where there was open water access with no or minimal existing marsh outside of the containment dike to improve fish access to the gap. The selected

gaps for fixed-area sampling were all constructed to widths of 50 ft (as designed). Two types of gaps are assessed for nekton monitoring:

- **Gaps along a flow pathway (GF; 2 stations):** Areas with mechanical cuts in containment dikes along a flow pathway designed to allow water drainage and exchange between the MCA and surrounding flow pathways/bayous/open water areas. Locations: MCA1A Gap 13 (29.6245, -90.07616) and MCA2B Gap 3 (29.622967, -90.06237) (Moffat & Nichol, 2024).
- **Gaps along an open bayou (GO; 3 stations):** Areas with gaps positioned adjacent to an open-water bayou or large channel. Locations: MCA2B Gap 5 (29.616522, -90.066313), MCA2B Gap 6 (29.6141, -90.0665), and MCA2B Gap 10 (29.608714, -90.063405) (Moffat & Nichol, 2024).

- **Pond (P; 3 stations):** A large, unvegetated deep-water area connected to the broader Project Area via a mechanically cut channel intersecting a flow pathway within the MCA1B footprint.

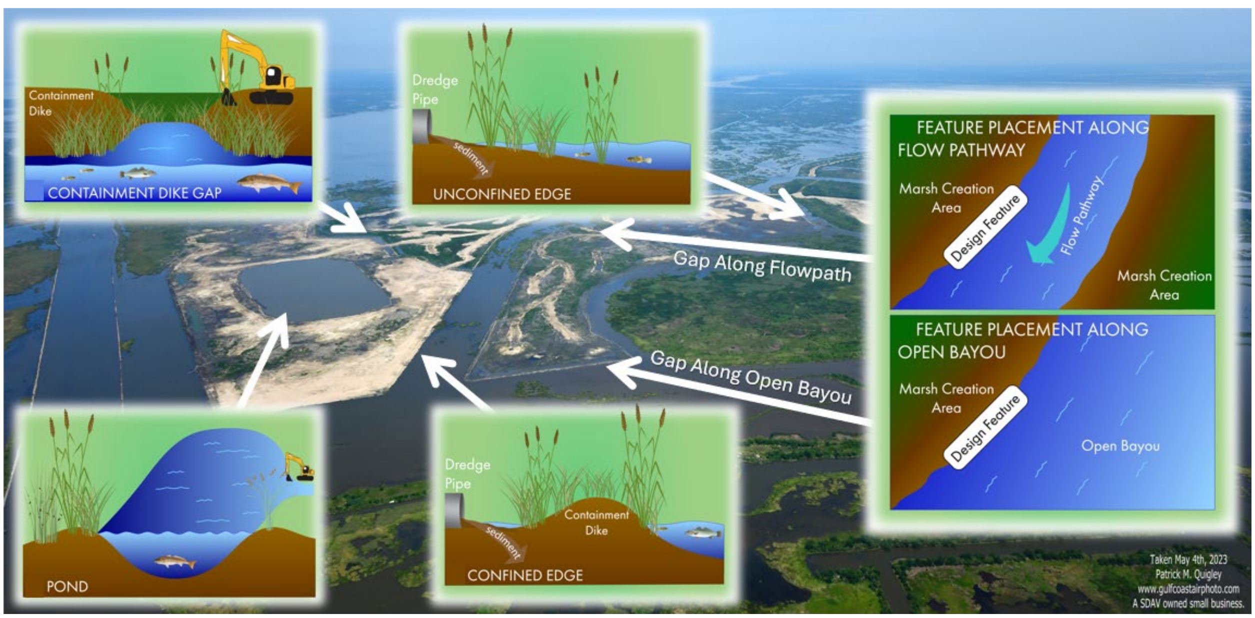


*Figure 17. Conceptual diagram of project design feature types sampled using fixed-area gears within the Project Area.*

After collection and fixation, nekton samples were enumerated and taxa identified by Rissa Inselman's laboratory at Nicholls State University in Thibodaux, LA, between January and July 2025 (Figure 18). Laboratory processing and data collection methodologies were modified from procedures originally developed by the NOAA Fisheries Southeast Fisheries Science Center (SEFSC) and documented in Kiskaddon et al. (2024). All organisms were counted, identified to species level (where possible), measured (TL or CW in mm), and weighed for wet weight biomass (in grams). In some cases, the rostrum of Brown and White Shrimp was damaged during sample collection and direct measurement of TL for biomass conversion (relevant to Section 2.3.3.2) was not possible. In these instances, unpublished conversion factors provided by the SEFSC were used to convert carapace length (CL) to TL: Brown Shrimp 1 mm CL = 4.78 mm TL; White Shrimp 1 mm CL = 4.53 mm TL.

*Figure 18. Undergraduate students process fixed-area samples in Rissa Inselman's laboratory at Nicholls State University. Photo credit: G. LaFleur.*

Environmental conditions observed during sample collection at the Reference Area were compared to the Project Area using t-tests with two-tailed *p*-values assuming unequal variances, and significance determined with an alpha of 0.05. Nekton samples were evaluated for presence/absence of target taxa separated by station location (Project or Reference) and habitat type (marsh edge or open water).

**Results:** Fixed-area nekton monitoring was conducted by The Water Institute between August 20–22, 2024. During the 2024 field event, a total of 16 stations within the Project Area and 6 stations in the Reference Area were attempted using the drop sampling gear type. Of the expected 32 drop samples from the Project Area from both EV and OW habitat types, only 27 samples were collected. Lack of flooded vegetation at 5 EV sites within the Project Area (specifically, 2 **GF** EV sites and 3 **GO** EV sites) prevented sampling at those locations. All six drop sampling stations in the Reference Area were sampled and 12 samples were retained for analysis. Throw trapping was attempted at only three **I** stations within the Project Area and only for OW habitat type. Of the three expected samples, site **I1** did not contain any nekton organisms. In total, 27 drop samples and two throw trap samples were successfully collected from the Project Area, and 12 drop samples were collected from the Reference Area.

Water quality variables and habitat characteristics collected in Project Year 1 (2024) were generally similar between the overall Project Area and Reference Areas except for three metrics (Table 14). Significantly greater water depths were recorded for open water samples in the Reference Area compared to the Project Area (42.43 ± 9.02 cm and 28.72 ± 16.17 cm, respectively; t = -2.62, $p$ = 0.02). Significantly higher salinity of marsh edge samples was observed in the Reference Area (4.14 ± 0.69 ppt) compared to the Project Area (2.75 ± 0.66 ppt; t = -4.00, $p$ = 0.00). Lastly, significantly higher turbidity tube values (indicating clearer water) was observed in open water samples of the Reference Area compared to the Project Area (13.67 ± 1.75 cm and 8.61 ± 4.94 cm, respectively; t = -3.77, $p$ = 0.00). SAV cover (mean ± SD: 3 ± 9.3 %) was only observed in open water habitats in the Project Area. Notably high SAV cover (40 %) was observed at one **GO** station.

*Table 14. Comparison of environmental variables collected in marsh edge or open water habitat types between the overall Project Area and the Reference Area in Project Year 1 (2024). Summary statistics are provided as means and standard deviation (SD) for each variable. The number of datapoints is indicated by n. Results of two-sample t-tests comparing values of each metric between Reference and Project Area include t-statistic and p-values, with significant differences based on α = 0.05 and indicated by asterisks (*). NA indicates statistical comparisons were not made. Acronyms: ME = marsh edge; OW = open water. Negative values of distance indicate distance land-ward of the marsh:water interface. All samples were collected by drop sampler except for interior sites sampled by throw trap.*

| **Environmental Variable** | **Habitat Type** | **Project Area** (mean ± SD) | **n** | **Reference Area** (mean ± SD) | **n** | **t-stat** | ***p*-value** |
|---|---|---|---|---|---|---|---|
| **Average Water depth (cm)** | ME | 20.84 ± 8.75 | 11 | 23.77 ± 12.65 | 6 | -0.51 | 0.63 |
| | OW | 28.72 ± 16.17 | 19 | 42.43 ± 9.02 | 6 | -2.62 | 0.02* |
| **Dissolved Oxygen (mg $L^{-1}$)** | ME | 10.75 ± 4.63 | 11 | 7.95 ± 3.62 | 6 | 1.38 | 0.19 |
| | OW | 10.69 ± 4.11 | 19 | 11.63 ± 3.16 | 6 | -0.59 | 0.57 |
| **Dissolved Oxygen (%)** | ME | 151.98 ± 68.43 | 11 | 113.02 ± 52.47 | 6 | 1.31 | 0.21 |
| | OW | 153.6 ± 62.47 | 19 | 167.33 ± 47.55 | 6 | -0.57 | 0.58 |
| **Salinity (ppt)** | ME | 2.75 ± 0.66 | 11 | 4.14 ± 0.69 | 6 | -4.00 | 0.00* |
| | OW | 3.14 ± 0.96 | 19 | 3.8 ± 1.09 | 6 | -1.31 | 0.23 |
| **Secchi Turbidity Tube (cm)** | ME | 10.78 ± 4.1 | 11 | 13.83 ± 1.72 | 6 | -2.14 | 0.05 |
| | OW | 8.61 ± 4.94 | 19 | 13.67 ± 1.75 | 6 | -3.77 | 0.00* |
| **Water Temperature (˚C)** | ME | 32.98 ± 1.69 | 11 | 32.98 ± 0.61 | 6 | -0.00 | 1.00 |
| | OW | 32.78 ± 2.35 | 19 | 33.28 ± 1.03 | 6 | -0.74 | 0.47 |
| **Stem Density (count 0.25 $m^{-2}$)** | ME | 12.45 ± 16.32 | 11 | 44.33 ± 66.47 | 6 | -1.16 | 0.30 |
| | OW | 0 ± 0 | | 0 ± 0 | | NA | NA |
| **Distance from Marsh Edge (cm)** | ME | -4.55 ± 15.08 | 11 | 0 ± 0 | 6 | -1.00 | 0.34 |
| | OW | 272.11 ± 94.73 | 19 | 231.67 ± 46.65 | 6 | 1.40 | 0.18 |
| **Percent Cover SAV (%)** | ME | 0 ± 0 | 11 | 0 ± 0 | 6 | NA | NA |
| | OW | 3 ± 9.3 | 19 | 0 ± 0 | 6 | 1.41 | 0.18 |

Nearly all target nekton taxa were observed in at least one sample collected from within the Project Area and the Reference Area in Year 1 across both fixed-area gear types (Table 15), however Brown Shrimp were not observed in the Reference Area. Red Drum were not observed in either the Reference nor Project areas, which may have been due to the timing of monitoring activities which occurred before most early juveniles typically recruit to marsh habitats. Blue Crabs and White Shrimp were the most ubiquitous target taxa, with both species being documented at all project features and habitat types, except for **I** open water stations (no White Shrimp) and **GF** open water stations (no Blue Crabs). Killifish spp. and Other Shrimps were also collected from **I** open water stations.

*Table 15. Presence/absence of target species observed by fixed-area gears in 2024. Data separated by habitat type (marsh edge or open water) and by project feature, the overall Project Area, and the Reference Area in Project Year 1 (2024). Acronyms: ME = marsh edge; OW = open water; CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; I = interior; Y (green cells) = the target taxa was observed in at least one sample collected within the indicated calendar year; N (red cells) = the target taxa was not observed in any sample collected within the indicated calendar year; "–" (light grey cells) = no samples were collected within the indicated calendar year. All samples collected by drop sampler except for interior I sites sampled by throw trap.*

| Species | Habitat Type | Project Feature | | | | | | | Project Area | Reference Area |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CF | CO | U | GF | GO | P | I | | |
| **Blue Crab** | ME | Y | Y | Y | – | – | Y | – | Y | Y |
| | OW | Y | Y | Y | N | Y | Y | Y | Y | Y |
| **Brown Shrimp** | ME | N | Y | N | – | – | N | – | Y | Y |
| | OW | N | Y | N | Y | N | N | N | Y | N |
| **Killifish spp.** | ME | Y | Y | Y | – | – | Y | – | Y | Y |
| | OW | N | N | Y | N | Y | N | Y | Y | Y |
| **Other Shrimps** | ME | Y | Y | Y | – | – | Y | – | Y | Y |
| | OW | N | N | Y | N | Y | Y | Y | Y | Y |
| **Red Drum** | ME | N | N | N | – | – | N | – | N | N |
| | OW | N | N | N | N | N | N | N | N | N |
| **White Shrimp** | ME | Y | Y | Y | – | – | Y | – | Y | Y |
| | OW | Y | Y | Y | Y | Y | Y | N | Y | Y |

**Project Performance Assessment:**

- ***Performance Criteria:*** *Brown Shrimp, White Shrimp, Other Shrimps, Killifish spp., and Blue Crab are present in the habitat types sampled by* ***fixed-area samplers*** *(marsh edge: open water, marsh edge: vegetated, and marsh interior) at the Project Area.*
    - **Project Year 1 (2024):** ***Performance Criteria Not Met*** – Brown Shrimp, White Shrimp, Other Shrimps, Killifish spp., and Blue Crab were observed in marsh edge and open water habitat types using the drop sampler gear type. However, only Other Shrimps, Killifish spp., and Blue Crab—not White nor Brown Shrimp—were observed in interior ponds (unvegetated open water) using the throw trap gear type.

### *2.2.2.3 Assemblage composition of nekton: 50 ft seine, 6 ft trawl, and fixed-area gear types*

**Methods:** Two univariate metrics of community assemblage were utilized to provide context for Upper Barataria Project nekton monitoring: Shannon-Weiner Diversity (hereafter "Shannon Diversity") and raw Species Richness.

Diversity metrics were calculated for Reference FIMP seine samples collected between 2012 and 2024, for Project FIMP trawl samples collected in 2024, and for fixed-area samples collected in 2024. Notably, comparisons between Project and Reference areas using trawl data were *not* possible, as only penaeid shrimp were assessed at the Reference FIMP trawl stations in 2024 per standard LDWF sampling protocols in place at the time of sampling. However, such comparisons may be possible for future synthesis reports as LDWF FIMP protocols are adjusted and data are made available from Reference FIMP trawl stations.

Diversity measurements over the period of interest were summarized as median and interquartile range (IQR)—hereafter notated as: "**median[IQR]**" —unless otherwise specified. This approach was used because nekton count and diversity data are often non-normally distributed and heavily skewed, often with an excess of zero values and a long tail of high counts for few samples (outliers). Therefore, utilization of the median provides a more accurate representation of the data's central tendency for the majority of samples and is resistant to skew caused by outliers. Diversity data were visualized to assess general trends.

Next, the composition of nekton communities sampled by each gear type (seine, trawl [Project stations only], and fixed-area) in Project Year 1 (2024) were investigated further by identifying the top ten most numerically dominant species (based on total count across all samples) at stations associated with the Project and Reference areas. Only the top ten were summarized for ease of reporting. Permutational multivariate analyses of variance (PERMANOVA) tests were used to investigate differences in nekton communities (all taxa included) between Project and Reference areas collected by seines and fixed-area gear types. A multivariate analysis of the 2024 FIMP trawl data was not conducted due to lack of comparable datasets between Reference and Project stations stemming from differences in LDWF sample processing methodologies.

**Results – FIMP Seine and Trawl Gear:** In the pre-construction period between 2012 and 2021, the annual median Species Richness and Shannon Diversity observed at Reference FIMP seine stations ranged from 8.5[7–12] to 13[9–16.25] and 1.2[0.9–1.6] to 1.8[1.2–2.1], respectively (Figure 19), and measures were variable between years. In 2022, two years after data collection at Project FIMP seine stations was initiated, slightly lower Species Richness and Shannon Diversity were observed at Project FIMP stations compared to Reference. In 2024, both metrics were lower at Project FIMP seine stations (10[7.5–12] and 1.4[0.9–1.5]) compared to Reference (14[8–12] and 1.4[1.1–1.7]), although the differences were not statistically significant (Figure 19).

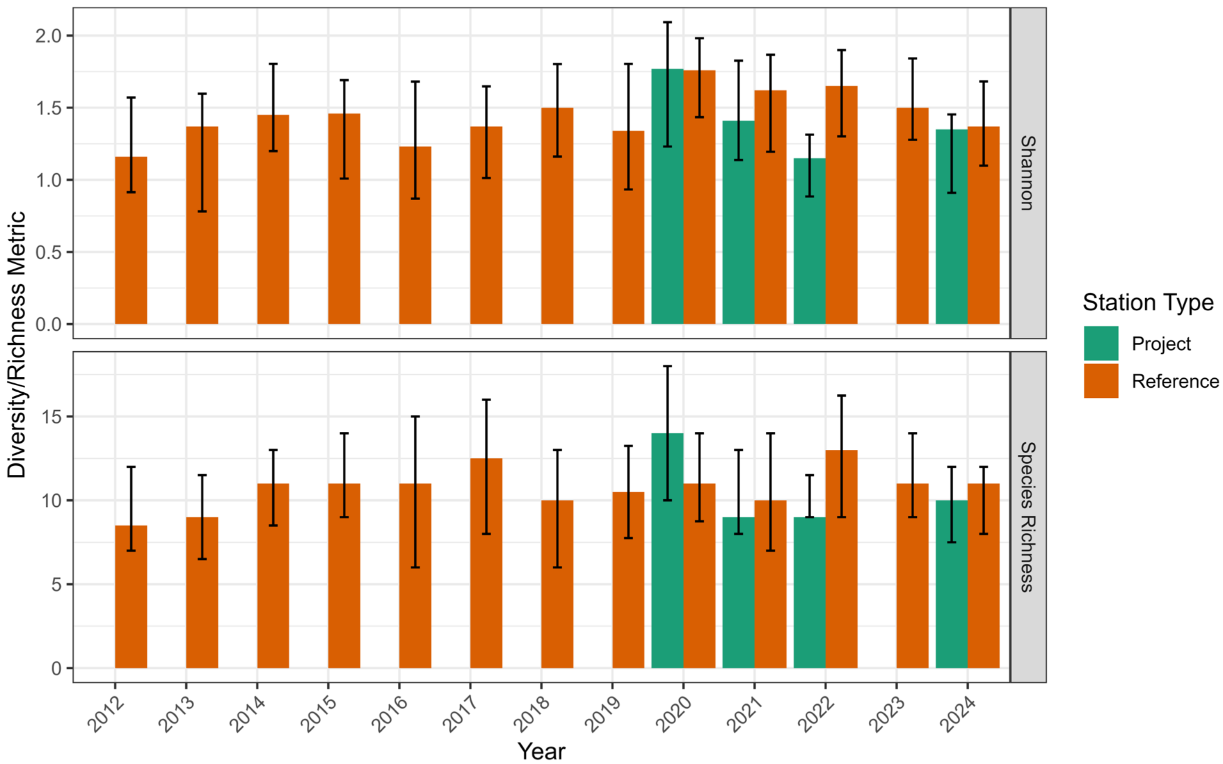


*Figure 19. Shannon Diversity and Species Richness of nekton observed at FIMP seine stations between 2012 and 2024. Bars represent annual medians and vertical lines represent the interquartile range. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Note: sampling at Project FIMP seine stations was not initiated until 2020, and no samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of the FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

Shannon Diversity and Species Richness at Project FIMP trawl stations in 2024 were 0.81 [0.47–1.0] and 7.0 [4.0–8.0], respectively (Figure 20).

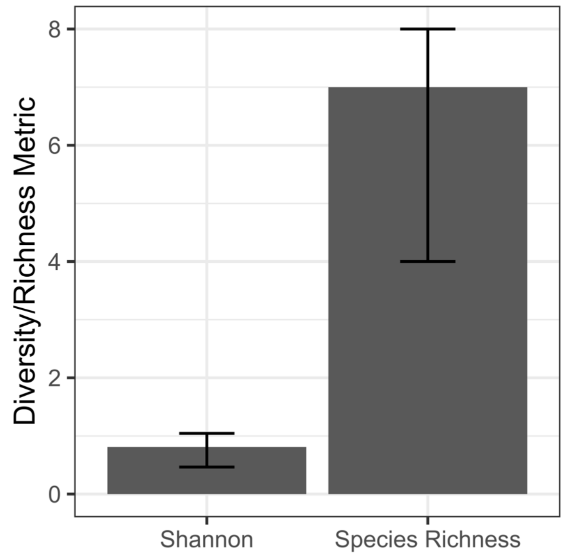


*Figure 20. Shannon Diversity and Species Richness of nekton observed at Project FIMP trawl stations between January 1 and December 31, 2024. Bars represent annual medians and vertical lines represent the interquartile range. Project FIMP trawl stations: 1081, 1085, 1086. Raw data were collected as part of the FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

In 2024, the dominant (by total count) nekton taxa observed by FIMP seines (Table 16) were Bay Anchovy (*Anchoa mitchilli*), Gulf Menhaden (*Brevoortia patronus*), and Brown Shrimp (*Penaeus aztecus*). Dominant taxa observed by FIMP Project trawls also included Brown Shrimp, Bay Anchovy, and Atlantic Croaker (*Micropogonias undulatus*; Table 17).

*Table 16. The top ten numerically dominant nekton taxa observed by FIMP seine stations in 2024. Data span catches from January 1 to December 31, 2024. Data are provided as total counts of individuals observed, and n indicates the number of samples analyzed from six Reference seine stations and three Project seine stations.*

| **FIMP Project Seine Stations (n=27 seine samples)** | | **FIMP Reference Seine Stations (n=44 seine samples)** | |
|---|---|---|---|
| **Species** | **Total Count** | **Species** | **Total Count** |
| *Anchoa mitchilli* | 3321 | *Anchoa mitchilli* | 2056 |
| *Brevoortia patronus* | 1408 | *Brevoortia patronus* | 1653 |
| *Penaeus aztecus* | 830 | *Penaeus aztecus* | 1334 |
| *Palaemon spp.* | 403 | *Palaemon spp.* | 1211 |
| *Menidia beryllina* | 185 | *Micropogonia undulatus* | 393 |
| *Micropogonia undulatus* | 150 | *Penaeus setiferus* | 333 |
| *Penaeus setiferus* | 144 | *Menidia beryllina* | 152 |
| *Cyprinodontidae spp.* | 84 | *Citharichthys spilopterus* | 126 |
| *Citharichthys spilopterus* | 41 | *Callinectes sapidus* | 117 |
| *Callinectes sapidus* | 36 | *Cynoscion arenarius* | 67 |

*Table 17. The top ten numerically dominant nekton taxa observed by FIMP trawl stations in 2024. Data span catches from January 1 and December 31, 2024, although sampling occurs only for portions of April/May and June/July (LDWF, 2022). Data are provided as total counts of individuals observed, and n indicates the number of samples analyzed from two Reference trawl stations and the three Project trawl stations. "–" = taxa beyond Brown and White Shrimp were not identified or enumerated at Reference trawl stations per standard LDWF FIMP protocols (LDWF, 2018).*

| **FIMP Project Trawl Stations (n=25 trawl samples)** | | **FIMP Reference Trawl Stations (n=6 trawl samples)** | |
|---|---|---|---|
| **Species** | **Total Count** | **Species** | **Total Count** |
| *Penaeus aztecus* | 4965 | *Penaeus aztecus* | 49 |
| *Anchoa mitchilli* | 1287 | *Penaeus setiferus* | 3 |
| *Micropogonias undulatus* | 262 | – | – |
| *Penaeus setiferus* | 133 | – | – |
| *Cynoscion arenarius* | 119 | – | – |
| *Callinectes sapidus* | 50 | – | – |
| *Brevoortia patronus* | 18 | – | – |
| *Palaemon spp.* | 11 | – | – |
| *Leiostomus xanthurus* | 11 | – | – |
| *Citharichthys spilopterus* | 7 | – | – |

Multivariate analysis of the 2024 FIMP seine data indicates that the nekton assemblage composition at the Project stations is successfully mirroring the conditions found at Reference stations one year after project completion (Figure 21). A PERMANOVA test confirmed no significant difference in the community centroids between station types ($F_{1,69} = 1.49$, $p = 0.134$), with station type explaining only 2.1% of the total variation. Furthermore, a test of multivariate dispersion showed no significant difference in community variability between the Project and Reference stations ($F_{1,69} = 0.69$, $p = 0.424$).

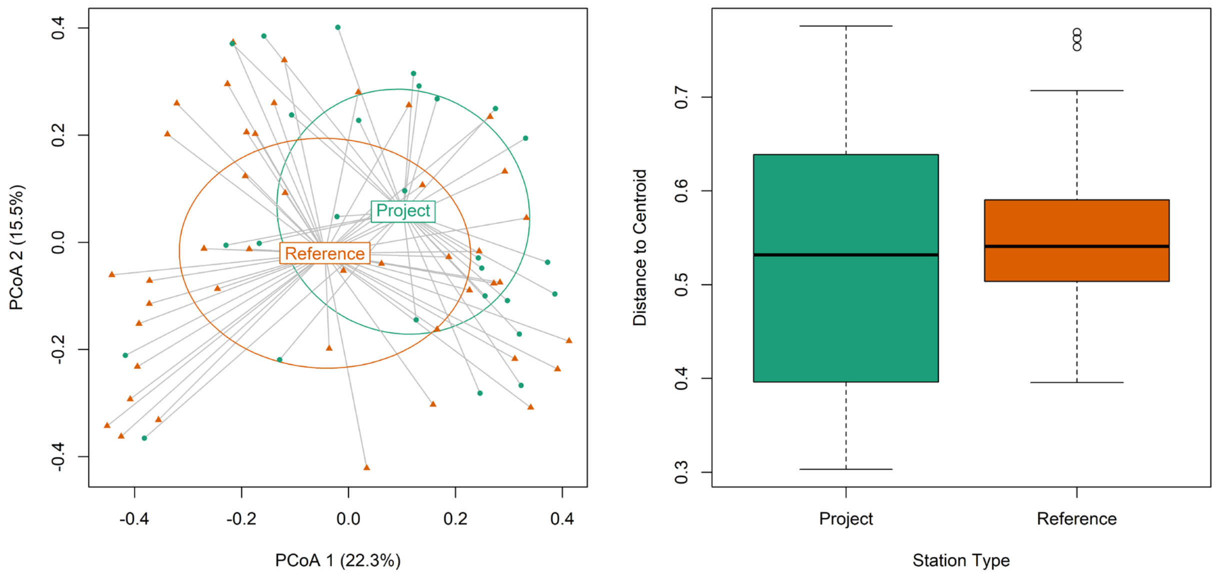


*Figure 21. Results of multivariate analysis of nekton communities sampled at FIMP seine stations in 2024. (Left) Principal Coordinates Analysis (PCoA) ordination plot based on a Bray-Curtis dissimilarity matrix of nekton CPUE collected from seines at Project and Reference FIMP seine stations. The ellipses represent the distribution of each group around its centroid, and individual samples are connected to their respective group centroids via spider lines. (Right) Boxplot representing the multivariate dispersion (distance to centroid) for seine samples from Project and Reference station types.*

**Results – Fixed-Area Gear:** In Year 1 (2024), the median Species Richness in samples collected by both drop sampling and throw trap fixed-area gear types was consistently higher in marsh edge habitats compared to open water habitats across all project features, the overall Project Area, and the Reference Area (Figure 22). For both habitat types, median Species Richness was slightly higher in the overall Project Area (open water = 4.5[4–6]; marsh edge = 8[6–9]) compared to the Reference Area (open water = 4[3.75–5.25]; marsh edge = 6[5.5–7.5]), although the differences were small. Median Species Richness was highest at **CO** stations in marsh edge habitat (9[9–9.5]). No marsh edge samples were collected at **GO** or **GF** stations due to the absence of a flooded marsh edge. As a reminder, only open water samples were collected at **I** stations.

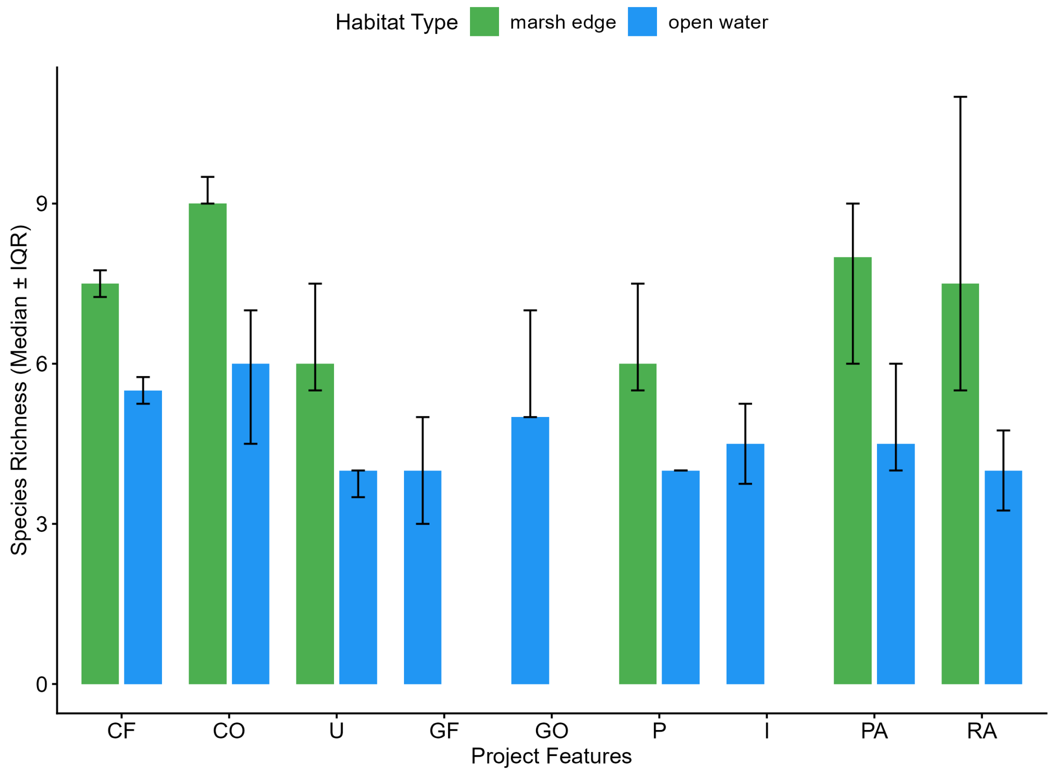


*Figure 22. Species Richness of nekton observed by fixed-area gear types in 2024. Data summarized by marsh edge or open water habitat across project features, the overall Project Area, and Reference Area in Project Year 1 (2024). Bars represent medians and error bars represent the Interquartile Range (IQR). Acronyms: ME = marsh edge; OW = open water; CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; I = interior; PA = project area; RA = reference area. All samples collected by drop sampler except for interior I sites sampled by throw trap; due to nature of throw trap sampling of interior sites, only open water samples were collected.*

Median Shannon Diversity was higher in marsh edge habitat compared to open water (Figure 23). In marsh edge habitat, Shannon Diversity was slightly higher in the overall Project Area (1.6[1.4–1.7]) compared to the Reference Area (1.5[1.4–1.6]) in Year 1 (2024). For open water habitat types, the reverse was observed: Shannon Diversity was slightly higher at the Reference Area (1.2[0.9–1.4]) compared to the Project Area (1.1[0.6–1.3]). The highest median Shannon Diversity was observed in marsh edge habitat at **CO** stations (1.7[1.6–1.8]) and lowest in open water habitat at **U** stations (0.3[0.2–0.5]).

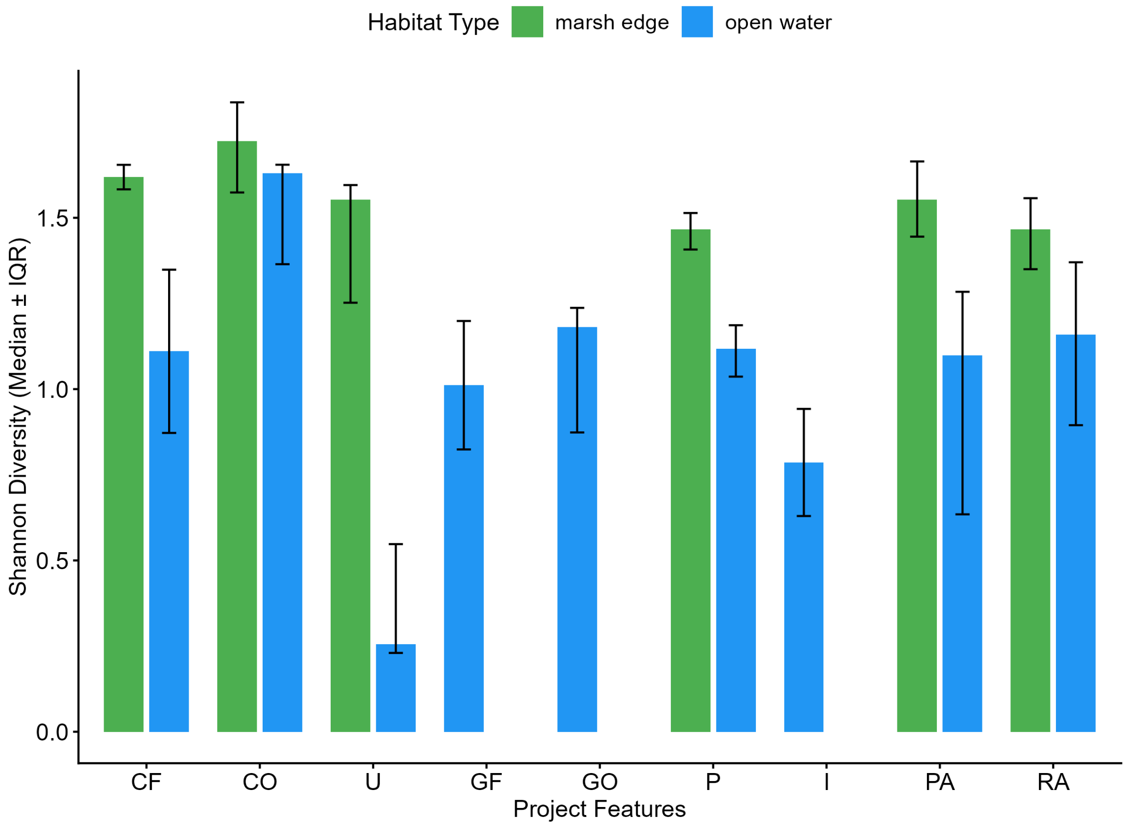


*Figure 23. Shannon diversity of nekton observed by fixed-area gear types in 2024. Data summarized by marsh edge or open water habitat across project features, the overall Project Area, and Reference Area in Project Year 1 (2024). Bars represent medians and error bars represent standard deviation (SD). Acronyms: ME = marsh edge; OW = open water; CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; I = interior. PA = project area; RA = reference area.All samples collected by drop sampler except for interior sites sampled by throw trap.*

The dominant nekton taxa by total count observed in marsh edge habitats in 2024 were similar between Project and Reference Areas and included Grass Shrimps (*Palaemon pugio* and *Palaemon* spp.), White Shrimp (*Penaeus setiferus*), Sailfin Molly (*Poecilia latipinna*), and two goby species (*Gobiosoma robustum* and *Gobiosoma bosc;* Table 18).

*Table 18. The top ten numerically dominant nekton taxa observed in marsh edge habitat collected by drop sampling in August 2024. Data are provided as total counts of individuals observed; n indicates the number of samples analyzed.*

| **Project Area (n=11 drop samples)** | | **Reference Area (n=6 drop samples)** | |
|---|---|---|---|
| **Species** | **Total Count** | **Species** | **Total Count** |
| *Palaemon pugio* | 236 | *Palaemon pugio* | 397 |
| *Palaemon* spp. | 106 | *Palaemon* spp. | 194 |
| *Poecilia latipinna* | 94 | *Penaeus setiferus* | 96 |
| *Penaeus setiferus* | 35 | *Gobiosoma robustum* | 57 |
| *Gobiosoma bosc* | 34 | *Palaemon vulgaris* | 55 |

| Project Area (n=11 drop samples) | | Reference Area (n=6 drop samples) | |
|---|---|---|---|
| **Species** | **Total Count** | **Species** | **Total Count** |
| *Gobiosoma robustum* | 23 | *Poecilia latipinna* | 52 |
| *Cyprinodon variegatus* | 20 | *Anchoa mitchilli* | 18 |
| *Fundulus grandis* | 16 | *Gobiosoma bosc* | 15 |
| *Membras martinica* | 13 | *Palaemon mundusnovus* | 13 |
| *Palaemon vulgaris* | 12 | *Rhithropanopeus harrisii* | 6 |

Similarly dominant nekton taxa were observed in open water habitats and also included species with pelagic-oriented life histories such as Anchovy (*Anchoa mitchilli*; Table 19). However, comparisons should be made with caution as these totals include both drop sampling and throw trapping samples together. The large number of Sailfin Molly observed in the Project Area was driven by a small number of throw trap samples collected from Interior habitats which contained very high densities of this species.

*Table 19. The top ten numerically dominant nekton taxa observed in open water habitat collected by both drop sampling and throw trapping in August 2024. Data are provided as total counts of individuals observed; n indicates the number of samples analyzed.*

| Project Area (n=16 drop samples, n=2 throw samples) | | Reference Area (n=6 drop samples) | |
|---|---|---|---|
| **Species** | **Total Count** | **Species** | **Total Count** |
| *Anchoa mitchilli* | 232 | *Anchoa mitchilli* | 53 |
| *Poecilia latipinna* | 204 | *Gobiosoma bosc* | 29 |
| *Palaemon pugio* | 88 | *Penaeus setiferus* | 16 |
| *Palaemon* spp. | 68 | *Callinectes sapidus* | 14 |
| *Cyprinodon variegatus* | 56 | *Anchoa hepsetus* | 9 |
| *Penaeus setiferus* | 37 | *Fundulus* spp. | 2 |
| *Gobiosoma robustum* | 29 | *Palaemon pugio* | 1 |
| *Membras martinica* | 21 | *Gobiosoma robustum* | 1 |
| *Callinectes sapidus* | 20 | *Rhithropanopeus harrisii* | 1 |
| *Gobiosoma bosc* | 18 | *Mugil cephalus* | 1 |

The variation within the fixed-area density data as driven by location, habitat, and other environmental factors was explored using PERMANOVA. This analysis was conducted on all samples collected by fixed-area gear types (throw trap and drop samples combined). This test revealed that factors including location (Project vs. Reference area), habitat type (marsh edge vs. open water), distance to edge, and average water depth caused a significant difference in the multivariate community composition derived from fixed-area nekton density data (Table 20). Overall, the factor of habitat type explained the greatest proportion of total variation ($R^2 = 0.14$). Differences in nekton communities across different feature types (CF, CO, U, FG, CO, P, I, PA, and RA) for different habitat types by PERMANOVA will be assessed in future synthesis reports as sample sizes from 2024 were too low to adequately conduct this comparison. Densities of target nekton are compared across different feature types in Section 2.3.3.2.

*Table 20. PERMANOVA statistical output for fixed-area nekton data collected in August 2024. Reported statistics include degrees of freedom (Df), sum of squares (SS), R squared ($R^2$), F-statistic (F-stat), and the p-value.*

| Variable | Df | Sum of Squares | R2 | F-stat | *p*-value |
|---|---|---|---|---|---|
| Area (Project, Reference) | 1 | 0.65 | 0.04 | 2.38 | 0.01* |
| Habitat (ME, OW) | 1 | 2.11 | 0.14 | 7.66 | 0.00* |
| Distance to Edge (cm) | 1 | 0.59 | 0.04 | 2.15 | 0.02* |
| Average Water Depth (cm) | 1 | 0.66 | 0.04 | 2.39 | 0.01* |
| Water Temperature (°C) | 1 | 0.43 | 0.03 | 1.58 | 0.08 |
| Dissolved Oxygen (mg $L^{-1}$) | 1 | 0.23 | 0.02 | 0.82 | 0.64 |
| Dissolved Oxygen (% saturation) | 1 | 0.19 | 0.01 | 0.70 | 0.78 |
| Turbidity (cm) | 1 | 0.46 | 0.03 | 1.66 | 0.06 |
| Salinity (ppt) | 1 | 0.32 | 0.02 | 1.16 | 0.29 |
| Vegetation Species | 11 | 3.67 | 0.25 | 1.21 | 0.07 |
| Stems ($0.25m^{-2}$) | 1 | 0.24 | 0.02 | 0.89 | 0.60 |
| SAV (%) | 1 | 0.31 | 0.02 | 1.13 | 0.32 |
| Residual | 18 | 4.95 | 0.33 | | |
| Total | 40 | 14.82 | 1.00 | | |

**Project Performance Assessment:** Community assemblage is monitored as a context variable, thus there are no defined performance targets for this monitoring parameter.

#### *2.2.2.4 Red drum utilization of the Project Area by acoustic telemetry*

No monitoring activities were conducted to inform this parameter pre-construction or during Year 1 (2024). Monitoring is expected to be conducted in Years 3–5 and will be assessed in a future Upper Barataria Project monitoring synthesis report. The metric used to evaluate this parameter includes:

- **Red drum utilization of Project Area by acoustic telemetry** assessed by the total number of detections over monitoring duration and the use of different constructed features in the Project Area **(Purpose: Performance).**

## 2.3 OBJECTIVE #3: PRODUCTIVITY

### 2.3.1 Parameter #5: Primary productivity

This parameter utilizes vegetation measurements to assess community composition and vigor of vegetation on the created marsh platform and berm to directly evaluate performance of the Project Area against the Reference Area. Soil properties and porewater characteristics are contextual measurements used to interpret the vegetation data. The metrics used to evaluate this parameter include:

- **Primary productivity** assessed by average vegetation height, total vegetation % cover, and % cover by species **(Purpose: Performance)**
- **Floristic Quality Index (Purpose: Performance)**
- **Vegetation Volume Index (Purpose: Performance)**

- **Soil porewater characteristics (Purpose: Context)**
- **Soil properties (Purpose: Context).**

**Methods:** Vegetation monitoring methodology and assessment of the Upper Barataria Project's performance was developed to operate synergistically with the CRMS monitoring program. For detailed methodology of vegetation data collection at CRMS sites, see chapter 7.1.1 of Folse et al. (2020). USGS data collection at the Reference Area occurred along the existing CRMS0248 vegetation linear transect where ten 0.25 $m^2$ vegetation plots were surveyed spanning a distance of approximately 78 m adjacent to the existing CRMS0248 boardwalk. USGS also collected more vegetation data at the Reference Area and the Project Area sites using methodology consistent with the CRMS protocols, except for the use of a 0.25 $m^2$ quadrat for vegetation metrics rather than the 4 $m^2$ quadrat used for CRMS.

Vegetation survey stations were strategically established within each of three discrete habitat types (herbaceous, shrub, and bare) found within each MCA and at the Reference Area following methodologies adapted from Hester & Willis, (2015) and Enwright et al. (2021). These habitat types were identified based upon geo-rectified satellite imagery, elevation data, and vegetation dominant species. One vegetation station was established per habitat type identified at the Reference Area and within each MCA. The number of vegetation stations varied across the MCAs and Reference Area depending on the number of habitat types present. The location of vegetation stations and sample plots were randomly established within the desired vegetation cover class using a random direction and distance (30–100 m) from the shoreline. No stations were established further than 100 m inland due to resource constraints.

Each vegetation station consisted of one central vegetation survey plot and four additional plots located at each cardinal direction (N, S, E, W) within approximately a 2 $km^2$ area. In total, three vegetation stations were established at the Reference Area, with a total of 15 0.25 $m^2$ vegetation plots (Table 21). A total of 24 stations were positioned across the Project Area and a total of 122 plots were surveyed (Table 21).

*Table 21. Summary of vegetation monitoring effort in 2024. Total numbers of stations and plots surveyed by USGS as part of Project Year 1 (2024) vegetation and soil monitoring within the Project and Reference areas are provided.*

| Area | No. Vegetation Stations | No. 0.25 $m^2$ Vegetation Plots Surveyed | No. Soil Cores for Soil Properties | No. Soil Cores for Grain Size |
|---|---|---|---|---|
| MCA1A | 6 | 30 | 3 | 3 |
| MCA1B | 4 | 20 | 2 | 2 |
| MCA2A | 6 | 30 | 3 | 3 |
| MCA2B | 4 | 22 | 2 | 2 |
| MCA3A | 4 | 20 | 2 | 2 |
| Project Area | 24 | 122 | 12 | 12 |
| Reference | 3 | 15 | 2 | 2 |

USGS also collected soil cores in 2024 to assess soil properties consistent with the CRMS protocols. One soil core was collected at the center vegetation plot (replicate A) at a subset of vegetation stations located within the Project Area (n = 12 cores) and Reference Area (n = 2 cores). A second core was offset from the first by 0.10 m (replicate B; n = 12 cores from the Project Area and n = 2 cores from the Reference

Area). Replicate A was sectioned into 4-cm increments (0–24 cm depth) and analyzed for soil specific conductance (µS $cm^{-1}$), soil bulk density (g $cm^{-3}$), and soil organic matter content (%). Replicate B was sectioned into two 12-cm increments (0–24 cm depth) and analyzed for grain size distribution (% sand, % silt, and % clay, as well as particle size [phi] mean, median, and standard deviation). Note: only two depth intervals were analyzed for particle size in 2024 due to the compact nature of the soils in the Project Area and difficulties in obtaining sufficient material for analysis; future monitoring efforts will attempt to analyze particle size for 4-cm depth increments.

All soil samples were analyzed at the Louisiana State University (LSU) Wetland Biogeochemistry Laboratory. USGS monitoring for Upper Barataria Project monitoring also includes collection of porewater characteristics—soil specific conductance (µS $cm^{-1}$), porewater pH, and porewater temperature (°C)—in parallel with soil sampling; however, due to the hard and compact soils at all sites at the time of monitoring these data were not collected in 2024.

All vegetation and soils monitoring data for the Upper Barataria Project and the Reference Area were made available for this report via CIMS (https://cims.coastal.louisiana.gov/monitoring-data/) and the CRMS Charting Tool (https://lacoast.gov/chart/Charting.aspx?laf=crms). In the first results section, the long-term (2012–2024) vegetation, soil porewater, and soil characteristics data collected at the Reference Area are summarized and visualized to provide pre-construction context. In the second results section, data collected from Project Year 1 (2024) are visualized and statistically analyzed for differences between Project Area and Reference Stations using nonparametric Mann-Whitney U tests where appropriate. Parametric analysis of variance (ANOVA) and Tukey honest significant difference tests or nonparametric Kruskal-Wallis tests and post hoc Dunn's tests based on normality of the data are used to statistically compare metrics observed between MCAs of the Project Area to the Reference Area.

#### *2.3.1.1 Primary Productivity: Vegetation Height, Cover, and Indices of Community Composition and Vegetation Vigor*

**Results – Long-Term Trends at Reference Site:** Between 2012 and 2021 the mean total vegetation cover at the Reference Area (CRMS0248) was relatively high with limited variability—ranging from 82.0 % to 93.0 % across established monitoring plots (Figure 24). During this period, mean height of the dominant vegetation type—an individual species covering greater than 20 % of the total plot area: *Spartina patens* (also known as *Sporobolus pumilus*)—ranged from 67.9 to 109.7 cm (Figure 25 and Figure 26). Further, the Reference Area was largely dominated by *S. patens* and, to a lesser extent, *Spartina alterniflora* and *Distichlis spicata* during that period. In 2023, *Iva frutescens* surpassed *S. patens* as the most dominant species, and by 2024, *Ipomoea sagittata* became most dominant with notable coverage by *D. spicata*, *I. frutescens, S. patens*, and *Baccharis halimifolia* taxa. The lowest mean total vegetation cover and highest variability in both total cover and dominant vegetation height was observed in 2022 when three of seven plots were measured with lower than 25 % total cover. Total vegetation cover at the Reference Area decreased in 2023 and 2024 (70.0 ± 39.9 % and 70.0 ± 38.8 %, respectively) relative to the prior decade, and in 2024 the lowest observed mean height of the dominant vegetation type *S. patens* (67.9 ± 33.8 cm) was recorded. Data collected in 2024 is discussed in more detail within the following results section.

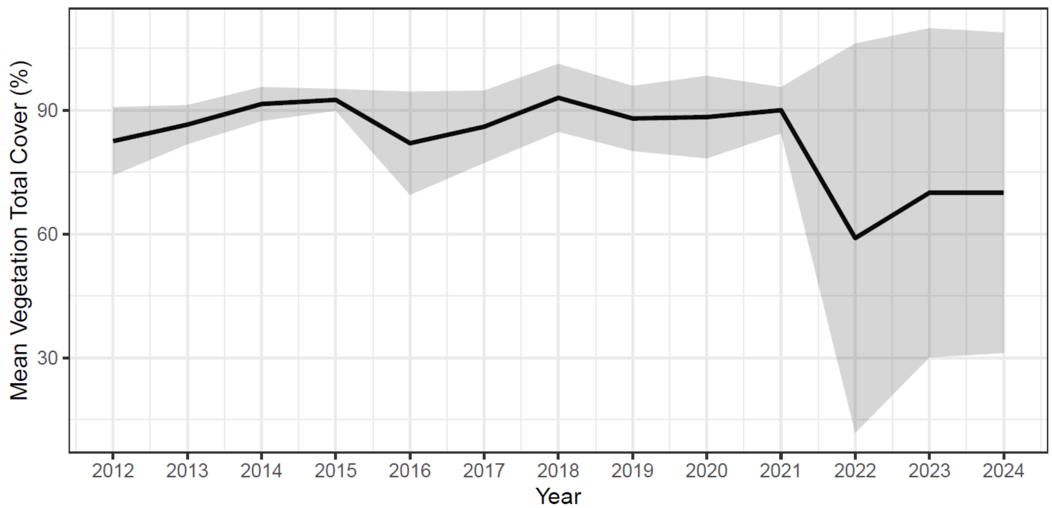


*Figure 24. Mean vegetation total cover (%) at the Reference Area between 2012 and 2024. The solid black line represents the mean value per year and shaded grey region indicates the standard deviation. Mean vegetation total cover per year was derived by calculating the mean of the total vegetation cover across plots within the site for each year of observation. Data for CRMS0248 was collected by USGS on a yearly basis and accessed in February 2025 via CIMS.*

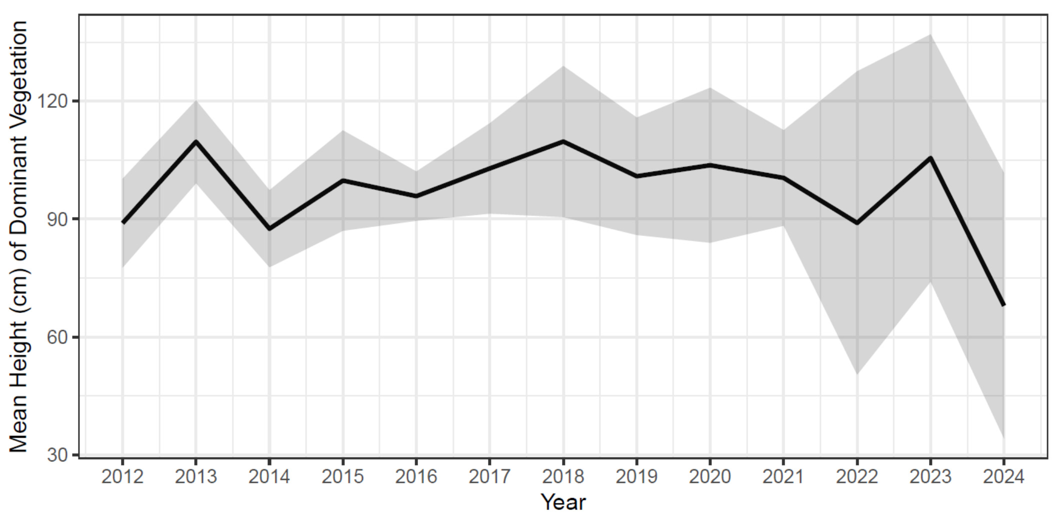


*Figure 25. Mean vegetation height (cm) of the dominant vegetation type at Reference Area between 2012 and 2024. The solid black line represents the mean value per year and shaded grey region indicates the standard deviation. Mean height per year was derived by calculating the mean of the dominant vegetation heights across plots within the site for each year of observation. Data for CRMS0248 was collected by USGS on a yearly basis and accessed in February 2025 via CIMS.*

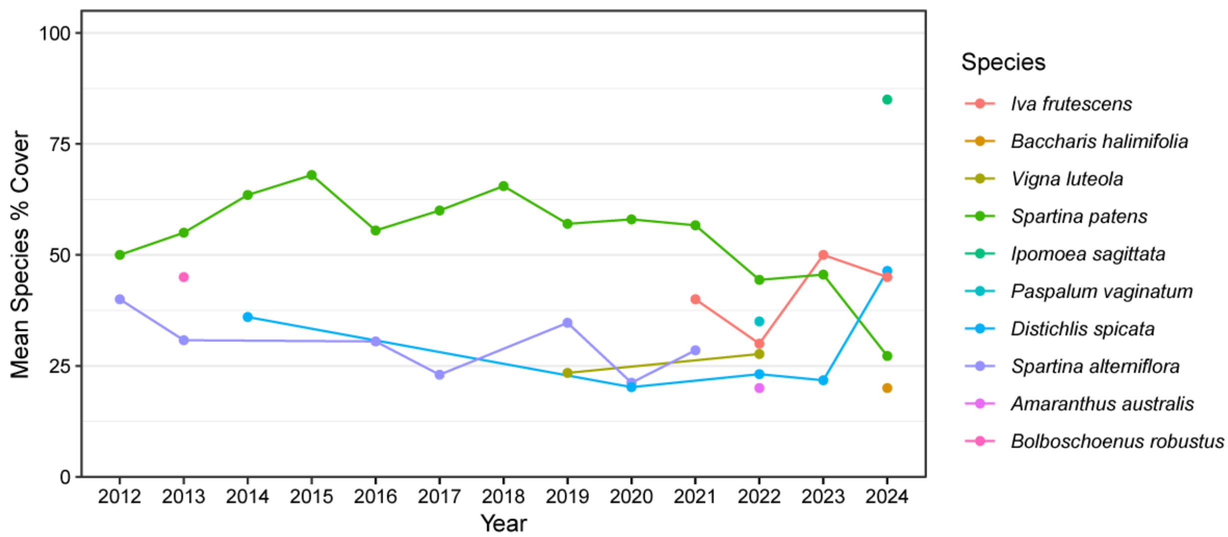


*Figure 26. Mean cover (%) of vegetation species accounting for greater than 20% total vegetation cover at the Reference Area between 2012 and 2024. The value for each vegetation species per year was derived by calculating the mean cover of each species across plots within the site for species whose cover was greater than 20%. Data for CRMS0248 was collected by USGS on a yearly basis and accessed in February 2025 via CIMS.*

Aspects of community composition and vegetation vigor are also reflected in values of the Floristic Quality Index (FQI) and the Vegetation Volume Index (VVI). Between 2012 and 2021, the FQI values for the Reference Area were observed to decline from a mean value of 91.2 ± 1.1 to 84.9 ± 2.2 (Figure 27). A notable drop in FQI was observed in 2022, when values declined to 59.6 ± 12.0. Values remained similarly low in 2023 and 2024. The lower observed FQI scores between 2022 and 2024 were likely driven by reduction in total cover (see Figure 24), and specifically by reduced cover of two vegetation species characteristic of vigorous coastal wetland communities at the site: *S. patens* and *S. alterniflora* (Figure 26).

Greater coverage of *D. spicata*, similarly highly tolerant to disturbance with high fidelity to a habitat, was unable to bolster the overall FQI score for the site to pre-2022 values. VVI values at the Reference Area were more variable over time compared to the FQI (Figure 27). Higher VVI values in 2015 relative to other monitoring years mirror the overall higher total vegetation cover observed for the same year (Figure 24). Similar to the temporal pattern observed for FQI, a drop in VVI was detected in 2022 through 2024 and was likely a result of more numerous sparsely vegetated plots present during that period and greater presence of *D. spicata*, a species that tends to be smaller in height compared to others.

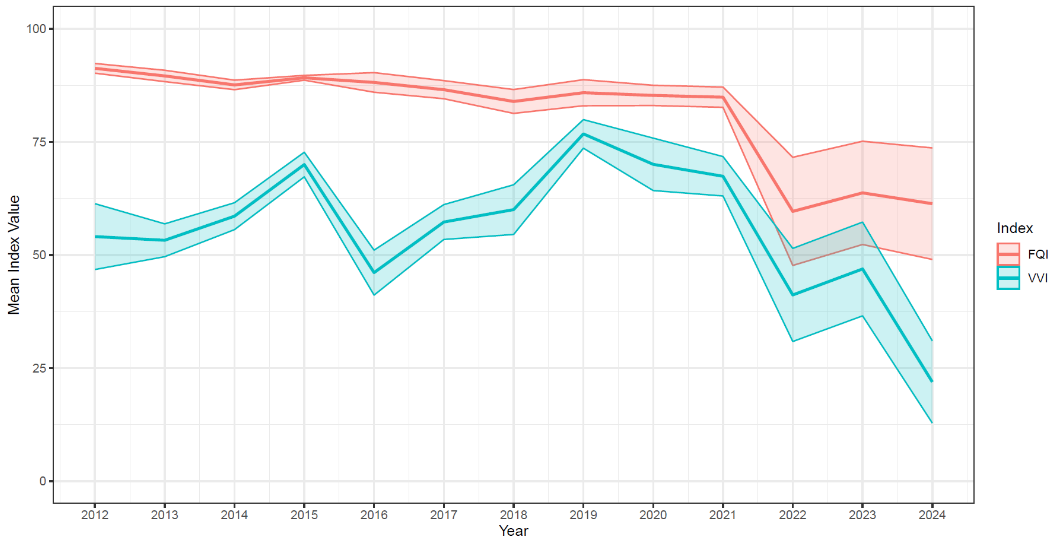


*Figure 27. Floristic Quality Index (FQI) and Vegetation Volume Index (VVI) values at the Reference Area between 2012 and 2024. Index values are provided annually (solid red line) with a measure of standard error (shaded red region). Data for CRMS0248 was collected by USGS and accessed in February 2025 via the CRMS Charting Tool.*

**Results – Project Year 1:** Figure 28 shows the locations at which USGS field teams conducted vegetation and soils monitoring in October 2024. **At the time of writing, no 2024 FQI data were available for inclusion in this synthesis report due to calculation issues within the CIMS reporting tool and thus are not discussed further.**

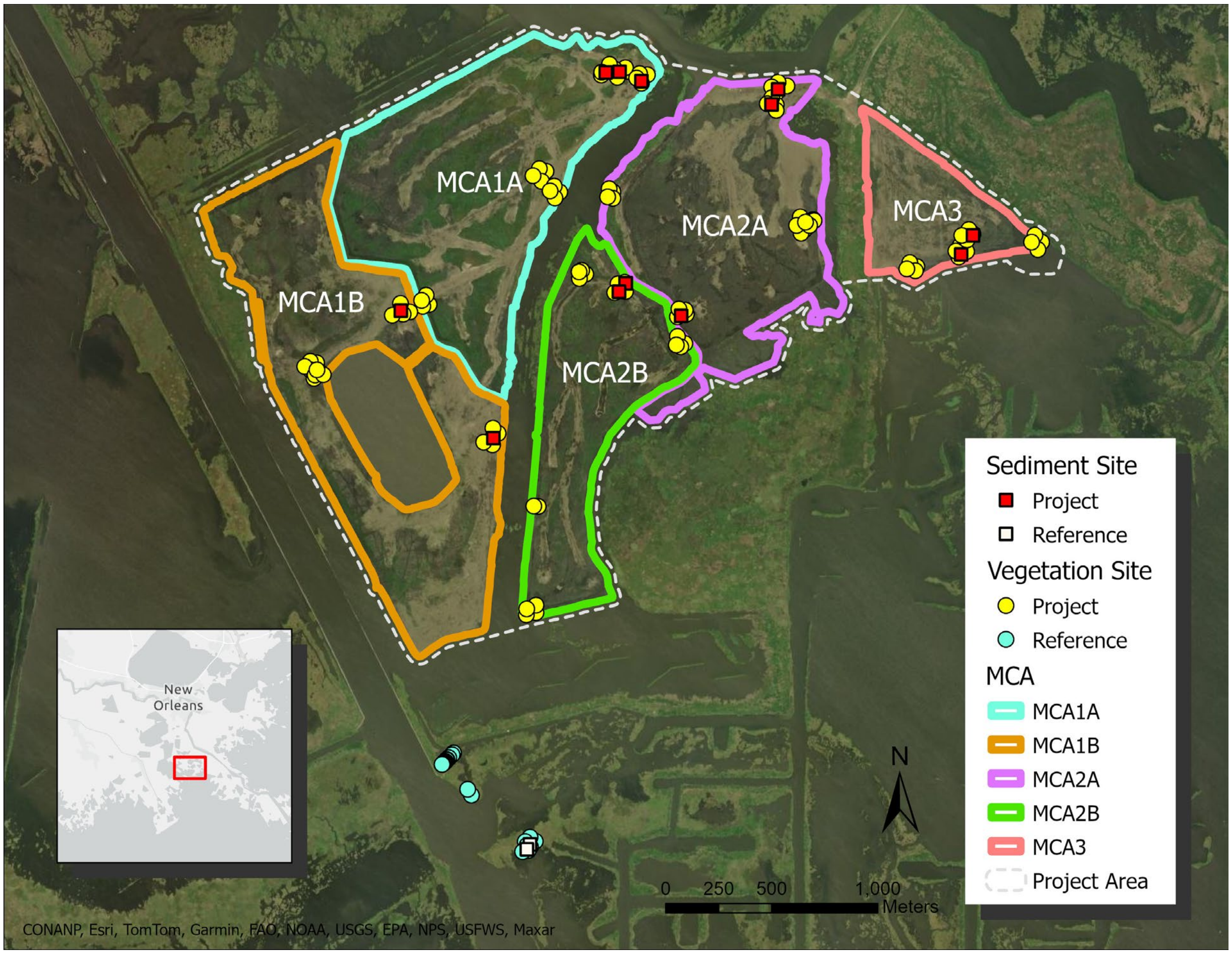


*Figure 28. Map of vegetation and soils monitoring sites within the Project and Reference areas. Additional Project Area components are also identified, including delineations of each MCA and the outer perimeter of the Project Area.*

In 2024, the most dominant vegetation species by spatial cover observed at the Reference Area included *Sparganium* spp., *D. spicata*, *S. patens, I. frutescens,* and *B. halimifolia*, whereas *B. halimifolia, Paspalum vaginatum, Panicum repens, Sparganium* spp., and *Polygonum punctatum* were dominant in the Project Area (Table 22). The most dominant species by average cover for each MCA include: *B. halimifolia* (MCA1A, mean ± SD = 22.6 ± 22.9 %; MCA2A, mean ± SD = 36.3 ± 24.3 %), *Typha domingensis* (MCA1B, mean ± SD = 10.6 ± 10.0 %), *P. vaginatum* (MCA2B, mean ± SD = 21.4 ± 24.4 %), and *Bacopa monnieri* (MCA3, mean ± SD = 23.9 ± 40.5 %). Qualitative observations by USGS noted high coverage of *Phragmites australis* in MCA1B (Figure 29).

*Table 22. The top ten dominant vegetation taxa (by average cover) observed in August 2024. Vegetation cover data are provided as means ± standard deviation (SD) separated by Project and Reference Area type; n indicates the number of survey plots analyzed; NA indicates calculation of standard deviation was not possible due to lack of data.*

| **Project Area (n=15 survey plots)** | | **Reference Area (n=122 survey plots)** | |
|---|---|---|---|
| **Species** | **% Cover (mean ± SD)** | **Species** | **% Cover (mean ± SD)** |
| *Baccharis halimifolia* | 19.2 ± 23.6 | *Sparganium* spp. | 33.3 ± 31.8 |
| *Paspalum vaginatum* | 19.3 ± 22.2 | *Distichlis spicata* | 32.4 ± 29.8 |
| *Panicum repens* | 11.6 ± 19.3 | *Spartina patens* | 24.5 ± 29.2 |
| *Sparganium* spp. | 10.3 ± 18.3 | *Iva frutescens* | 19.0 ± 25.7 |
| *Polygonum punctatum* | 9.5 ± 17.9 | *Baccharis halimifolia* | 16.3 ± 26.2 |
| *Bacopa monnieri* | 7.8 ± 21.4 | *Ipomoea sagittata* | 14.3 ± 31.3 |
| *Eleocharis montana* | 7.8 ± 15.6 | *Spartina alterniflora* | 5.5 ± 6.3 |
| *Phragmites australis* | 6.9 ± 13.2 | *Cuphea viscosissima* | 5.0 ± NA |
| *Juncus roemerianus* | 6.3 ± 17.7 | *Alternanthera philoxeroides* | 5.0 ± NA |
| *Typha domingensis* | 6.1 ± 8.9 | *Schoenoplectus americanus* | 2.7 ± 4.9 |

*Figure 29. Image of the Phragmites australis in MCA1B on the Project Area observed in October 2024. Photo credit: Brett A. Patton, USGS.*

Mean total vegetation cover at sites surveyed by USGS within the Project Area (mean ± SD: 31.02 ± 29.08 %) was significantly less than that observed at the Reference Area (mean ± SD: 64.0 ± 30.4 %; W = 663.5, *p*-value = 0.00; Figure 30). Significant differences in total vegetation cover in individual MCAs compared to the Reference Area were identified using ANOVA (F = 10.4, df = 5, *p* = 0.00), and a post-hoc Tukey significance test identified significantly lower vegetation total cover at MCA1B (mean ± SD: 9.4 ± 10.5 %) compared to the other MCAs (Figure 31, Table 23).

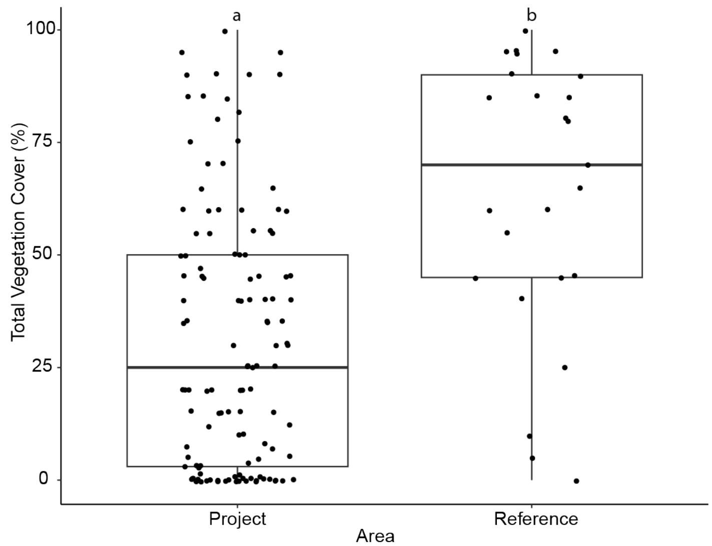


*Figure 30. Box and whisker plots of total vegetation cover (%) at the Reference and Project Areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data were collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

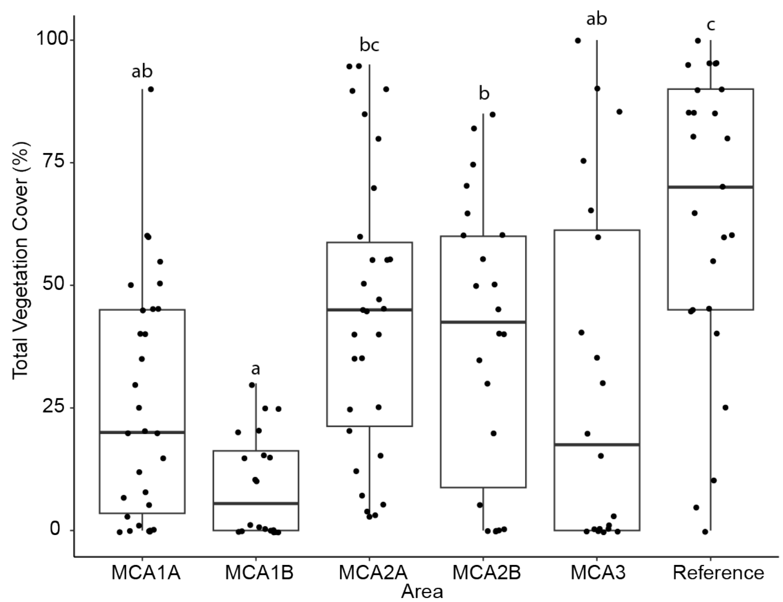


*Figure 31. Box and whisker plots of total vegetation cover (%) at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the ANOVA test and post-hoc Tukey test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data were collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

*Table 23. Summary of vegetation cover observed in 2024. Summary statistics (mean ± SD) of total vegetation cover (%) are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1 (2024).*

| Area | Total Cover (%) |
|---|---|
| MCA1A | 26.0 ± 24.0 |
| MCA1B | 9.4 ± 10.5 |
| MCA2A | 44.4 ± 29.3 |
| MCA2B | 39.4 ± 28.9 |
| MCA3 | 31.0 ± 35.5 |
| Project Area | 31.0 ± 29.1 |
| Reference Area | 64.0 ± 30.4 |

Although significant differences in total vegetation cover between the Project and Reference areas were observed, the mean height of dominant vegetation was not different (W = 1143, *p*-value = 0.96; Figure 32) nor were any differences identified between MCAs and the Reference Area (Kruskal-Wallis rank sum test; Chi squared = 6.1, df = 5, p = 0.30; Figure 33 and Table 24).

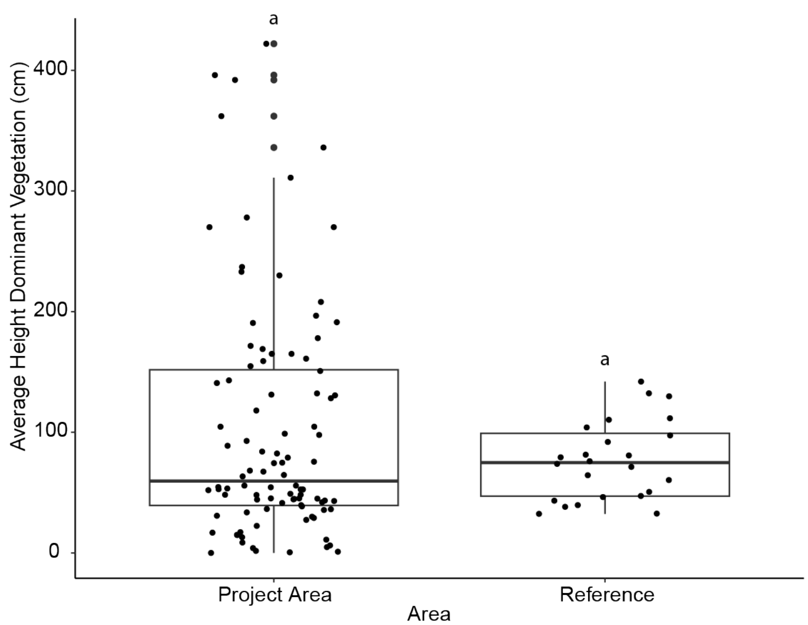


*Figure 32. Box and whisker plots of average height of dominant vegetation (cm) at the Reference and Project Areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data were collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

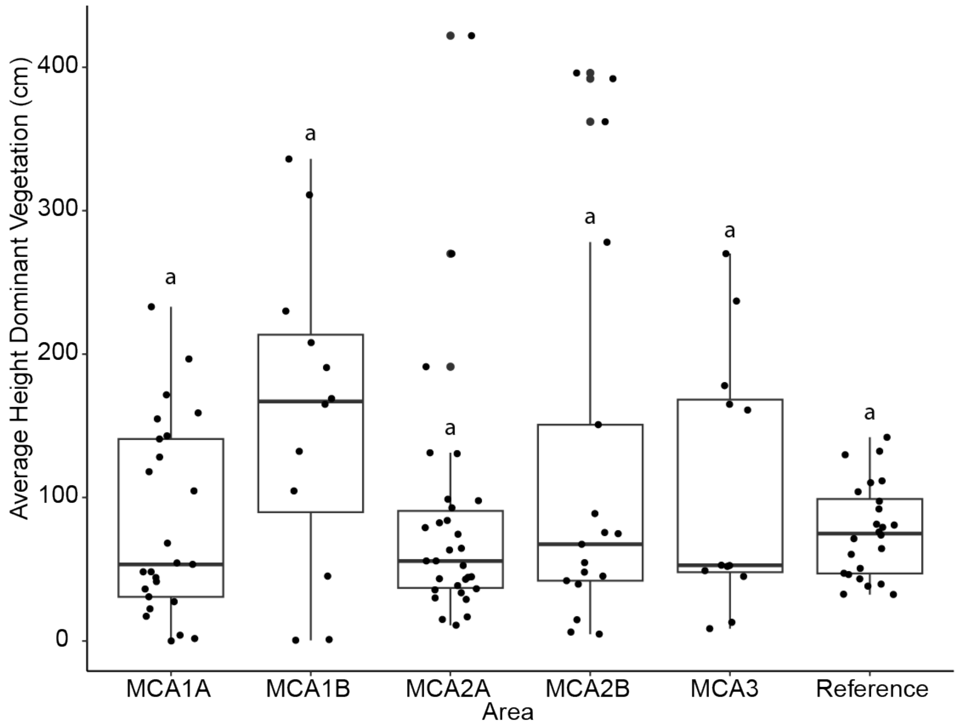


*Figure 33. Box and whisker plots of average height of dominant vegetation (cm) at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the Kruskal-Wallis rank sum test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

*Table 24. Summary of vegetation height observed in 2024. Summary statistics (mean ± SD) of dominant vegetation height (cm) are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1 (2024).*

| Area | Dominant Veg Height (cm) |
|---|---|
| MCA1A | 81.9 ± 67.1 |
| MCA1B | 157.6 ± 108.6 |
| MCA2A | 82.3 ± 84.0 |
| MCA2B | 125.9 ± 138.4 |
| MCA3 | 107.0 ± 90.2 |
| Project Area | 102.4 ± 97.8 |
| Reference Area | 76.5 ± 32.8 |

The vegetation community evenness measured by the Pielou Evenness index was not significantly different between the Project and References areas (mean ± SD: 0.5 ± 0.4 and 0.6 ± 0.2, respectively; W = 1046.5, *p*-value = 0.40; Figure 34). Significant differences in the evenness of vegetation communities were identified (Kruskal-Wallis test, Chi squared = 18.0, df = 5, *p* = 0.00; Figure 35, Table 25), yet pairwise comparisons only identified significantly lower evenness between MCAs (MCA1B compared to MCA1A and MCA2A) and not between any MCAs and the Reference Area.

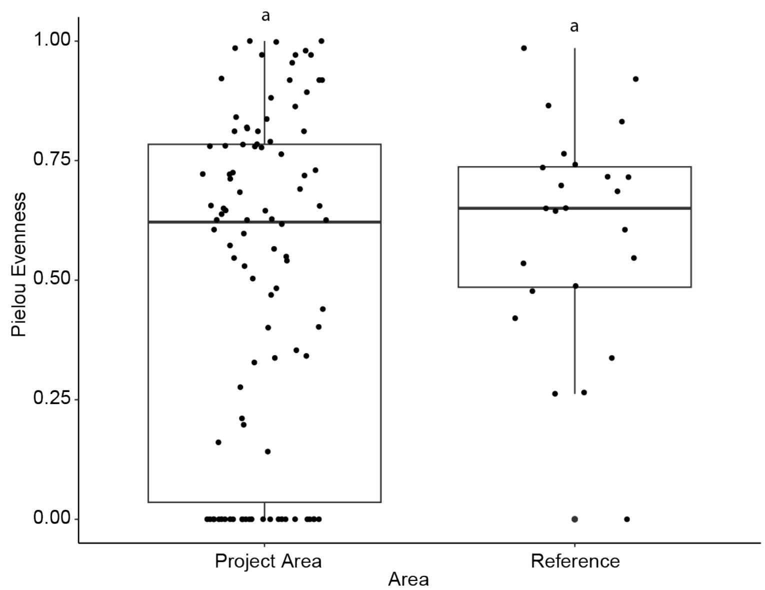


*Figure 34. Box and whisker plots of vegetation Pielou Evenness observed at the Reference and Project areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

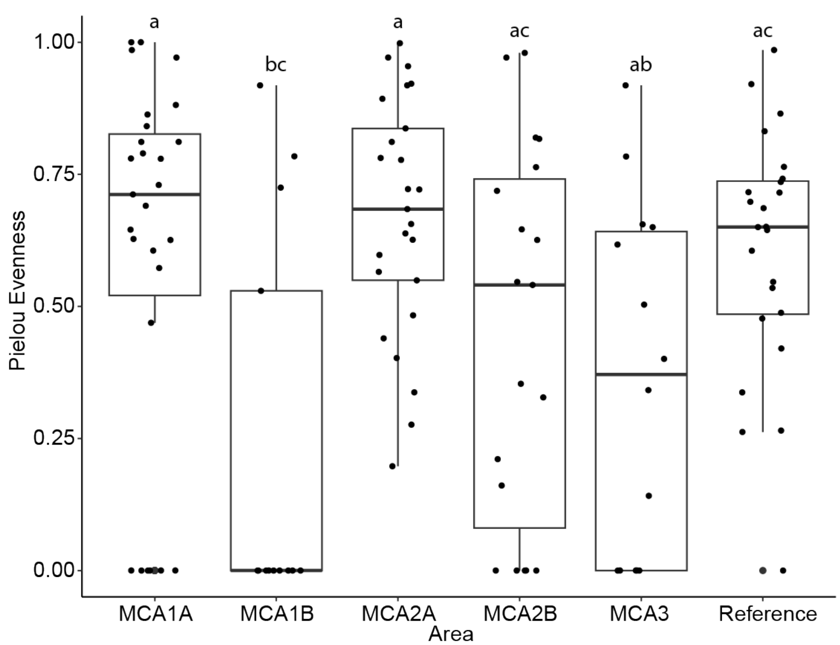


*Figure 35. Box and whisker plots of vegetation Pielou Evenness observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the Kruskal-Wallis test and post-hoc Dunn's test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

*Table 25. Summary of vegetation Pielou Evenness observed in 2024. Summary statistics (mean ± SD) of Pielou Evenness are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1. (2024).*

| Area | Pielou Evenness |
|---|---|
| MCA1A | 0.6 ± 0.4 |
| MCA1B | 0.2 ± 0.4 |
| MCA2A | 0.7 ± 0.2 |
| MCA2B | 0.4 ± 0.4 |
| MCA3 | 0.4 ± 0.3 |
| Project Area | 0.5 ± 0.4 |
| Reference | 0.6 ± 0.2 |

The vegetation community diversity measured by the Shannon Diversity index was significantly higher at the Reference Area (mean ± SD: 0.7 ± 0.3) compared to the Project Area (mean ± SD: 0.4 ± 0.4; W = 930, *p*-value = 0.00; Figure 36). When the Reference Area was evaluated against the individual MCAs of the Project Area, significant differences were observed (Kruskal-Wallis test, Chi squared = 29.9, df = 5, *p* = 0.00). Shannon Diversity was significantly higher in the Reference Area over MCA1B (mean ± SD: 0.1 ± 0.3) and MCA3 (mean ± SD: 0.2 ± 0.3; Figure 37, Table 26).

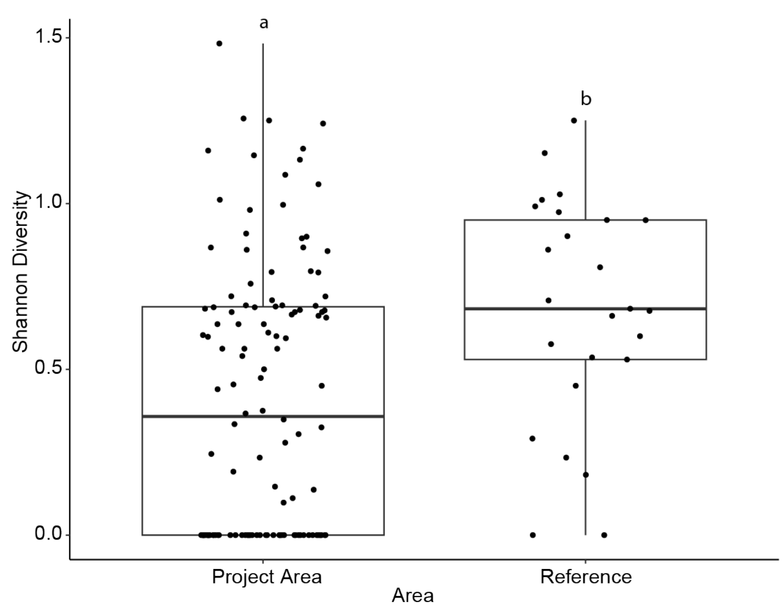


*Figure 36. Box and whisker plots of vegetation Shannon Diversity observed at the Reference and Project areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

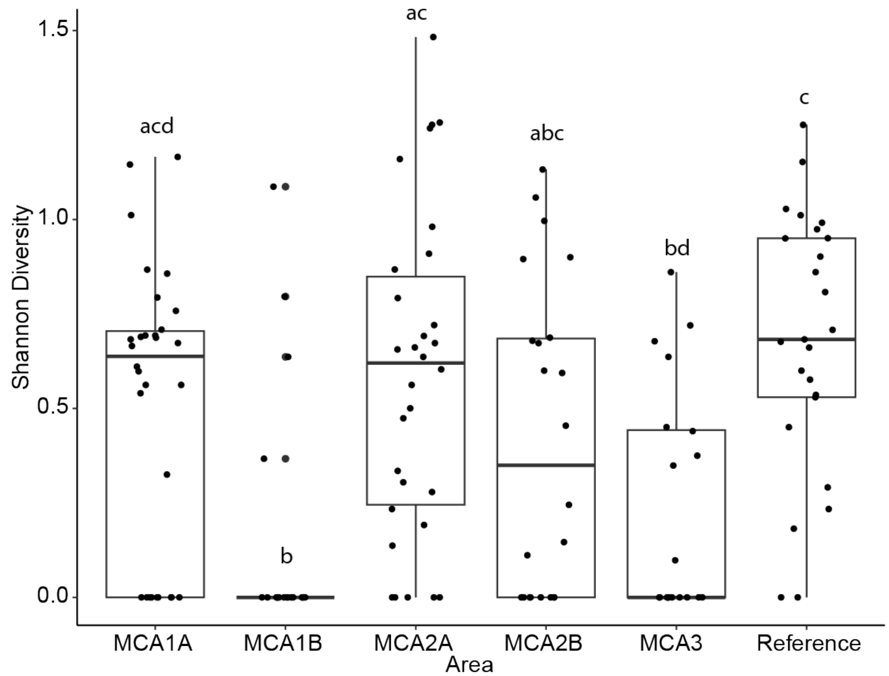


*Figure 37. Box and whisker plots of vegetation Shannon Diversity observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the Kruskal-Wallis test and post-hoc Dunn's test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

*Table 26. Summary of vegetation Shannon Diversity observed in 2024. Summary statistics (mean ± SD) of Shannon Diversity are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1 (2024).*

| **Area** | **Shannon Diversity** |
|---|---|
| MCA1A | 0.5 ± 0.4 |
| MCA1B | 0.1 ± 0.3 |
| MCA2A | 0.6 ± 0.4 |
| MCA2B | 0.4 ± 0.4 |
| MCA3 | 0.2 ± 0.3 |
| Project Area | 0.4 ± 0.4 |
| Reference | 0.7 ± 0.3 |

Species richness of the vegetation community was significantly higher in the Project Area (mean ± SD: 5.6 ± 1.6) compared to the Reference Area (mean ± SD: 7.0 ± 3.1; W = 2016.5, *p*-value = 0.01; Figure 38). Significant differences were also observed in comparisons between species richness of the Reference Area and individual MCAs (ANOVA, df = 5, F stat = 13.5, $p = 0.00$), with significantly higher Species Richness at MCA2A (mean ± SD: 9.5 ± 2.8) over other areas (Figure 39, Table 27).

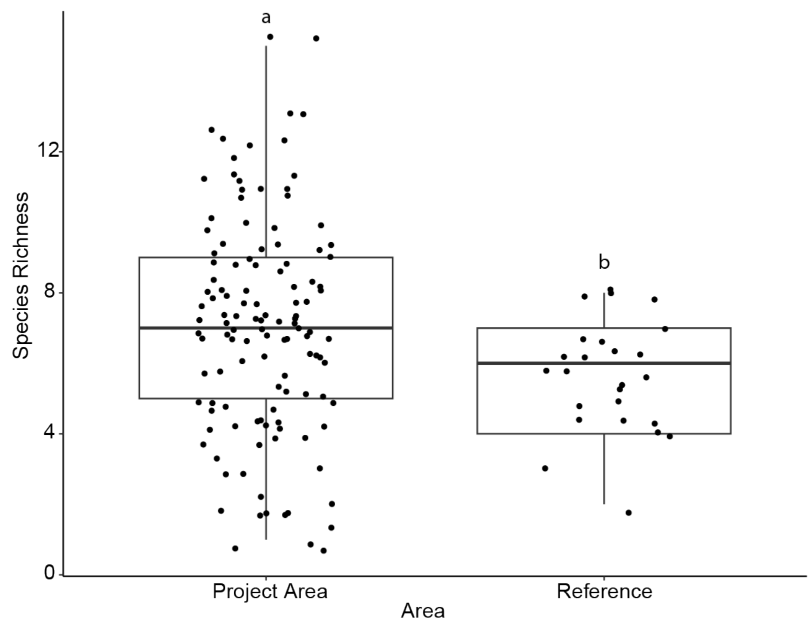


*Figure 38. Box and whisker plots of vegetation species richness observed at the Project and Reference areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

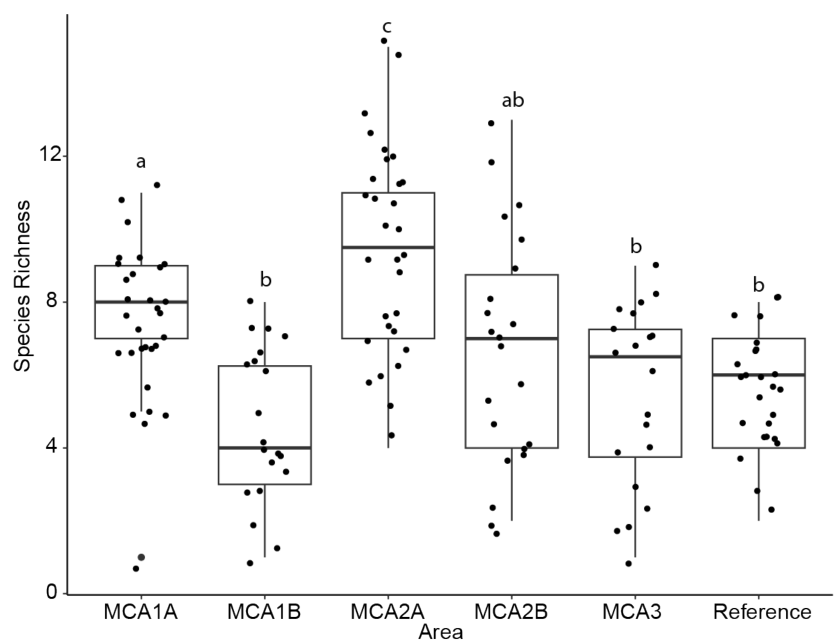


*Figure 39. Box and whisker plots of vegetation species richness observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the ANOVA test and post-hoc Tukey test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in April 2025 via CIMS.*

*Table 27. Summary of vegetation species richness observed in 2024. Summary statistics (mean ± SD) of species richness are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1 (2024).*

| Area | Species Richness |
|---|---|
| MCA1A | 7.5 ± 2.0 |
| MCA1B | 4.6 ± 2.1 |
| MCA2A | 9.5 ± 2.8 |
| MCA2B | 6.7 ± 3.2 |
| MCA3 | 5.5 ± 2.5 |
| Project Area | 7.0 ± 3.1 |
| Reference | 5.6 ± 1.6 |

VVI values based on 2024 vegetation surveys revealed no significant differences between the Project Area (mean ± SD: 23.7 ± 19.7) and the Reference Area (mean ± SD: 27.9 ± 22.0; W = 608, *p*-value = 0.68; Figure 40). Statistical comparisons of VVI values among MCAs and the Reference Area also yielded no significant differences (ANOVA, df = 5, F stat = 0.8, *p* = 0.54; Figure 41, Table 28).

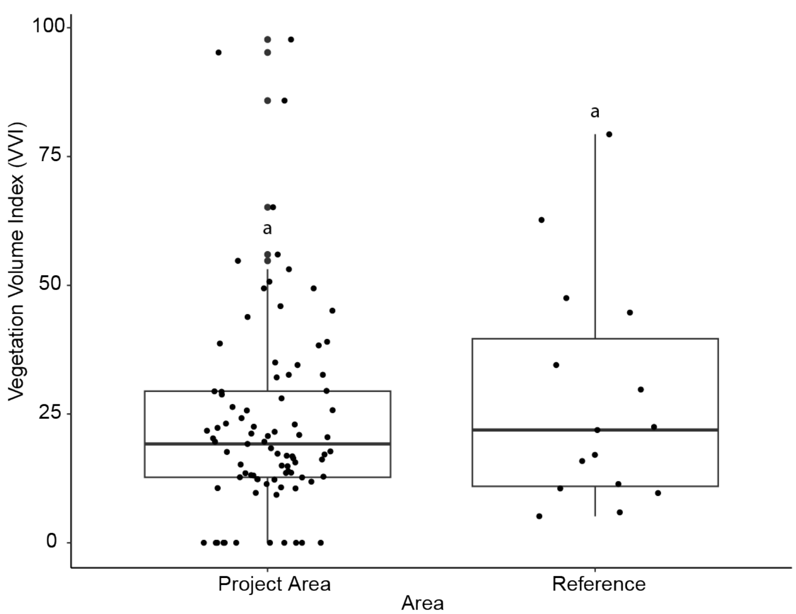


*Figure 40. Box and whisker plots of the Vegetation Volume Index (VVI) observed at the Project and Reference areas observed in 2024. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in May 2025 via the CRMS Charting Tool.*

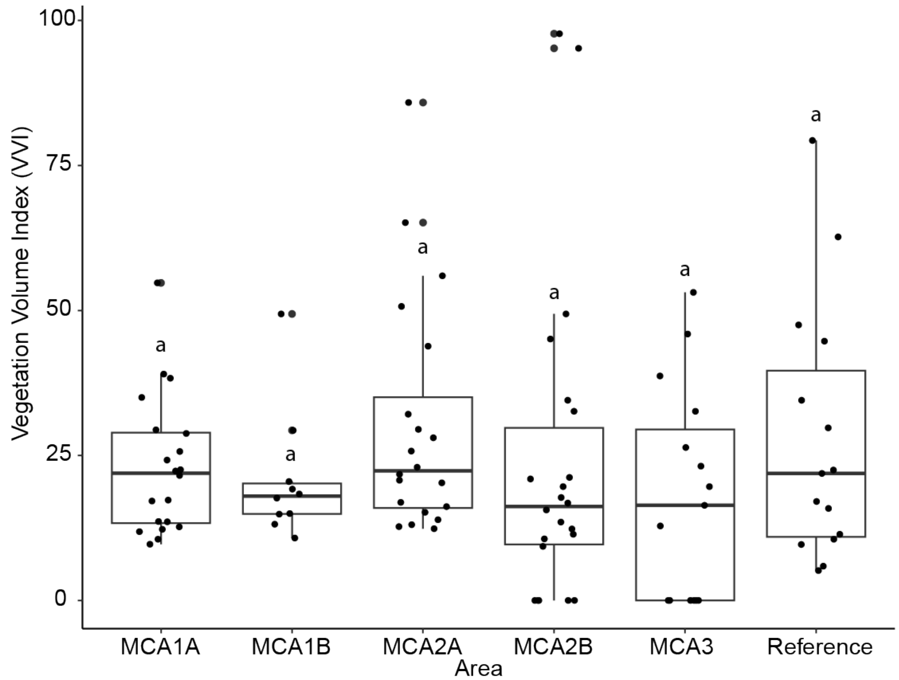


*Figure 41. Box and whisker plots of the Vegetation Volume Index (VVI) observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Groups that do not share a letter are significantly different based on the ANOVA test and post-hoc Tukey test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in May 2025 via the CRMS Charting Tool.*

*Table 28. Summary of Vegetation Volume Index (VVI) observed in 2024. Summary statistics (mean ± SD) of Vegetation Volume Index (VVI) are provided by individual MCA, the overall Project Area, and Reference Area observed in Project Year 1 (2024). No FQI data were available for analysis at the time of writing.*

| Area | VVI |
|---|---|
| Reference | 27.9 ± 22.0 |
| MCA1A | 23.0 ± 11.8 |
| MCA1B | 20.8 ± 11.2 |
| MCA2A | 30.1 ± 20.1 |
| MCA2B | 23.8 ± 27.3 |
| MCA3 | 17.9 ± 18.4 |
| Project Area | 23.7 ± 19.7 |

**Project Performance Assessment:**

- ***Performance Criteria:*** *Within 6 years of construction, marsh cover is* *not significantly less* *than reference marshes at CRMS0248.*
- **Project Year 1 (2024):** ***Performance Criteria Not Yet Met*** – Mean total vegetation cover (%) was significantly lower within the Project Area compared to the Reference Area.

- ***Performance Criteria:*** *The marsh vegetation composition and vigor is typical of a healthy intertidal marsh with respect to inundation and salinity regime (reference marsh at CRMS0248 after 3 years).*
    - **Project Year 1 (2024):** ***Performance Criteria Not Yet Met*** – No significant differences were identified between Project and Reference Area metrics of VVI, Pielou Evenness, nor vegetation height, yet significant differences were observed between MCAs of the Project Area when compared to the Reference Area. Further, significantly higher values of Shannon Diversity were calculated for the Reference Area compared to the Project Area, and significantly higher species richness were calculated at the Project Area compared to the Reference Area.

### *2.3.1.2 Soil Porewater Characteristics*

**Results – Long-Term Trends:** Assessment of long-term trends in soil porewater characteristics monitored at the Reference Area was used to contextualize trends in primary productivity. Values of soil porewater specific conductance (µS/cm) were relatively stable between 2012 and 2021 (Figure 42), with mean annual soil specific conductance ranging from 9961.9 ± 2456.4 to 7302.6 ± 3504.0 µS cm$^{-1}$ in 2012 and 2020. This trend shifted in 2022 through 2024 when values of mean annual soil specific conductance were higher than those observed throughout the prior decade, with the highest observed soil specific conductance value of 15060.0 ± 6066.5 µS cm$^{-1}$ recorded in 2023. This is mirrored in the trend in soil porewater salinity (ppt) to a lesser extent, whereas mean annual soil temperature (°C) remained relatively stable over time.

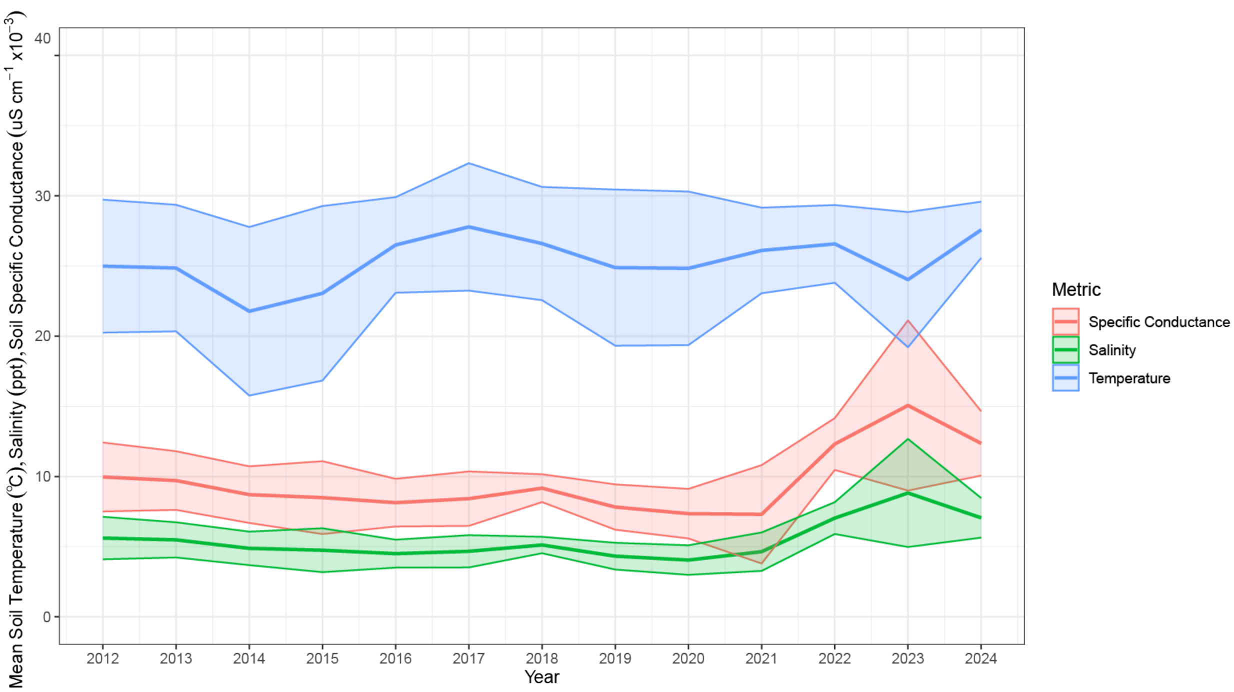


*Figure 42. Summary of soil porewater characteristics at the Reference Area over time. Depth-averaged mean soil temperature (°C), porewater salinity (ppt), and soil specific conductance (µS cm$^{-1}$ x10$^{-3}$) observed at the Reference Area between 2012 and 2024. Solid lines represent the annual mean and shaded regions indicate the associated standard deviations. Data from CRMS0248 was collected by USGS and accessed in February 2025 via*

*CIMS.* **Results – Project Year 1:** Due to the hard and compact nature of the soils present within the Project Area in October 2024 at the time of monitoring, USGS did not collect data relevant to soil porewater characteristics–soil specific conductance (µS $cm^{-1}$), porewater pH, and porewater temperature (°C). Thus, these data are not discussed as part of Year 1 monitoring. Future monitoring efforts will attempt to collect these data.

#### *2.3.1.3 Soil Properties*

**Results – Long-Term Trends:** No pre-construction soil grain size data from the Reference Area was available prior to the Upper Barataria Project monitoring effort; thus, long-term trends in grain size are not discussed. Soil bulk density and soil organic matter were evaluated twice since the establishment of the Reference Area: once in 2007 and again in 2018. Only very small differences in bulk density at depths between 4 and 16 cm were observed between the timepoints, ranging from 0.150 ± 0.0 to 0.250 ± 0.0 g $cm^3$ within that depth range (Figure 43). Greater differences were observed in surface sediments (0–4 cm depth) and at depths below 16 cm between years sampled. Soil bulk density both at the surface and at depth in 2007 was greater than that observed in 2018.

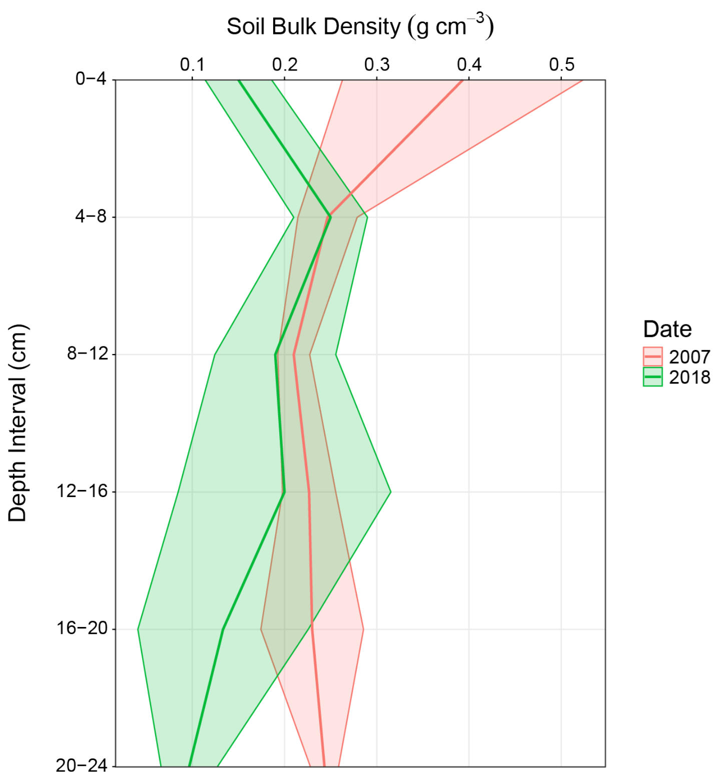


*Figure 43. Mean soil bulk density (g $cm^{-3}$) by depth interval measured at the Reference Area. Data visualized for 2007 and 2018. Mean bulk density (solid lines) and standard deviation (shaded region) were calculated by taking the mean across values provided for each depth interval across the three replicate cores collected at the site per year (2007 and 2018). Discrete measurements of bulk density were collected once upon site establishment (2007) and again in 2018. Data from CRMS0248 was collected by USGS and accessed in February 2025 via CIMS.*

The amount of soil organic matter in samples from the Reference Area was similar between 2007 and 2018 in the top 16 cm of soil, with organic matter content ranging from 29.2 ± 2.1 to 38.4 ± 4.3 % in the top 4 cm, and 30.0 ± 2.7 to 35.8 ± 12.8 % between 12–16 cm depth (Figure 44). Soil organic content diverged substantially between the 2 years of data collection at depths below 16 cm. Mean soil organic content at depths 20–24 cm in 2007 was 23.3 ± 0.6 % compared to 57.7 ± 12.8 % observed in 2018.

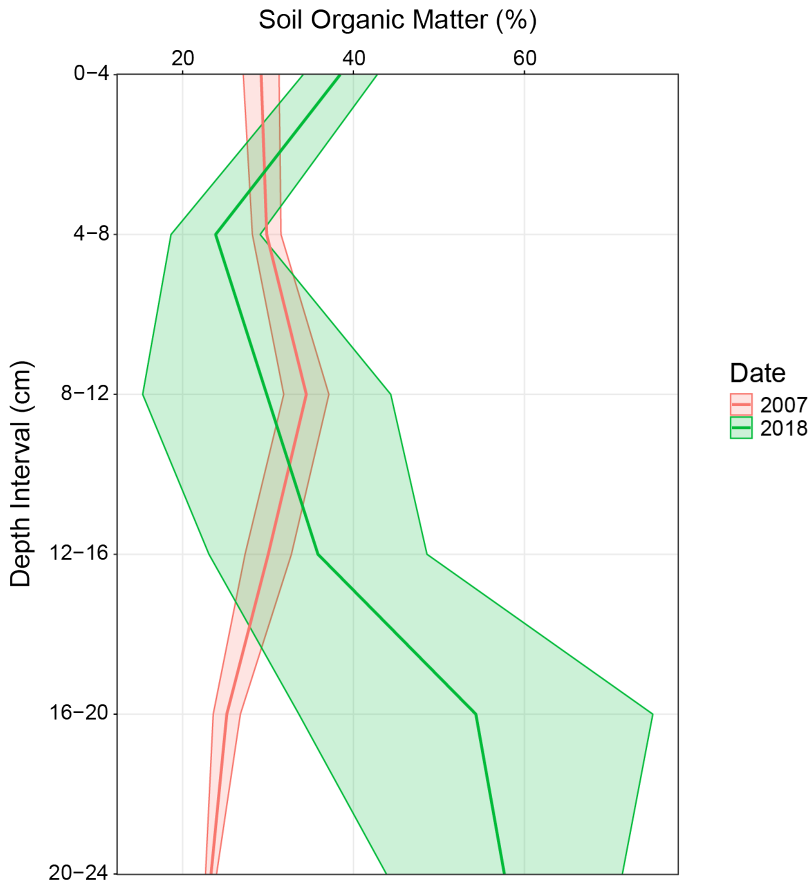


*Figure 44. Mean soil organic matter (%) by depth interval measured at the Reference Area. Data visualized for 2007 and 2018. Mean values (solid lines) and standard deviation (shaded region) were calculated by taking the mean across values provided for each depth interval across the three replicate cores collected at the site per year (2007 and 2018). Discrete measurements of bulk density were collected once upon site establishment (2007) and again in 2018. Data from CRMS0248 was collected by USGS and accessed in February 2025 via CIMS.*

**Results – Project Year 1:** In October 2024, USGS field teams collected soil samples to assess soil properties at both Project and Reference areas (Figure 45). Several soil parameters were measured, including soil specific conductance (µS $cm^{-1}$), soil bulk density (g $cm^{-3}$; related to soil moisture content), soil organic matter content (%), and particle size (% sand content).

*Figure 45. Photographs of soil monitoring in the Project and Reference areas. Left: Image of compact and hard soils observed at MCA1A in October 2024. Right: Image of Emily Fromenthal taking a soil core at the Reference Area in October 2024. Photo credit: Brett A. Patton, USGS.*

Measurements of soil specific conductance in the Project Area were significantly lower than the Reference Area (W = 34, $p = 0.00$; Figure 46). Further, specific conductance was significantly higher at the Reference Area compared to MCA1A, MCA2B, and MCA3 (Figure 47; Kruskal-Wallis chi-squared = 31.5, df = 5, $p = 0.00$), and varied by depth (Figure 48, Table 29).

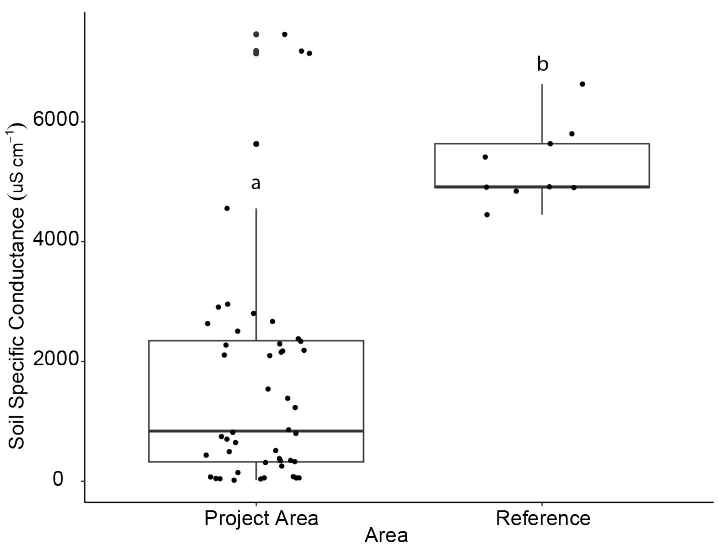


*Figure 46. Box and whisker plots of soil specific conductance (µS cm$^{-1}$) observed at the Project and Reference areas observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

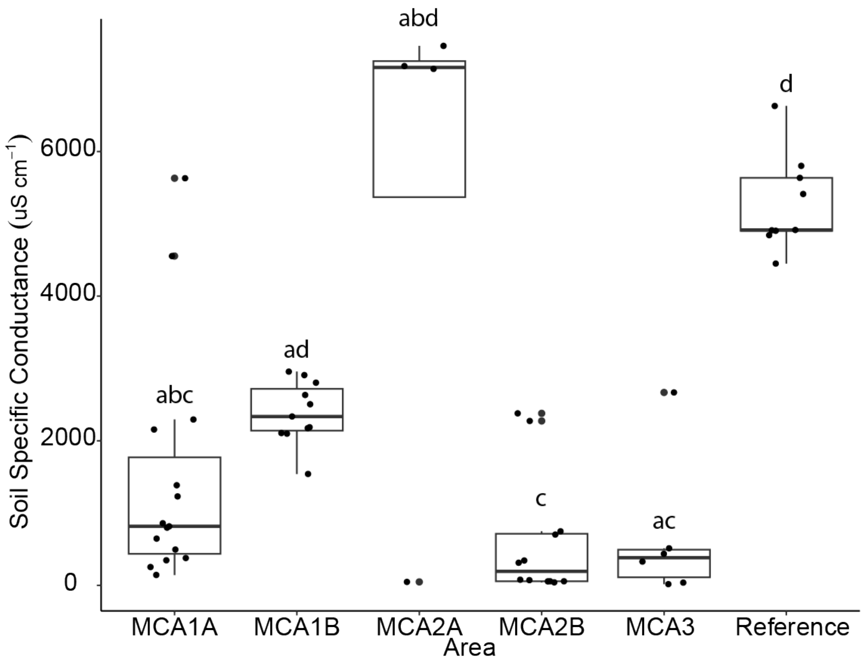


*Figure 47. Box and whisker plots of soil specific conductance (µS cm*$^{-1}$*) observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the Kruskal-Wallis test and post-hoc Dunn's test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

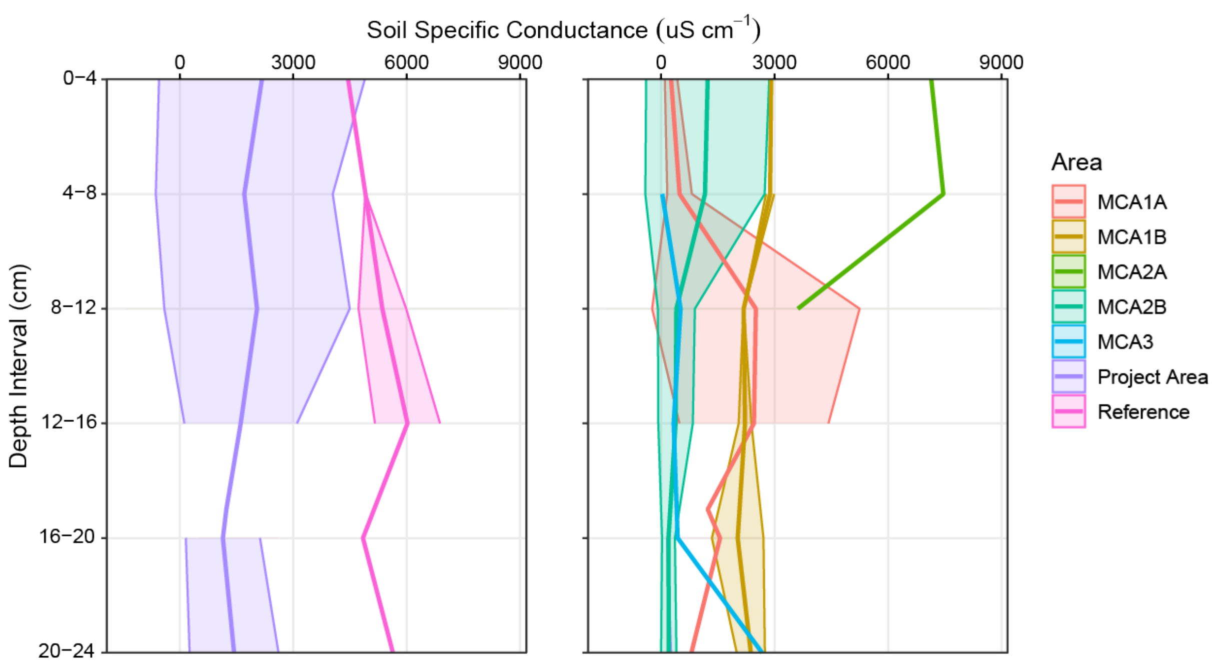


*Figure 48. Soil specific conductance (µS cm*$^{-1}$*) by depth observed in 2024. Solid lines represent the mean across samples per depth interval and shaded regions indicate the associated standard deviations (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Areas without shading indicate summary calculations were not possible due to a lack of data. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

*Table 29. Summary of soil specific conductance observed in 2024. Summary statistics (mean ± SD) of soil specific conductance (μS cm⁻¹) were calculated for multiple depth intervals by individual MCA, the overall Project Area, and Reference Area; NA indicates calculation of standard deviation was not possible due to lack of data; – indicates no data were collected.*

| **Depth Interval (cm)** | **MCA1A** | **MCA1B** | **MCA2A** | **MCA2B** | **MCA3** | **Project Area (n = 12)** | **Reference Area (n = 2)** |
|---|---|---|---|---|---|---|---|
| 0-4 | 261.5 ± 165.2 | 2908.0 ± NA | 7142.0 ± NA | 1228.9 ± 1626.5 | – | 2171.8 ± 2720.1 | 4450.0 ± NA |
| 4-8 | 487.0 ± 325.6 | 2879.5 ± 108.2 | 7460.0 ± NA | 1158.1 ± 1578.1 | 28.0 ± 14.6 | 1705.2 ± 2339.7 | 4909.5 ± 7.8 |
| 8-12 | 2503.6 ± 2743.8 | 2180.5 ± 9.2 | 3614.8 ± 5043.4 | 402.1 ± 489.2 | 512.9 ± NA | 2041.9 ± 2451.2 | 5355.5 ± 630.0 |
| 12-16 | 2452.4 ± 1970.2 | 2217.0 ± 168.3 | – | 380.0 ± 456.8 | 329.0 ± NA | 1610.1 ± 1489.6 | 6020.5 ± 860.5 |
| 16-20 | 1555.4 ± 1044.5 | 2023.0 ± 681.7 | – | 193.1 ± 169.9 | 437.0 ± NA | 1140.0 ± 981.2 | 4843.0 ± NA |
| 20-24 | 798.9 ± NA | 2370.0 ± 371.9 | – | 200.8 ± 203.1 | 2668.0 ± NA | 1434.8 ± 1174.7 | 5635.0 ± NA |

Soil bulk density was significantly lower at the Reference Area compared to the Project Area (W = 767, $p$ = 0.00; Figure 49), and soil bulk density of all MCAs except MCA2A was significantly higher than the Reference Area (ANOVA df = 5, F-value = 11.3, $p$ = 0.00; Figure 50). Soil bulk density in the Reference Area was less variable by depth compared to MCAs and the Project Area (Figure 51, Table 30).

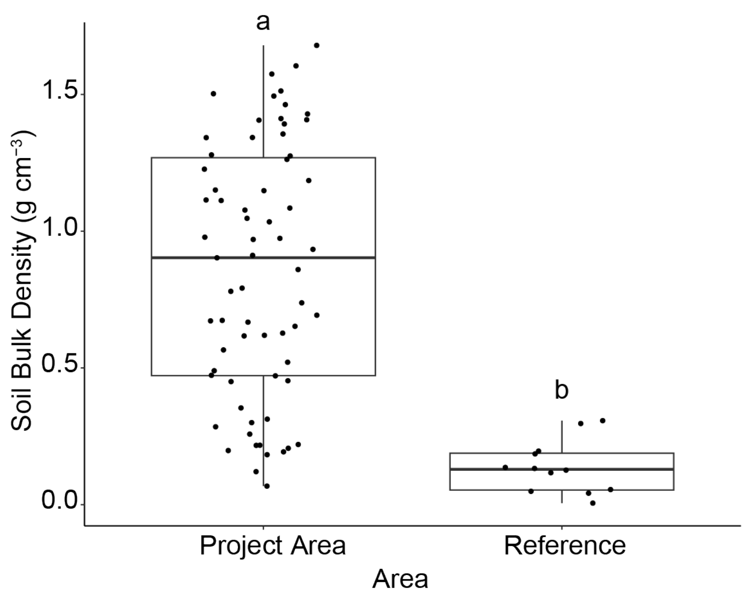


*Figure 49. Box and whisker plots of soil bulk density (g cm⁻³) observed at the Project and Reference areas observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

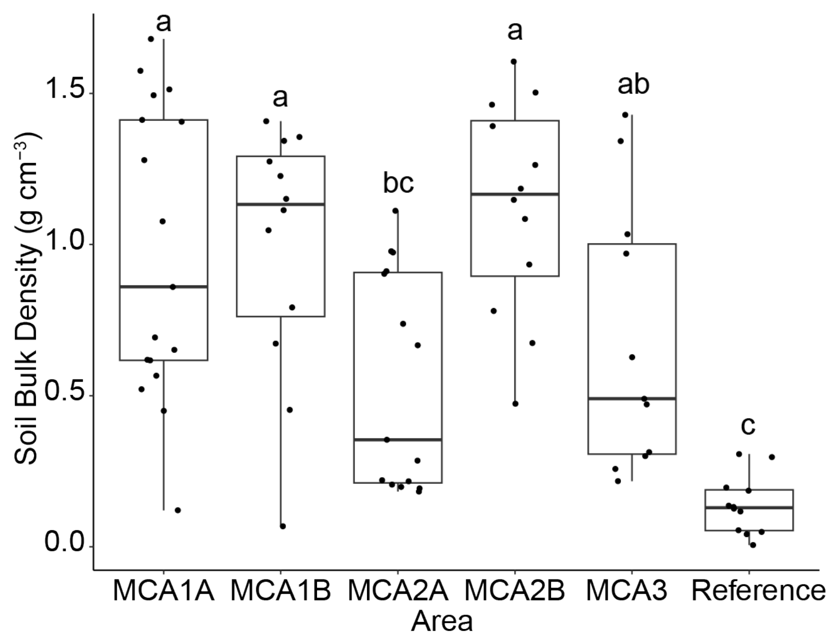


*Figure 50. Box and whisker plots of soil bulk density (g $cm^{-3}$) observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the ANOVA test and post-hoc Tukey test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

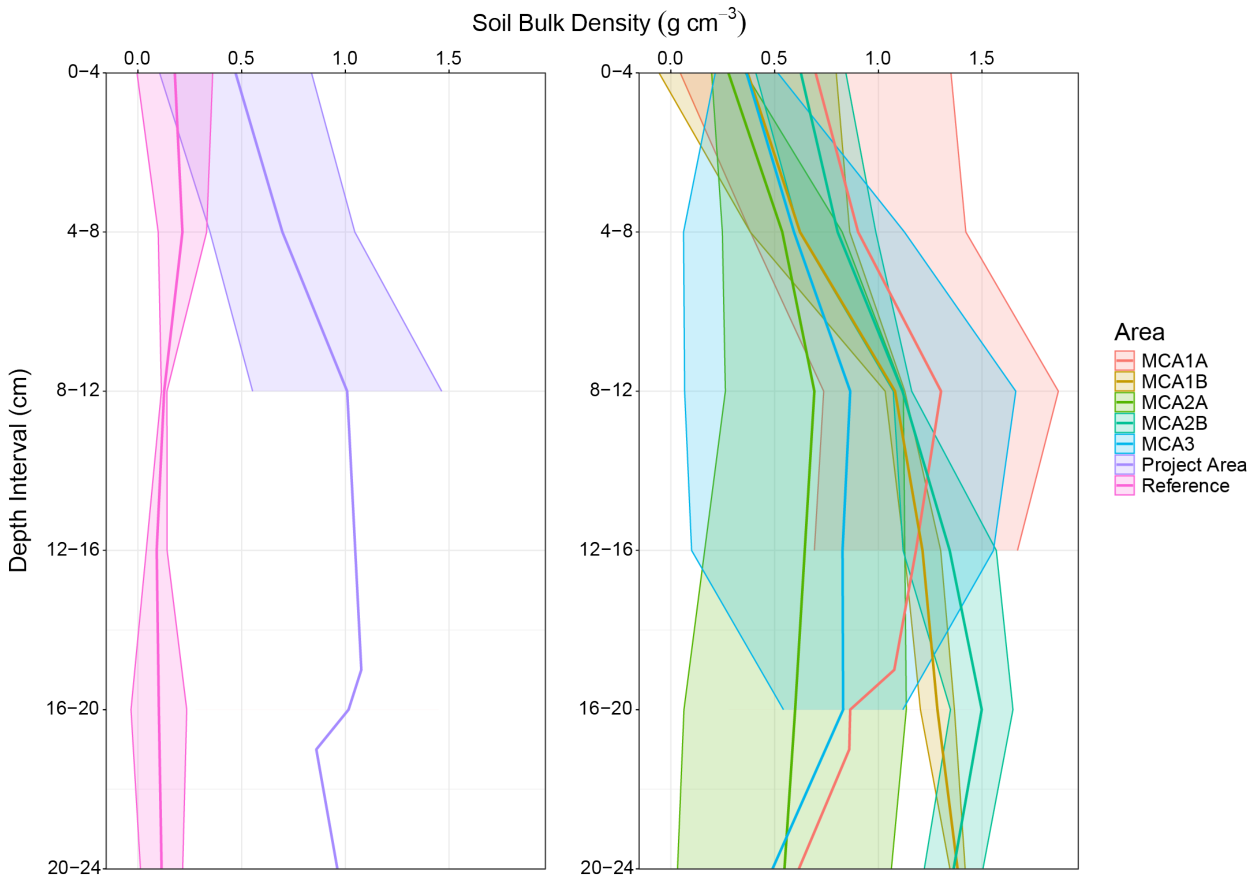


*Figure 51. Soil bulk density (g cm$^{-3}$) by depth observed in 2024. Solid lines represent the mean across samples per depth interval and shaded regions indicate the associated standard deviations (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Areas without shading indicate summary calculations were not possible due to a lack of data. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

*Table 30. Summary of soil bulk density observed in 2024. Summary statistics (mean ± SD) of soil bulk density (g cm$^{-3}$) were calculated for multiple depth intervals by individual MCA, the overall Project Area, and Reference Area; NA indicates calculation of standard deviation was not possible due to lack of data; – indicates no data were collected.*

| Depth Interval (cm) | MCA1A | MCA1B | MCA2A | MCA2B | MCA3 | Project Area (n = 12) | Reference Area (n = 2) |
|---|---|---|---|---|---|---|---|
| 0-4 | 0.7 ± 0.7 | 0.4 ± 0.4 | 0.3 ± 0.1 | 0.6 ± 0.2 | 0.4 ± 0.2 | 0.5 ± 0.4 | 0.2 ± 0.2 |
| 4-8 | 0.9 ± 0.5 | 0.6 ± 0.2 | 0.5 ± 0.3 | 0.8 ± 0.2 | 0.6 ± 0.5 | 0.7 ± 0.3 | 0.2 ± 0.1 |
| 8-12 | 1.3 ± 0.6 | 1.1 ± 0.0 | 0.7 ± 0.4 | 1.1 ± 0.0 | 0.9 ± 0.8 | 1.0 ± 0.5 | 0.1 ± 0.0 |
| 12-16 | 1.2 ± 0.5 | 1.2 ± 0.1 | – | 1.3 ± 0.2 | 0.8 ± 0.7 | 1.1 ± NA | 0.1 ± 0.1 |
| 16-20 | 0.9 ± 0.6 | 1.3 ± 0.1 | 0.6 ± 0.5 | 1.5 ± 0.2 | 0.8 ± 0.3 | 1.0 ± 0.4 | 0.1 ± 0.1 |
| 20-24 | 0.6 ± NA | 1.4 ± 0.0 | 0.5 ± 0.5 | 1.4 ± 0.1 | 0.5 ± NA | 1.0 ± 0.5 | 0.1 ± 0.1 |

The organic matter content was significantly different between the Project Area and the Reference Area (W = 26, $p$ = 0.00; Figure 52), and organic matter content in the MCAs of the Project Area was significantly less than in the Reference Area (Kruskal-Wallis chi-squared = 35.6, df = 5, $p$ = 0.00; Figure 53). Organic matter content was more variable by depth in the Reference Area compared to the MCAs of the Project Area (Figure 54, Table 31).

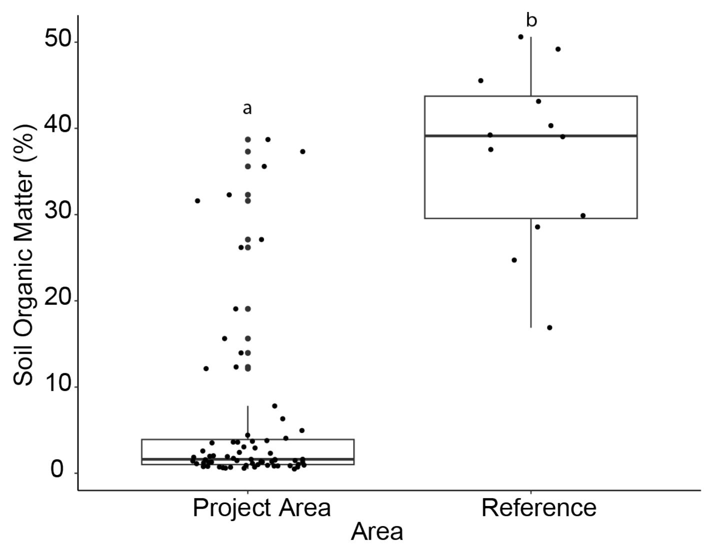


*Figure 52. Box and whisker plots of soil organic matter content (%) observed at the Project and Reference areas observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

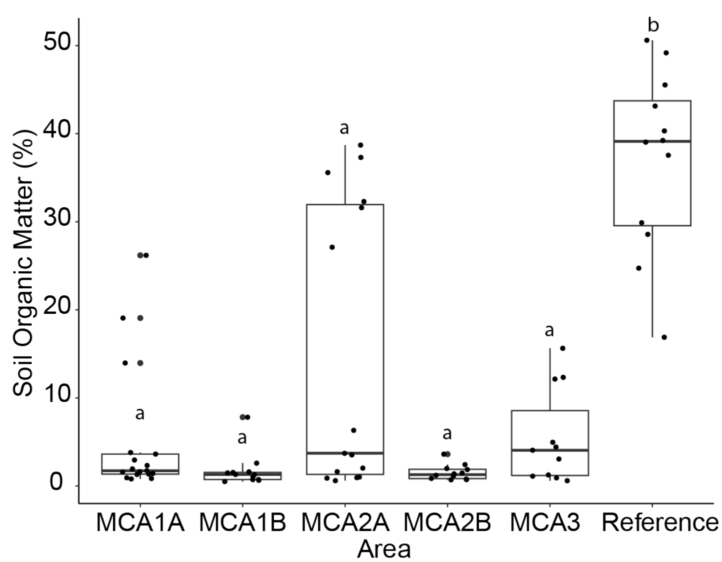


*Figure 53. Box and whisker plots of soil organic matter content (%) observed at the Reference Area and individual MCAs of the Project Area observed in 2024. Data from all depths are plotted (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Groups that do not share a letter are significantly different based on the Kruskal-Wallis test and post-hoc Dunn's test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data. Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

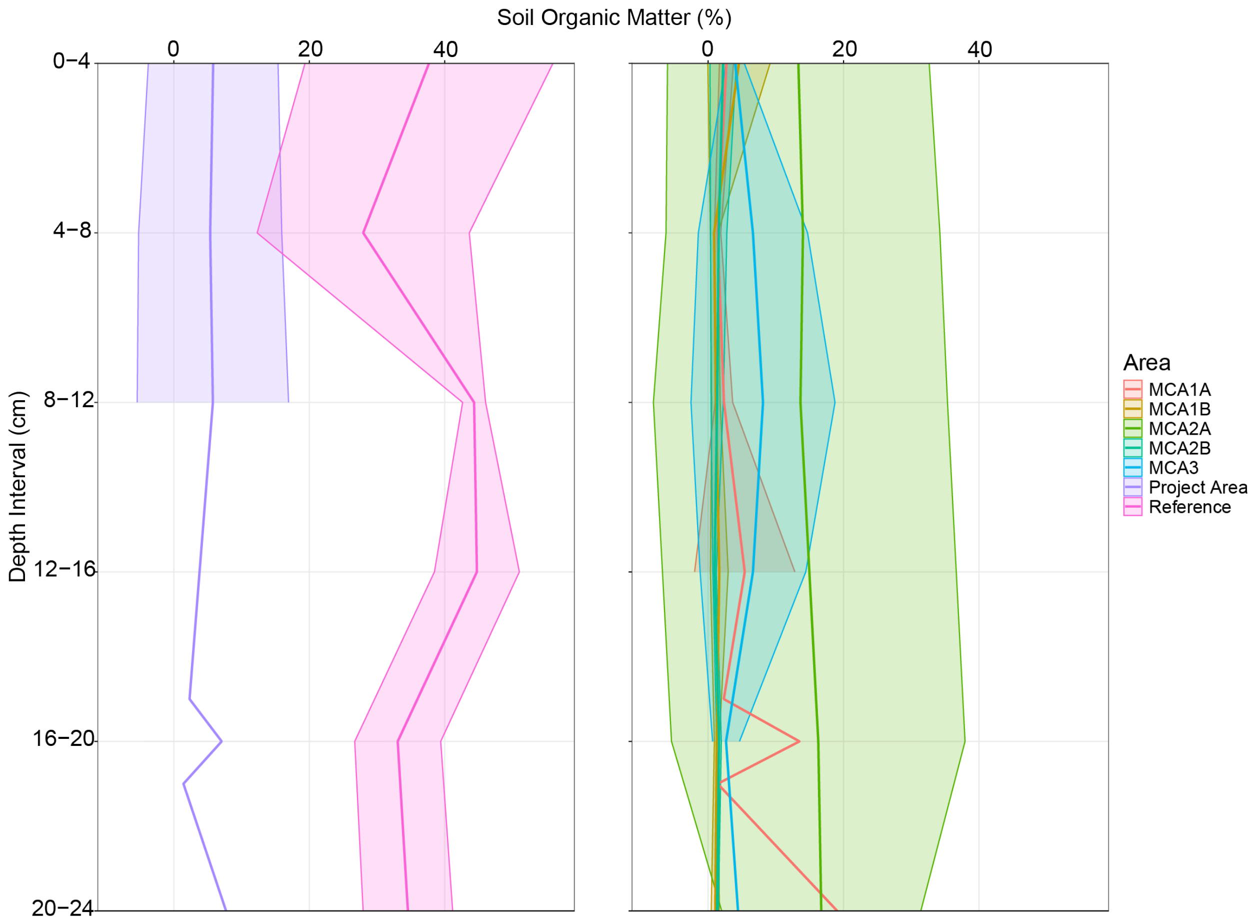


*Figure 54. Soil organic matter content (%) by depth observed in 2024. Solid lines represent the mean across samples per depth interval and shaded regions indicate the associated standard deviations (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Areas without shading indicate summary calculations were not possible due to a lack of data. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

*Table 31. Summary of soil organic matter observed in 2024. Summary statistics (mean ± SD) of soil organic matter (%) were calculated for multiple depth intervals by individual MCA, the overall Project Area, and Reference Area; NA indicates calculation of standard deviation was not possible due to lack of data; – indicates no data were collected.*

| Depth Interval (cm) | MCA1A | MCA1B | MCA2A | MCA2B | MCA3 | Project Area (n = 12) | Reference Area (n = 2) |
|---|---|---|---|---|---|---|---|
| 0-4 | 2.7 ± 1.0 | 4.6 ± 4.6 | 13.3 ± 19.3 | 2.2 ± 2.0 | 4.0 ± 1.3 | 5.8 ± 9.6 | 37.7 ± 18.3 |
| 4-8 | 1.4 ± 0.5 | 0.9 ± 0.6 | 14.0 ± 20.2 | 1.6 ± 1.2 | 6.6 ± 8.1 | 5.4 ± 10.6 | 28.0 ± 15.7 |
| 8-12 | 2.3 ± 1.3 | 1.2 ± 0.6 | 13.6 ± 21.7 | 1.3 ± 0.9 | 8.1 ± 10.6 | 5.8 ± 11.2 | 44.3 ± 1.7 |
| 12-16 | 5.4 ± 7.4 | 1.7 ± 1.3 | – | 1.0 ± 0.3 | 6.6 ± 7.8 | – | 44.8 ± 6.3 |
| 16-20 | 13.5 ± 17.9 | 1.3 ± 0.4 | 16.3 ± 21.7 | 1.6 ± 0.3 | 2.7 ± 2.0 | 7.1 ± 11.6 | 33.1 ± 6.3 |
| 20-24 | 19.1 ± NA | 1.1 ± 0.6 | 16.7 ± 14.7 | 1.3 ± 0.2 | 4.4 ± NA | 7.7 ± 9.9 | 34.6 ± 6.6 |

The sand content in surface soils (0–12 cm) of the Project Area (46.7 ± 35.7 %) was not significantly different than that of the Reference Area (56.3 ± 20.0; W = 10, $p = 0.79$), nor was it significantly different at depth (12-24 cm; Project Area: 56.3 ± 32.1, Reference Area: 63.4 ± 16.9; W = 9, $p = 0.77$; Figure 55). The proportion of sand varied amongst the MCAs of the Project Area; however, no significant differences were identified for the surface (ANOVA df = 5, F-stat = 0.96, $P = 0.50$) nor at depth (ANOVA df = 5, F-stat = 1.57, $P = 0.28$; Figure 56 and Table 32).

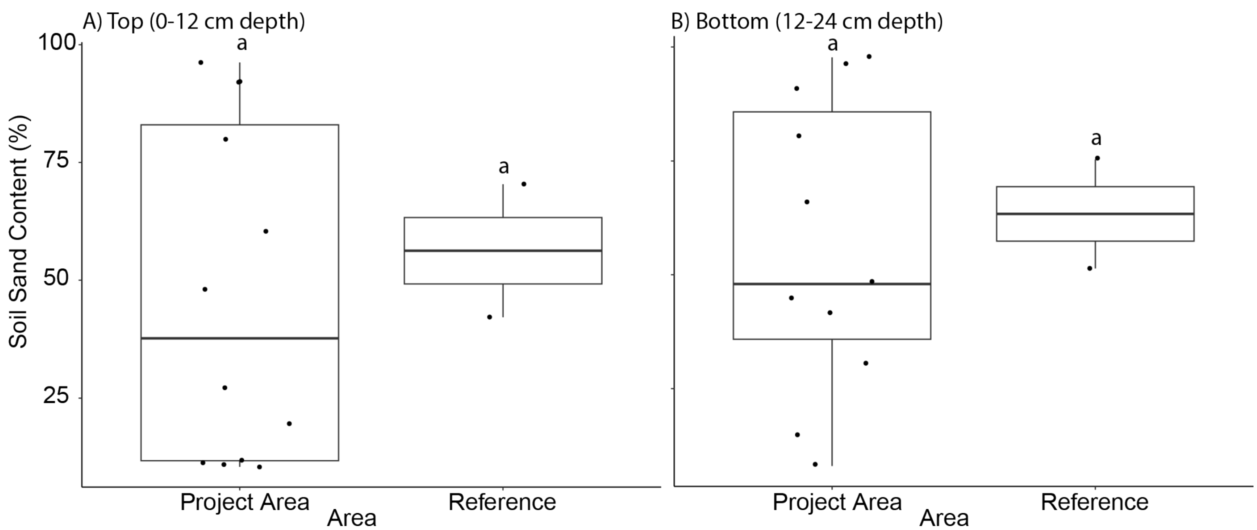


*Figure 55. Box and whisker plots of soil sand content (%) observed at the Project and Reference areas observed in 2024. Data are separated by depth fraction: (A) top 0–12 cm, (B) bottom 12–24 cm. Groups that do not share a letter are significantly different based on the Mann-Whitney U test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

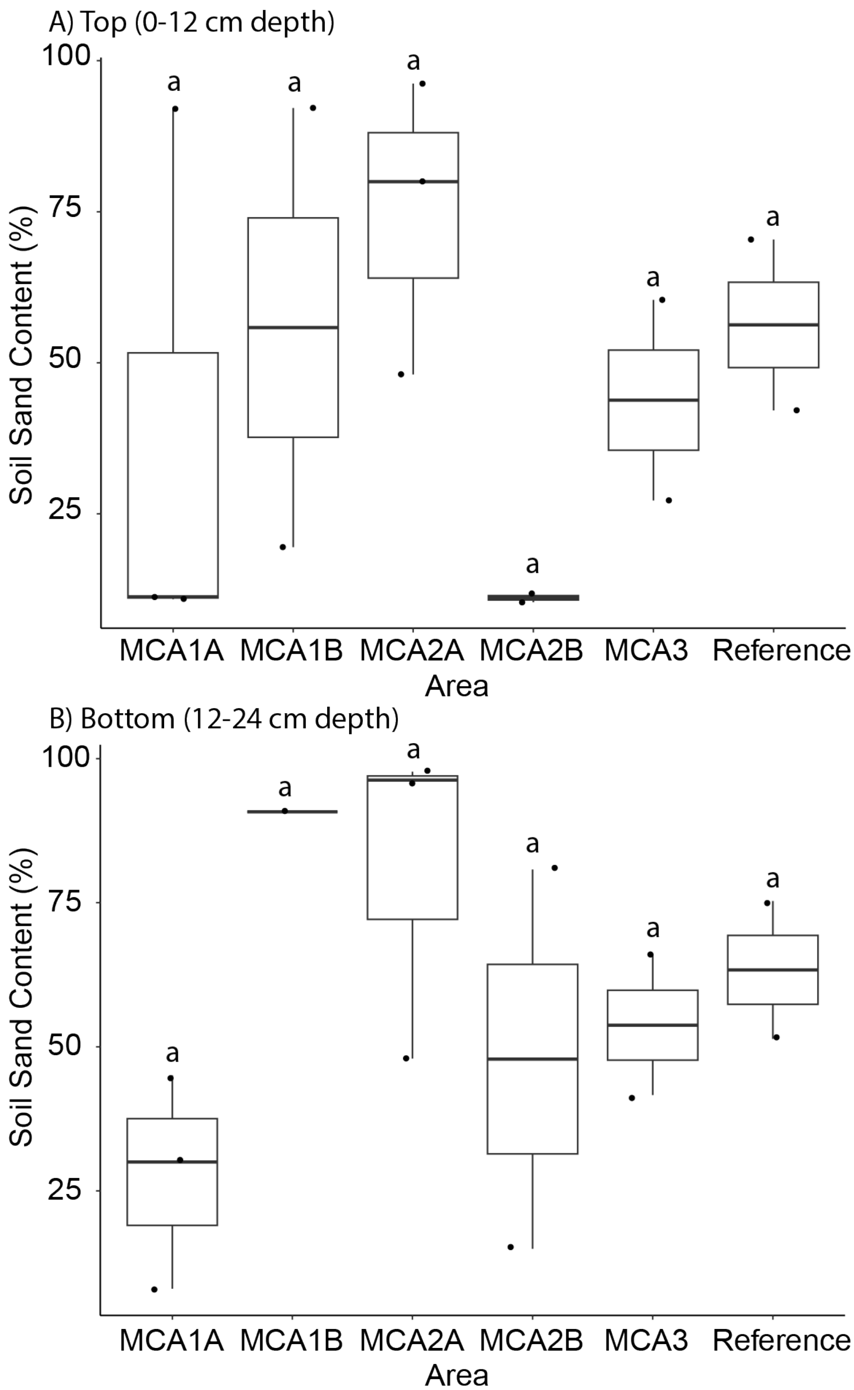


*Figure 56. Box and whisker plots of soil sand content (%) at the Reference Area and individual MCAs of the Project Area observed in 2024. Data are separated by depth fraction: (A) top 0–12 cm, (B) bottom 12–24 cm. Groups that do not share a letter are significantly different based on the ANOVA test and post-hoc Tukey test (α = 0.05). The solid black line represents the median and the boxes reflect lower and upper quartiles of the data (n = 12 cores from the Project Area, n = 2 cores from the Reference Area). Circles represent discrete observations. Data was collected by USGS in October 2024 and accessed in June 2025 via CIMS.*

*Table 32. Summary of soil sand content observed in 2024. Summary statistics (mean ± SD) of soil sand content (%) were calculated at surface and depth by individual MCA, the overall Project Area, and Reference Area. NA indicates calculation of standard deviation was not possible due to lack of data.*

| Area | Sand (%) at Surface (0-12 cm) (mean ± SD) | Sand (%) at Bottom (0-24 cm) (mean ± SD) |
|---|---|---|
| MCA1A | 38.1 ± 46.7 | 27.7 ± 18.6 |
| MCA1B | 55.8 ± 51.4 | 90.8 ± NA |
| MCA2A | 74.8 ± 24.5 | 80.7 ± 28.3 |
| MCA2B | 11.1 ± 1.0 | 47.9 ± 46.5 |
| MCA3 | 43.8 ± 23.4 | 53.7 ± 17.1 |
| Project (n = 12) | 46.7 ± 35.7 | 56.3 ± 32.1 |
| Reference (n = 2) | 56.3 ± 20.0 | 63.4 ± 16.9 |

**Project Performance Assessment:** Soil porewater and soil characteristics are monitored as context variables, thus there are no defined performance targets for these monitoring parameters.

### 2.3.2 Jefferson Parish Cypress Plantings

Although not directly incorporated into the restoration monitoring plan for the Upper Barataria Project, Jefferson Parish planted 500 2-year old cypress saplings in the northeast portion of the Project Area (MCA1A) in March 2024 (Figure 57). This area is located in close proximity to one of the vegetation monitoring stations in MCA1A. Qualitative observational data gathered in 2024 indicated that sapling survival was approximately 50 % at 10 months post-planting, and survival was 0 % in October 2024. Low survival was attributed to predation from small mammals (nutria, rabbits, etc.) and abiotic stressors (drought, above-average temperatures, and Hurricane Francine) in 2024. An additional planting was planned for March 2025 in the same area.

*Figure 57. Photograph of tree plantings conducted by Jefferson Parish.Image shows planted cypress tree saplings (vertical white markers) in MCA1A of the Project Area photographed in 2024. Photo credit: David Illgen.*

### 2.3.3 Parameter #6: Secondary productivity

Secondary productivity includes measures of the changes in potential habitat-based dietary resources and productivity of target nekton to directly evaluate performance of the Project Area against the Reference Area. The metrics used to evaluate this parameter include:

- **Abundance/density, size distribution, and biomass of target nekton collected by multiple gear types** (50 ft seine, 6 ft trawl, fixed-area) **(Purpose: Performance)**
- **Secondary productivity by overall production** (Estimated productivity based on density estimates from fixed-area sampling) **(Purpose: Performance)**
- **Secondary productivity by habitat resource index** (HRI and E-scape maps based on stable isotope values collected for major food sources and target nekton abundance/density data) **(Purpose: Performance).**

#### *2.3.3.1 Abundance, size distribution, and biomass of target nekton collected by multiple gear types: 50 ft seine and 6 ft trawl*

**Methods:** The median[IQR] annual catch (CPUE), biomass (g), and size (mm) data were summarized for each target nekton species collected by Reference FIMP stations between 2012 and 2024. Relative abundance (CPUE) and size distribution data were used to calculate total biomass (g) of each target species *per sample* based on length:weight conversions provided in Brown et al., (2013). [3] Graphical summaries were developed for values of CPUE annually to visualize long-term temporal dynamics. Biomass and size data, which exhibit significant seasonal variability, were summarized in tabular form to enable finer-scale comparisons across seasons. Each season is defined by the following months: fall = September through November, winter = December through February, spring = March through May, and summer = June through August.

Data collected in Project Year 1 (2024) were reported as median[IQR] for CPUE, biomass (g), and size (mm). Nonparametric Mann-Whitney U tests were used to statistically compare the average CPUE, biomass, and size of target nekton observed at Project FIMP stations to Reference FIMP stations for trawl and seine gear types. Differences in the distributions of CPUE, biomass, and size data between Reference and Project FIMP stations were evaluated by Cliff's *d* mean effect size following the methods outlined by (Norman, 1993). Cliff's *d* can be interpreted as the degree of non-overlap between two distributions and can range from -1 to +1, with the extremes indicating no overlap, and 0 indicating complete overlap. To interpret this index, *d* is considered significantly different from zero (no difference between reference site and Project Area) if its 95% confidence interval (CI) does not bracket zero.

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[3] Due to the lack of available length:weight conversion equations for Killifish spp. and Other Shrimps, analysis and comparison of biomass was only conducted for White and Brown Shrimp, Blue Crab, and Red Drum (where possible based on data availability).

**Results – Target Taxa Abundance: Long-Term Trends and Project Year 1 (2024):** Results in this section are separated by target taxon, with a summary table for all taxa provided at the end of the section in Table 33. Statistical comparisons were only made for data collected in 2024, whereas summaries of pre-construction data are provided for context. CPUE summaries and Cliff's d comparisons were omitted for Red Drum which exhibited extremely low observations.

*Blue Crab:* The annual median relative abundance of Blue Crab pre-construction (2012-2021) at Reference FIMP seine stations ranged from ~1 to 6 CPUE (Figure 58). Within this period, a peak in Blue Crab CPUE at these stations was observed in 2017. In 2020 when sampling at Project FIMP seine stations was initiated, annual median CPUE was higher at Project FIMP seine stations compared to Reference stations, although the differences were likely not statistically significant due to high variability. In Project Year 1 (2024), Blue Crab median CPUE at Project FIMP seine stations (1[0–2]) was not significantly different to median CPUE at Reference stations (1.5[0–4]; W = 482.5, $p = 0.18$, n = 27). It was not possible to evaluate differences in Blue Crab CPUE between Reference and Project FIMP trawl stations because these taxa were not identified at the Reference station samples in 2024.

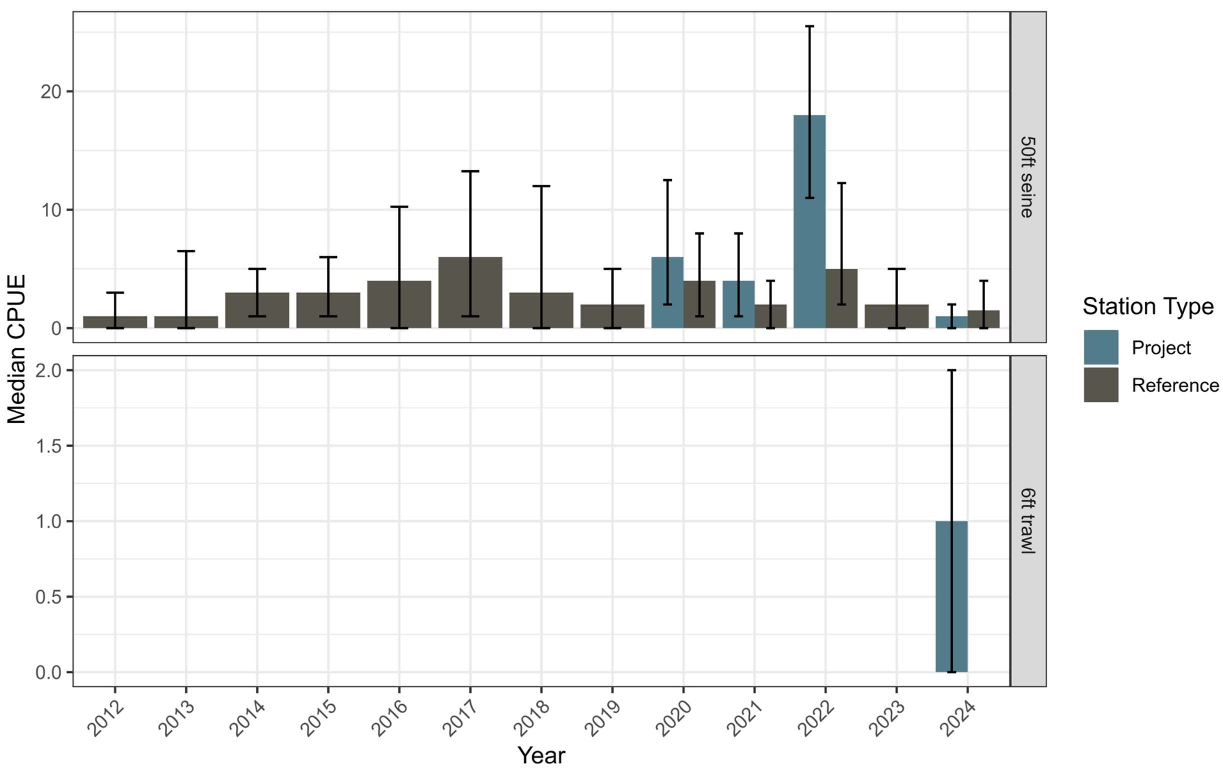


*Figure 58. Blue Crab CPUE at Project and Reference FIMP seine and trawl stations between 2012 and 2024. Bars represent annual median and lines represent IQR. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. Blue Crab were not identified from trawls until 2024, and at that time they were only identified from Project FIMP trawl stations (not Reference). No samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

*Brown Shrimp:* The annual median relative abundance of Brown Shrimp pre-construction (2012–2021) at Reference FIMP seine stations ranged from ~0 to 3 CPUE (Figure 59). The highest median CPUE of Brown Shrimp collected at Reference FIMP seine stations pre-construction was observed in 2017 (3[0–13.25]). Annual median CPUE pre-construction at Reference FIMP trawl stations ranged from ~0 to 33 CPUE, with the highest mean CPUE observed in 2012 (33[10.75–83.25]). In 2022, the first year of construction, no Brown Shrimp were observed at Project FIMP seine stations, whereas relatively low numbers were observed at Reference FIMP seine stations (2[0–8.75]). Conversely, in 2022 slightly higher median CPUE of Brown Shrimp was observed at the Project FIMP trawl stations relative to the Reference FIMP trawl stations.

As noted previously, no seine sampling was conducted at Project FIMP seine stations in 2023 due to active construction; however, at trawl stations in 2023, the median CPUE of Brown Shrimp was notably higher at Project FIMP trawl stations compared to Reference (213[208–228] and 29[9–55.5], respectively). No significant differences in Brown Shrimp CPUE were observed between Project (5[1–12.5]) and Reference FIMP seine stations (3[0-31]; W = 626.5, $p = 0.7$, n = 27) or the Project (86[4–236]) and Reference FIMP trawl stations (6.5[3–7]; W = 112, $p = 0.07$, n = 25) in 2024. It was not possible to evaluate differences in Blue Crab CPUE between Reference and Project FIMP trawl stations in 2024 because this taxon was not identified at the Reference station samples at that time.

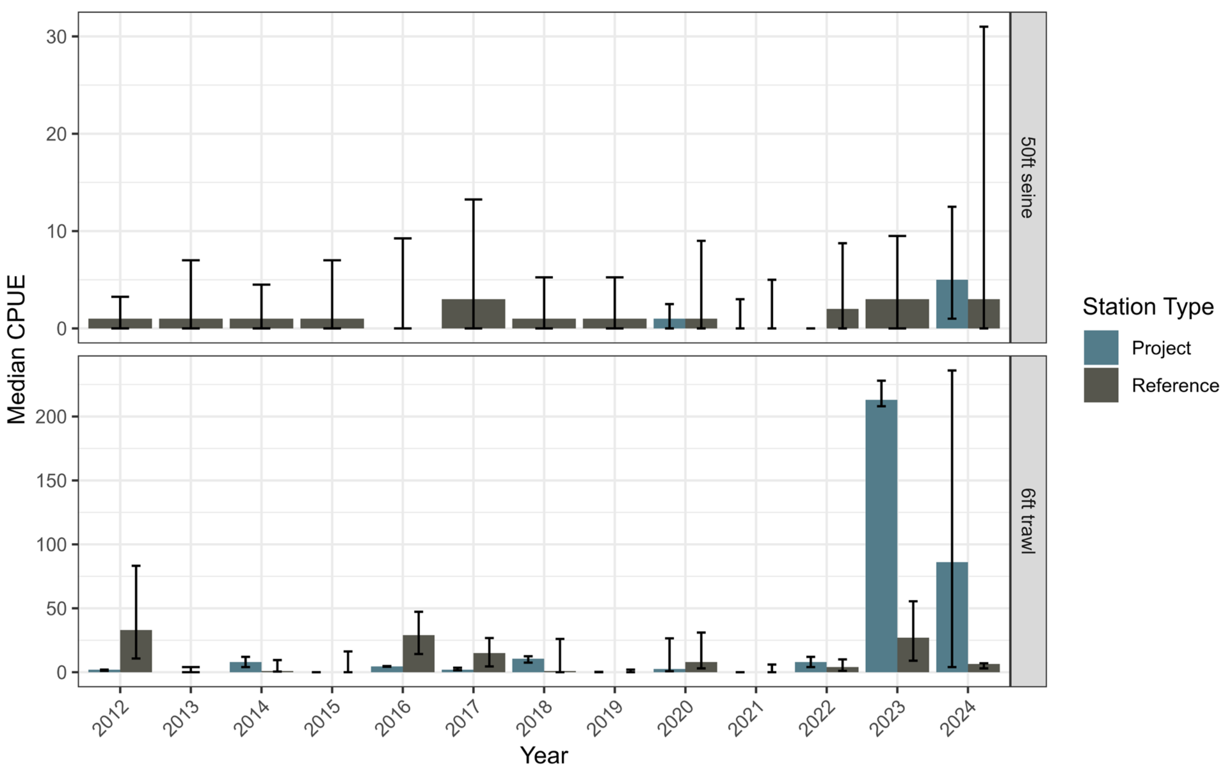


*Figure 59. Brown Shrimp CPUE at Project and Reference FIMP seine and trawl stations between 2012 and 2024. Bars represent annual median and lines represent IQR. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. No samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

*Killifish spp.:* The annual median relative abundance of Killifish spp. pre-construction (2012-2021) at Reference FIMP seine stations ranged from ~ 0 to 4 CPUE (Figure 60). Higher Killifish spp. CPUE was observed at Reference FIMP seine stations in 2017 compared to other pre-construction years. Once sampling at Project FIMP seine stations was initiated in 2020, annual median abundance of Killifish spp. in seines was higher at Project stations compared to Reference, although the differences are likely not statistically significant. No significant differences were identified between Project (0[0–1.5]) and Reference FIMP seine stations (0[0-0.25]; W = 711, $p = 0.1$, n = 27) in 2024. It was not possible to evaluate differences in Killifish spp. CPUE between Reference and Project FIMP trawl stations because these taxa were not identified at the Reference station samples in 2024.

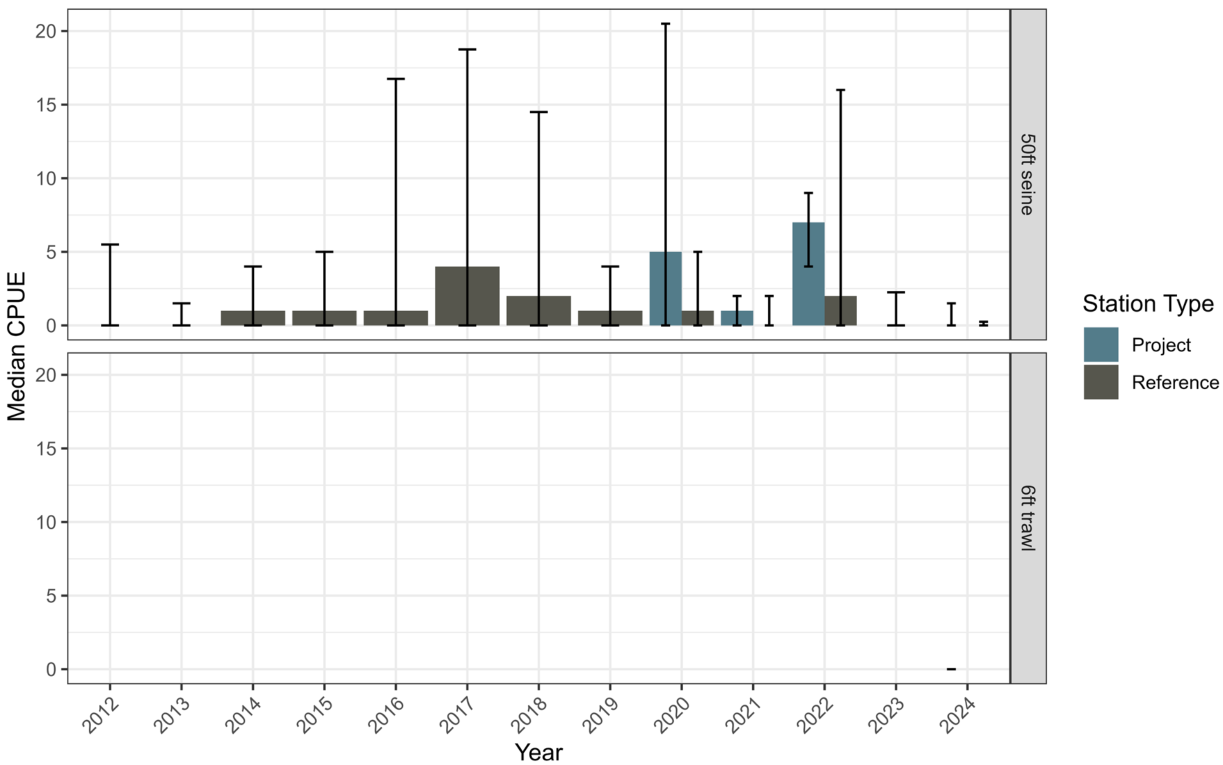


*Figure 60. Killifish spp. CPUE at Project and Reference FIMP seine and trawl stations between 2012 and 2024. Bars represent annual median and lines represent IQR. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. Killifish spp. were not identified from trawls until 2024, and at that time they were only identified from Project FIMP trawl stations (not Reference). No samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

*Other Shrimps:* The annual median relative abundance of Other Shrimps pre-construction (2012–2021) at Reference FIMP seine stations ranged from ~4.5 to 31 CPUE (Table 33, Figure 61), with the highest median CPUE of Other Shrimps at Reference FIMP seine stations observed in 2014. Once sampling at Project FIMP seine stations was initiated in 2020, annual median relative abundance of Other Shrimps was slightly higher at the Project FIMP seine stations to Reference FIMP seine stations. In 2024, the CPUE of Other Shrimps observed at Project FIMP seine stations (7[1.5–19]) was not significantly different than that observed at Reference FIMP seine stations (12[4–35.5], W = 470.5, $p$ = 0.14, n = 27). It was not possible to evaluate differences in Other Shrimps' CPUE between Reference and Project FIMP trawl stations for data collected in 2024 because these taxa were not identified at the Reference station samples during that time.

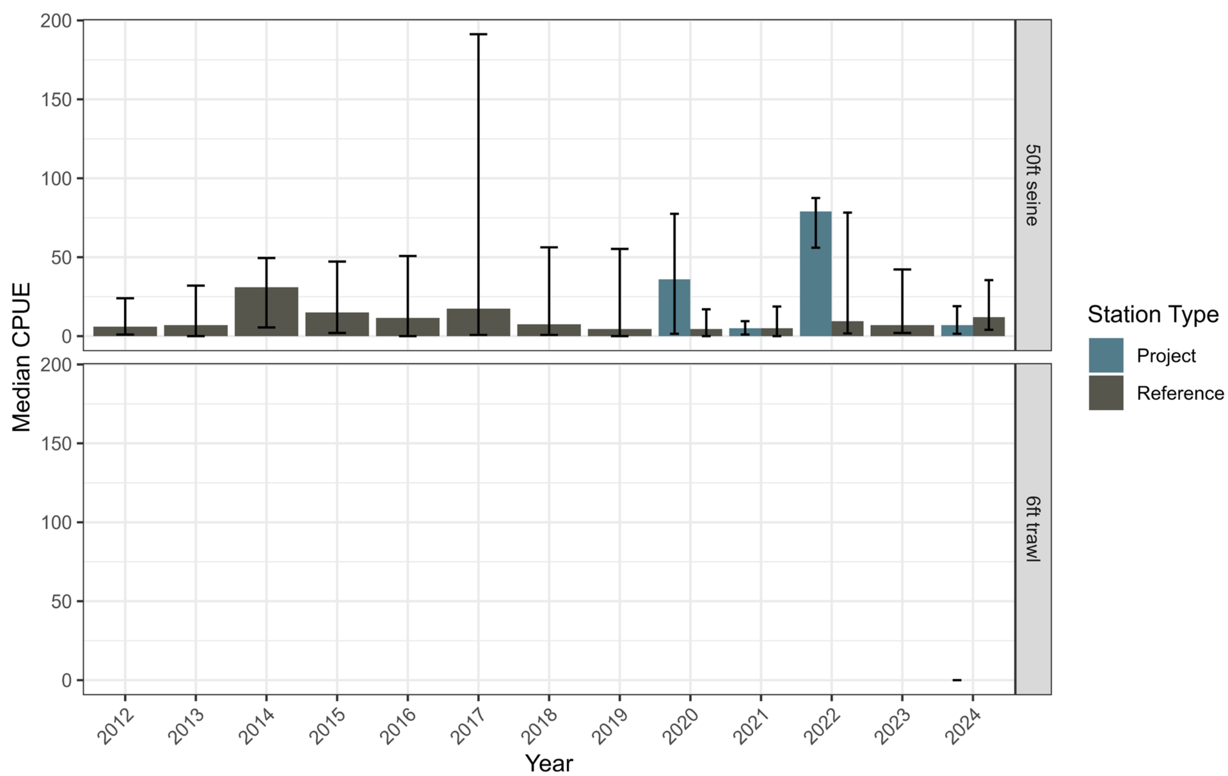


*Figure 61. Other Shrimps' CPUE at Project and Reference FIMP seine and trawl stations between 2012 and 2024. Bars represent annual median and lines represent IQR. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. Other Shrimps were not identified from trawls until 2024, and at that time they were only identified from Project FIMP trawl stations (not Reference). No samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

*White Shrimp:* The annual median relative abundance of White Shrimp pre-construction (2012–2021) at Reference FIMP seine stations ranged from 0 to 0.5 CPUE (Figure 62). The highest observed annual median White Shrimp CPUE collected by Reference FIMP seines (0.5) was observed in 2012. Relatively few White Shrimp were observed at the Reference FIMP trawl stations pre-construction (2012–2021), with only 14 total shrimp caught in trawls over those 10 years. In 2022, the first year of construction, no White Shrimp were observed at Project FIMP seine stations, whereas a median CPUE of 2 [0–10.25] was observed at Reference FIMP seine stations. Median CPUE of White Shrimp observed at Project and Reference FIMP trawl stations in 2022 were similar (1.5[0.75–2.25] and 1.5[1–5], respectively).

No seine sampling was conducted at Project FIMP seine stations in 2023 due to active construction, but median CPUE of White Shrimp collected at Project FIMP trawl stations was slightly higher than at Reference FIMP trawl stations. In 2024, the CPUE of White Shrimp observed at Project FIMP seine stations was not significantly different than that observed at Reference FIMP seine stations (W = 588, $p$ = 0.9, n = 27). Similarly, CPUE of White Shrimp observed at Project FIMP trawl stations was not significantly different than that observed at Reference FIMP trawl stations (W = 102.5, $p$ = 0.2, n = 25).

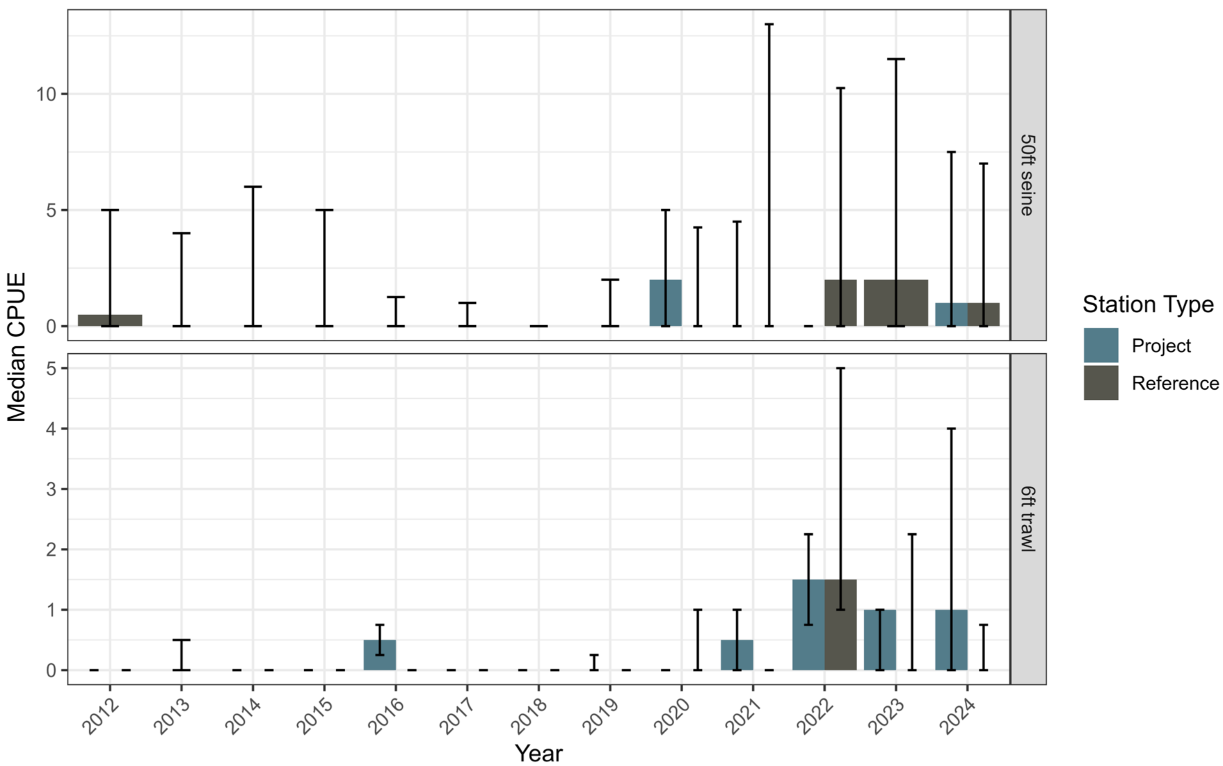


*Figure 62. White Shrimp CPUE at Project and Reference FIMP seine and trawl stations between 2012 and 2024. Bars represent annual median and lines represent IQR. Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Note: sampling at Project FIMP seine stations was not initiated until 2020. No samples were collected at Project FIMP seine stations in 2023 due to active project construction. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

*Table 33. Summary of target nekton CPUE at FIMP seine and trawl stations in 2024. CPUE data from Project and Reference FIMP seine and 6 ft trawl stations collected in Project Year 1 (2024) were summarized by median and IQR for each target nekton taxon (except for Red Drum). Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Asterisk (*) indicates statistically significant difference between Reference and Project stations based on Mann-Whitney U tests. Acronyms: p = p value, H = Kruskal-Wallis test statistic, "–" = individuals of that taxa were not enumerated within the indicated Reference area using the specified gear type. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| **Common Name** | **50 ft Seine** | | | | **6 ft Trawl** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Reference** | **Project** | ***p*** | **H** | **Reference** | **Project** | ***p*** | **H** |
| Blue Crab | 1.5 [0–4] | 1 [0–2] | 0.18 | 1.9 | – | – | – | – |
| Brown Shrimp | 3 [0–31] | 5 [1–12.5] | 0.70 | 0.2 | 6.5 [3-7] | 86 [4-236] | 0.07 | 3.4 |
| Killifish spp. | 0 [0–0.25] | 0 [0–1.5] | 0.10 | 2.8 | – | – | – | – |
| Other Shrimps | 12[4–35.5] | 7 [1.5–19] | 0.14 | 2.1 | – | – | – | – |
| White Shrimp | 1 [0–7] | 1 [0–7.5] | 0.94 | 0.0 | 0 [0-0.75] | 1 [0-4] | 0.15 | 2.1 |

Cliff's *d* mean effect size for CPUE of target nekton collected at seine stations in 2024 ranged from -0.2 (Other Shrimps) to 0.2 (Killifish spp.), with no significant effect sizes between the Project and Reference FIMP seine stations (Figure 63). At trawl stations, Cliff's *d* mean effect size analysis indicated that Brown Shrimp (*d* = 0.49 [0.1, 0.8]) were significantly larger in Project FIMP trawl stations compared to Reference FIMP trawl stations.

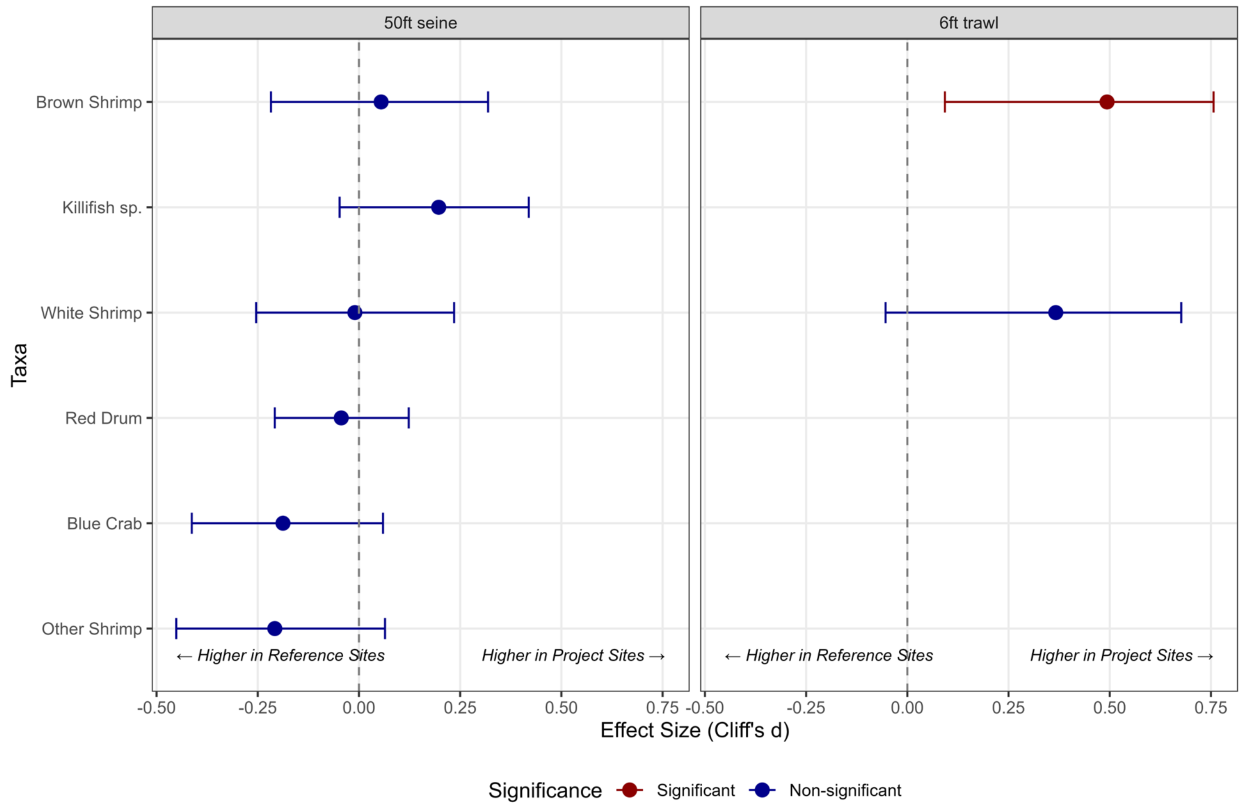


*Figure 63. Effect size (Cliff's* d*) of target nekton CPUE at the Project and Reference FIMP seine (left) and trawl (right) stations post-construction in Project Year 1 (2024). Circles represent the mean effect sizes; horizontal bars represent 95% CI; horizontal dotted line represents no difference between Project and Reference FIMP sites. Effect sizes are not considered significant if the 95% CI overlaps zero. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS. Missing plots represent instances where the target taxa was not enumerated by LDWF in Reference FIMP sites and no effect size could be calculated.*

**Results – Target Taxa Size and Biomass: Long-Term Trends and Project Year 1 (2024):** Table 34 and Table 35 summarize the median calculated biomass of target nekton collected at Reference FIMP seine and trawl stations for the pre-construction period (2012–2021) separated by season. Pre-construction, peak biomass of nekton collected at Reference FIMP seine stations was observed in the summer season for Blue Crab, Brown Shrimp, Red Drum, and White Shrimp. Calculation of biomass was not possible for Other Shrimps nor Killifish spp. due to a lack of reliable length:weight conversion factors. Peak biomass of nekton collected at Reference FIMP trawl stations was observed in spring for Brown Shrimp and White Shrimp. Full target nekton assessment at trawl stations was not possible as prior to 2024 since only White and Brown Shrimp were routinely evaluated per LDWF protocols for this gear type.

*Table 34. Median biomass (in grams CPUE) and IQR for Blue Crab, Brown Shrimp, Red Drum, and White Shrimp collected at Reference FIMP seine stations (2008, 2002, 2011, 2177, 2004, 2007) across all pre-construction years (2012–2021). Biomass (g CPUE) was calculated using established length:weight conversions. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| Common Name | Spring | Summer | Fall | Winter |
|---|---|---|---|---|
| Blue Crab | 3.85 [3.1-4.8] | 4.01 [3.1-5.5] | 3.49 [2.8-4.4] | 3.67 [2.8-4.6] |
| Brown Shrimp | 6.33 [5.5-7.1] | 7 [6.3-7.6] | 6.74 [6-7.4] | 6.4 [5.8-7] |
| Red Drum | 1 [0.28-14.3] | 14.5 [3.8-165.8] | 10 [0-31] | 0 [0-0.7] |
| White Shrimp | 9.68 [8.9-10] | 9.79 [6-8.1] | 7.84 [7-8.6] | 7.52 [6.5-8.4] |

*Table 35. Median biomass (in grams CPUE) and IQR for Brown Shrimp and White Shrimp collected at Reference FIMP trawl stations (1080, 1012) across all pre-construction years (2012–2021). Biomass was calculated using established length:weight conversions. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| Common Name | Spring | Summer |
|---|---|---|
| Brown Shrimp | 6.33 [5.2-7.1] | 6 [6-6.8] |
| White Shrimp | 10.06 [9.8-10.2] | 8.18 [7-9.3] |

No statistical differences in the median annual biomasses of Blue Crab, Brown Shrimp, and Red Drum were observed between Project and Reference FIMP seine stations in 2024 (Table 36). However, significantly greater biomass of White Shrimp was observed at Project FIMP seine stations compared to Reference stations. In terms of size, significantly larger White Shrimp were observed at Project FIMP seine stations compared to Reference stations (Table 36). At trawl stations, significantly greater biomass and larger Brown Shrimp were observed at the Project FIMP trawl stations compared to Reference FIMP trawl stations (Table 37).

*Table 36. Median annual target nekton biomass (in grams) and size (TL or CW, in mm) observed at Project and Reference FIMP seine stations in 2024. Values provided as median with IQR (n = total number of organisms measured). Reference FIMP seine stations: 2008, 2002, 2011, 2177, 2004, 2007; Project FIMP seine stations: 2174, 2173, 2175. Asterisk (*) indicates a statistically significant difference between Reference and Project stations based on a negative binomial generalized linear model. Acronyms: p = p value and H = Kruskal-Wallis test statistic. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| Common Name | Biomass | | | | Size | | | |
|---|---|---|---|---|---|---|---|---|
| | Reference | Project | *p* | H | Reference | Project | *p* | H |
| Blue Crab | 3.67 [3.07-4.71] (n=117) | 3.58 [3.23–4.08] (n=36) | 0.56 | 0.3 | 15 [12–22] (n=117) | 14.5 [12.75–17.5] (n=36) | 0.56 | 0.3 |
| Brown Shrimp | 6.74 [6.07-7.46] (n=453) | 6.63 [6–7.29] (n=247) | 0.13 | 2.3 | 54 [43–69] (n=453) | 52 [42–65] (n=247) | 0.13 | 2.3 |
| Red Drum | 95 [5.58-182.5] (n=14) | 163.4 [96.23–180.68] (n=8) | 0.52 | 0.5 | 206 [86.25–258.75] (n=14) | 252 [203.75–271.5] (n=8) | 0.37 | 0.9 |
| White Shrimp | 6.97 [6.23-7.99] (n=239) | 7.99 [6.06–9.05] (n=141) | <0.01* | 10.9 | 49 [39–67] (n=239) | 67 [37–93] (n=141) | <0.01* | 10.9 |

*Table 37. Median annual target nekton biomass (in grams) and size (TL or CW, in mm) observed at Project and Reference FIMP trawl stations in 2024. Values provided as median with IQR (n = total number of organisms measured). Reference FIMP trawl stations: 1080, 1012; Project FIMP trawl stations: 1081, 1085, 1086. Asterisk (*) indicates a statistically significant difference between Reference and Project stations based on a negative binomial generalized linear model. Acronyms: p = p value and H = Kruskal-Wallis test statistic. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

| Common Name | Biomass | | | | Size | | | |
|---|---|---|---|---|---|---|---|---|
| | Reference | Project | p | z | Reference | Project | p | z |
| Brown Shrimp | 6 [5.2-6.63] (n=49) | 7.59 [6.63-7.97] (n=825) | <0.01* | 34006 | 42 [32-52] (n=49) | 72 [52-82] (n=825) | <0.01* | 34006 |
| White Shrimp | 8.64 [7.12-8.64] (n=3) | 7.46 [7.16-7.99] (n=133) | 0.54 | 157.5 | 82 [57-82] (n=3) | 57 [52-67] (n=133) | 0.54 | 157.5 |

Cliff's *d* mean effect size for biomass of target nekton collected at FIMP seine stations in 2024 ranged from -0.07 (Brown Shrimp) to 0.2 (White Shrimp). A statistically significant effect size of White Shrimp biomass between Project and Reference FIMP seine stations was observed (*d* = 0.2 [0.08, 0.3]), indicating the statistically larger biomasses at Project stations is ecologically meaningful. At trawl stations, Cliff's *d* mean effect size for biomass (g) ranged from -2.1 (White Shrimp) to 0.7 (Brown Shrimp). Effect size of Brown Shrimp biomass indicated significant differences between Project and Reference FIMP trawl stations, with Brown Shrimp being significantly larger (*d* = 0.7 [0.6, 0.8]) in Project FIMP trawl stations.

Similarly, Cliff's *d* mean effect size for length (mm) of target nekton collected at seine stations in 2024 ranged from -0.07 (Brown Shrimp) to 0.3 (Red Drum), with significant effect sizes for White Shrimp being larger at Project FIMP seine stations compared to Reference (*d* = 0.2 [0.08, 0.3]). At trawl stations, Cliff's *d* mean effect size for length (mm) ranged from -0.2 (White Shrimp) to 0.7 (Brown Shrimp). Significant effect sizes for length between Project and Reference FIMP trawl stations were observed for Brown Shrimp (*d* = 0.7 [0.6, 0.8]) which were significantly larger in Project FIMP trawl stations compared to Reference FIMP trawl stations.

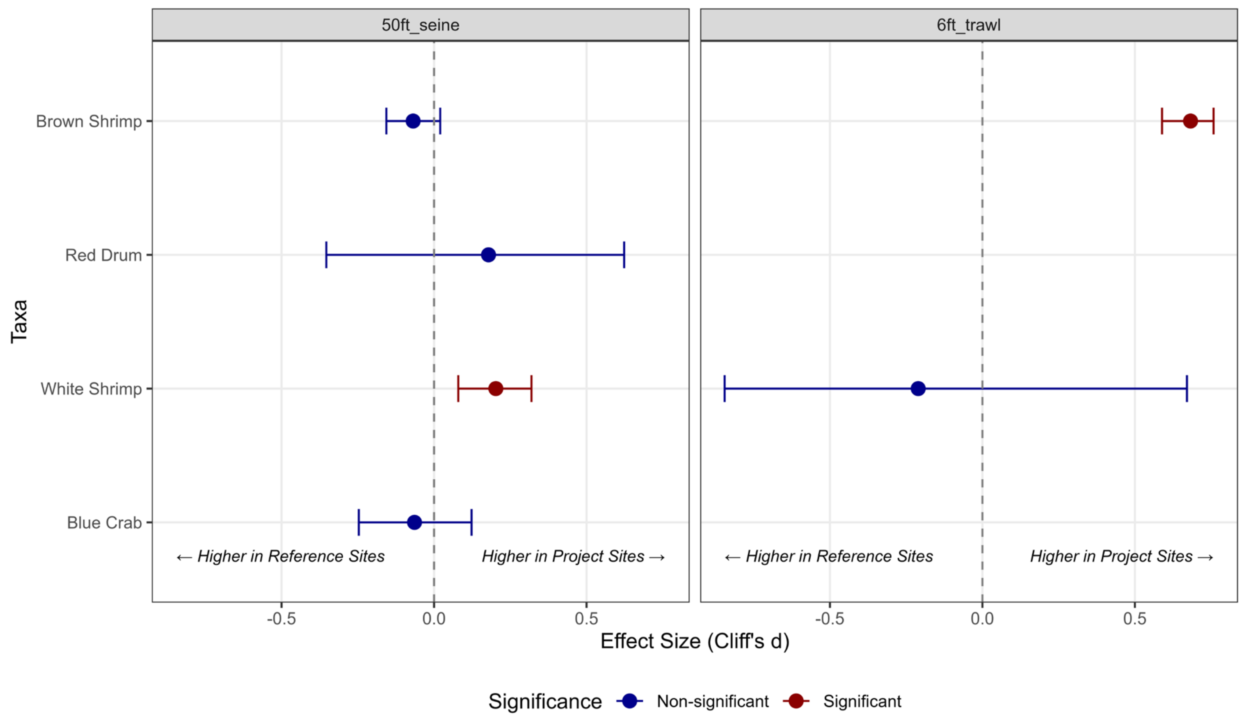


*Figure 64 Effect size (Cliff's* d*) of target nekton biomass (g) at the Project and Reference FIMP seine (left) and trawl (right) stations post-construction in 2024. Circles represent the mean effect sizes; horizontal bars represent 95% CI; horizontal dotted line represents no difference between Project and Reference FIMP sites. Effect sizes are not considered significant if the 95% CI overlaps zero. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

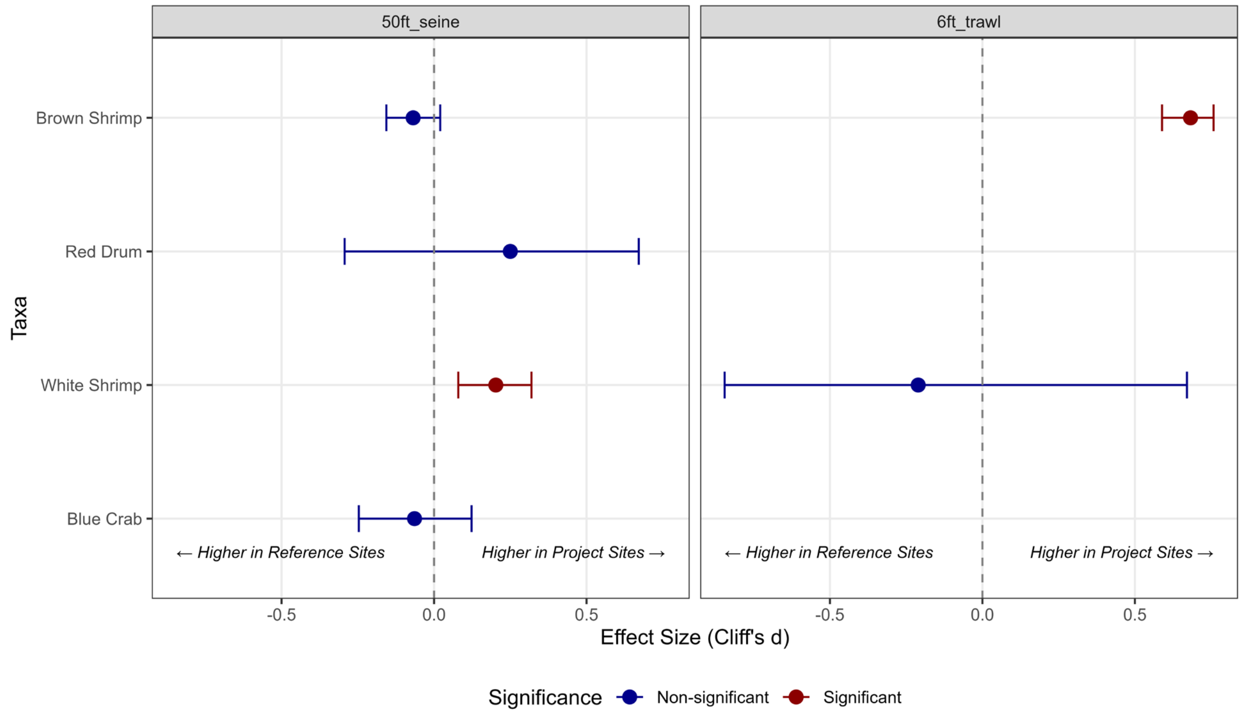


*Figure 65. Effect size (Cliff's* d*) of target nekton size (mm) at the Project and Reference FIMP seine (left) and trawl (right) stations post-construction in 2024. Circles represent the mean effect sizes; horizontal bars represent 95% CI; horizontal dotted line represents no difference between Project and Reference FIMP sites. Effect sizes are not considered significant if the 95% CI overlaps zero. Raw data were collected as part of FIMP conducted by LDWF and were accessed in February 2025 via CIMS.*

**Project Performance Assessment:**

- ***Performance Criteria:*** *CPUE, size distribution, and biomass of target nekton species adjacent to the Project Area sampled using seine and trawl gear types <u>are not significantly lower</u> than values of the same metrics at surrounding reference sites by Year 8.*
    - **Project Year 1 (2024):** ***Performance Criteria Not Yet Met***
        - **CPUE:** Significantly higher CPUE of Blue Crab collected by trawls was observed at Project FIMP trawl stations compared to Reference FIMP trawl stations. No other significant differences in target taxa CPUE were detected.
        - **Size and Biomass**: Significantly higher biomass and larger sizes of White Shrimp collected by seines and Brown Shrimp collected by trawls were observed at Project FIMP stations compared to Reference stations. No other significant differences in biomass nor size were detected for target taxa.

### *2.3.3.2 Density, size distribution, and biomass of target nekton collected by multiple gear types: Fixed-area gear types*

**Methods – Project Year 1 (2024):** Sampling methodology and environmental variables are summarized in Section 2.2.2**.** For data collected using fixed-area methods, the median[IQR] was used to summarize target nekton species density (indiv sample$^{-1}$), biomass (g sample$^{-1}$), and size (mm) for all analyses. Due to low sample size (n ≤ 3 for each project feature), the median[IQR] were used instead of mean and standard deviation to more accurately represent the distribution of data and to minimize the effect of extreme outliers on summary statistics.

Densities (indiv sample$^{-1}$) of target nekton taxa were analyzed first. Nonparametric Mann-Whitney U tests were used to statistically compare the median density of each target nekton species in the Project Area to the Reference Area. Next, nonparametric Kruskal-Wallis tests and post hoc Dunn's tests were used to statistically compare the median density of target nekton observed at the individual project design features to the Reference Area. Finally, the magnitude of the difference in density measured between the Project Area and the Reference Area was evaluated by Cliff's *d* mean effect size following the methods outlined by Norman (1993). See Section 2.3.3.1 for additional information about the interpretation of Cliff's *d*. Note: interior **I** samples collected using throw traps were removed from Cliff's *d* effect size analyses due to large outliers and no comparable throw trap sampling in the Reference Area.

Biomass (g sample$^{-1}$) and size (mm) of target nekton taxa were then analyzed. Nonparametric Mann-Whitney U tests were used to statistically compare biomass and median size of each target nekton species in the Project Area to the Reference Area. In contrast to analyses of density, differences in biomass and size between project features were not evaluated due to low sample sizes. Cliff's *d* was used to measure the magnitude of the difference in biomass and size measured between the Project Area and the Reference Area following the methods outlined by Norman (1993). As noted above, interior **I** samples collected using throw traps were omitted from Cliff's *d* effect size analyses.

**Results – Density: Project Year 1 (2024):** No statistically significant differences in median density of most target nekton taxa between Project and Reference areas was observed for data collected in 2024 (Table 38). However, statistically lower median densities were observed for White Shrimp collected in marsh edge habitats in the Project Area compared to the Reference Area (3.5 [2–5] and 17 [16–23], respectively; W = 13.3, $p = 0.02$).

*Table 38. Median and IQR of target nekton density observed at Project and Reference fixed-area stations in 2024 by habitat type. Asterisk (*) indicates statistically significant difference between Reference and Project stations based on Kruskal Wallis test. Acronyms: p = p value, H = Kruskal-Wallis test statistic, NA = statistical tests were not conducted due to low catch values, and "–" = no individuals of that taxa were collected within the indicated Project or Reference area, and therefore no analyses were possible.*

| Common Name | Marsh Edge | | | | Open Water | | | |
|---|---|---|---|---|---|---|---|---|
| | **Reference** | **Project** | ***p*** | **H** | **Reference** | **Project** | ***p*** | **H** |
| Blue Crab | 1 [1–2] | 1 [1–2] | 0.66 | 3.3 | 5 [4.5–5] | 1 [1–2] | 0.32 | 8.2 |
| Brown Shrimp | 1 [1–1] | 1 [1–1] | NA | NA | – | 1 [1–1] | NA | NA |
| Red Drum | 0 | 0 | – | – | 0 | 0 | – | – |
| Killifish spp. | 4.5 [2.5–19.5] | 14 [10–22] | 0.22 | 6.9 | 2 [2–2] | 2 [2–53] | 0.99 | 0.32 |
| Other Shrimps | 81 [47–110] | 23.5 [7.75–35.5] | 0.51 | 4.3 | 0.5 [0.25–0.75] | 1.5 [1–18] | 0.15 | 8.1 |
| White Shrimp | 17 [16–23] | 3.5 [2–5] | 0.02* | 13.3 | 2 [1.25–4.25] | 2 [1–4] | 0.45 | 6.8 |

All subsequent results in this section are separated by target taxon, but all taxa are discussed together for Cliff's *d* at the end of this section:

*Blue Crab:* In marsh edge habitats, median density was highest at **P** stations (3 [3–3]; Figure 66 left). In open water, median density was highest at **GO** stations (4 [2.5–5.5]; Figure 66 right). However, no statistically significant differences in Blue Crab density were observed across project features and the Reference Area for marsh edge and open water habitat types ($p$ = 0.56 and 0.33, respectively).

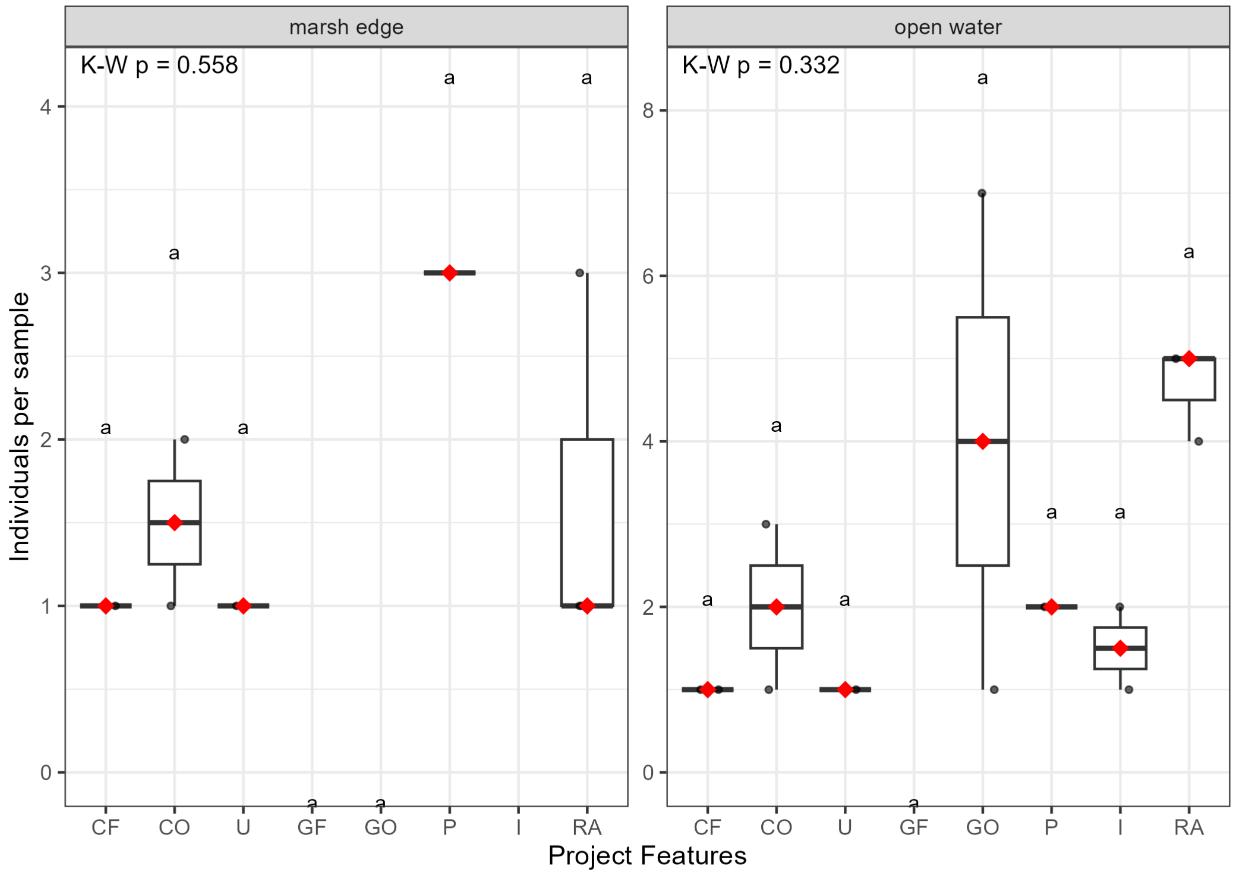


*Figure 66. Boxplots (median and IQR) of Blue Crab density in marsh edge and open water habitat at fixed-area stations in Project Year 1 (2024). Red diamonds represent medians; upper and lower bounds of the box represent Q3 and Q1, respectively; vertical bars represent the largest/smallest values no further than 1.5*IQR; black dots represent raw data; groups that do not share a letter are significantly different based on a post-hoc Dunn's test with a Benjamini-Hochberg correction (α = 0.05). Acronyms: CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; K-W = Kruskal-Wallis (omnibus). All samples collected by drop sampler gear type.*

*Brown Shrimp:* In marsh edge habitats in the Project Area, only a single Brown Shrimp was collected at the **CO** station. In open water habitats, only two Brown Shrimp were collected within the Project Area, one at a **CO** station and one at a **GF** station. No statistical tests were conducted for Brown Shrimp densities due to insufficient sample sizes.

*Killifish spp.:* In marsh edge habitats within the Project Area (Figure 67, left), median Killifish spp. density was highest in **U** stations (30 [26–36]). Very few Killifish spp. were observed from open water habitats, with these taxa detected only at **U**, **GO**, and **I** stations in the Project Area ($p$ = 0.956; Figure 67, right). Notably, very high Killifish spp. density was observed at the **I** stations within the Project Area (open water habitat); however, this should be interpreted with caution as **I** stations were sampled only by the throw trap gear type, only three samples were collected, and no comparable throw trap samples were collected from the Reference Area. No statistically significant differences were observed.

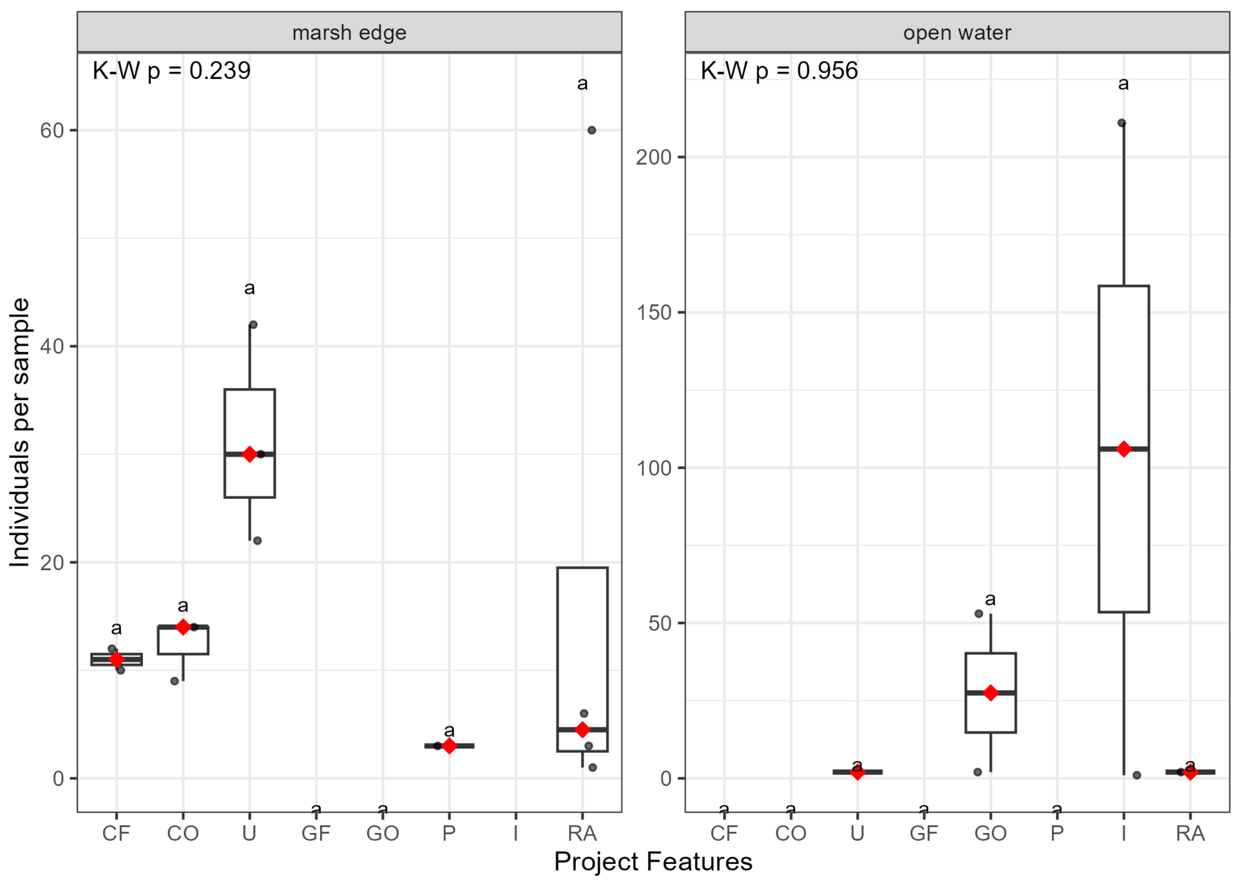


*Figure 67. Boxplots (median and IQR) of Killifish spp. density in marsh edge and open water habitat at fixed-area stations in Project Year 1 (2024). Red diamonds represent medians; upper and lower bounds of the box represent Q3 and Q1, respectively; vertical bars represent the largest/smallest values no further than 1.5*IQR; black dots represent raw data; groups that do not share a letter are significantly different based on a post-hoc Dunn's test with a Benjamini-Hochberg correction (α = 0.05). Acronyms :CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; K-W = Kruskal-Wallis (omnibus). All samples collected by drop sampler gear type.*

*Other Shrimps*: Across project features in marsh edge habitat, median density of Other Shrimps was highest at **P** stations (28 [23.5–62]) and lowest at **U** stations (13.5 [7.25–19.75]; Figure 68 left). Notably, one marsh edge sample collected in the Reference Area yielded 399 individuals. For samples collected from open water habitats, median density was highest at **GO** stations (78 [55.5–100.5]), primarily driven by a single sample with 118 individuals (Figure 68, right). No statistically significant differences were observed.

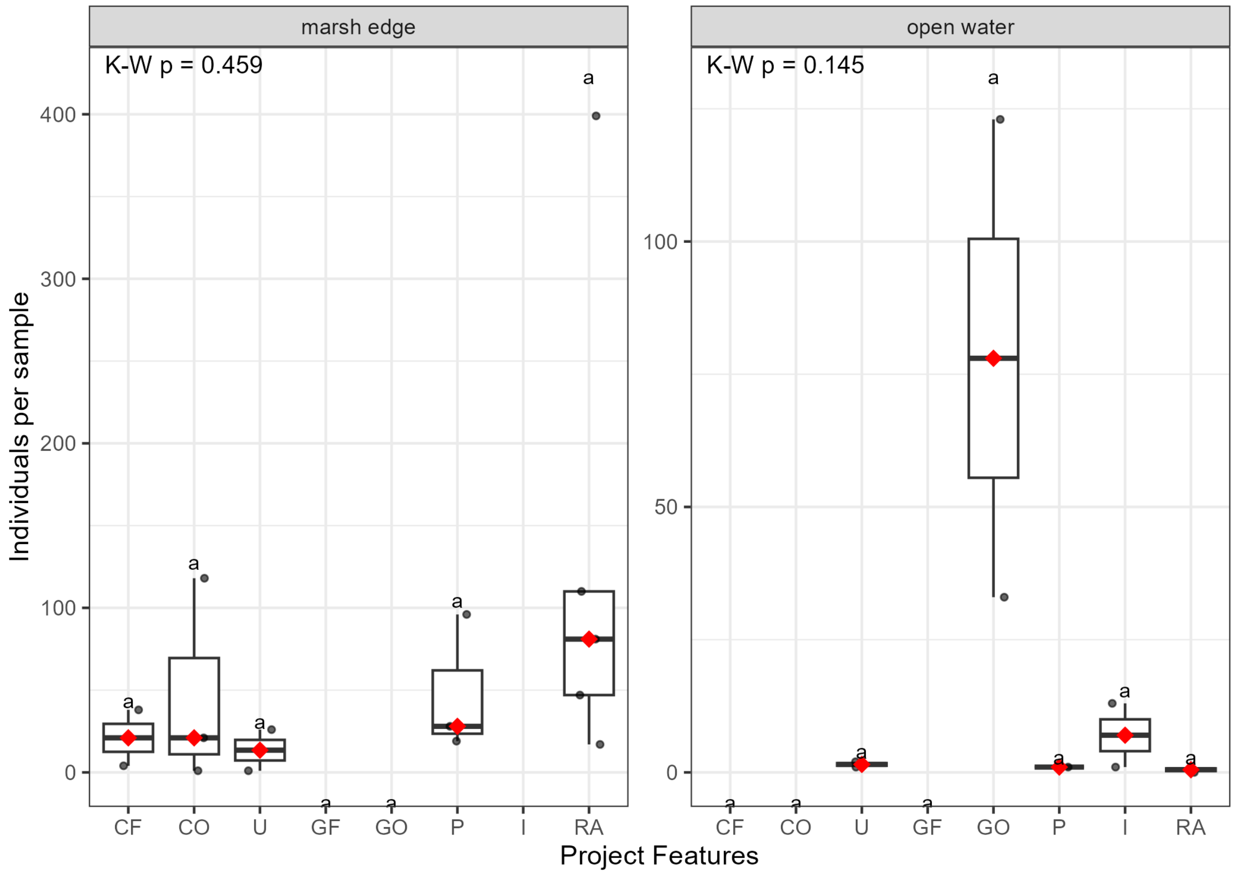


*Figure 68. Boxplots (median and IQR) of Other Shrimps density in marsh edge and open water habitat at fixed-area stations in Project Year 1 (2024). Red diamonds represent medians; upper and lower bounds of the box represent Q3 and Q1, respectively; vertical bars represent the largest/smallest values no further than 1.5*IQR; black dots represent raw data; groups that do not share a letter are significantly different based on a post-hoc Dunn's test with a Benjamini-Hochberg correction (α = 0.05). Acronyms: ME = marsh edge; OW = open water; CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; K-W = Kruskal-Wallis (omnibus); I = interior. All samples collected by drop sampler gear type.*

*White Shrimp:* Statistical comparisons of the median density of White Shrimp across marsh edge habitats of the Project Area features and the Reference Area indicated a statistically significant overall difference based on the Kruskal Wallice test ($p$ = 0.04; Figure 69 left). However, post-hoc pairwise comparisons failed to isolate any specific between-feature differences. No significant differences were observed for White Shrimp densities in open water habitats at project features compared to the Reference Area ($p$ =

0.33; Figure 69 right). The highest median density was identified in open water habitat at **GO** stations (6 [3.5–6]).

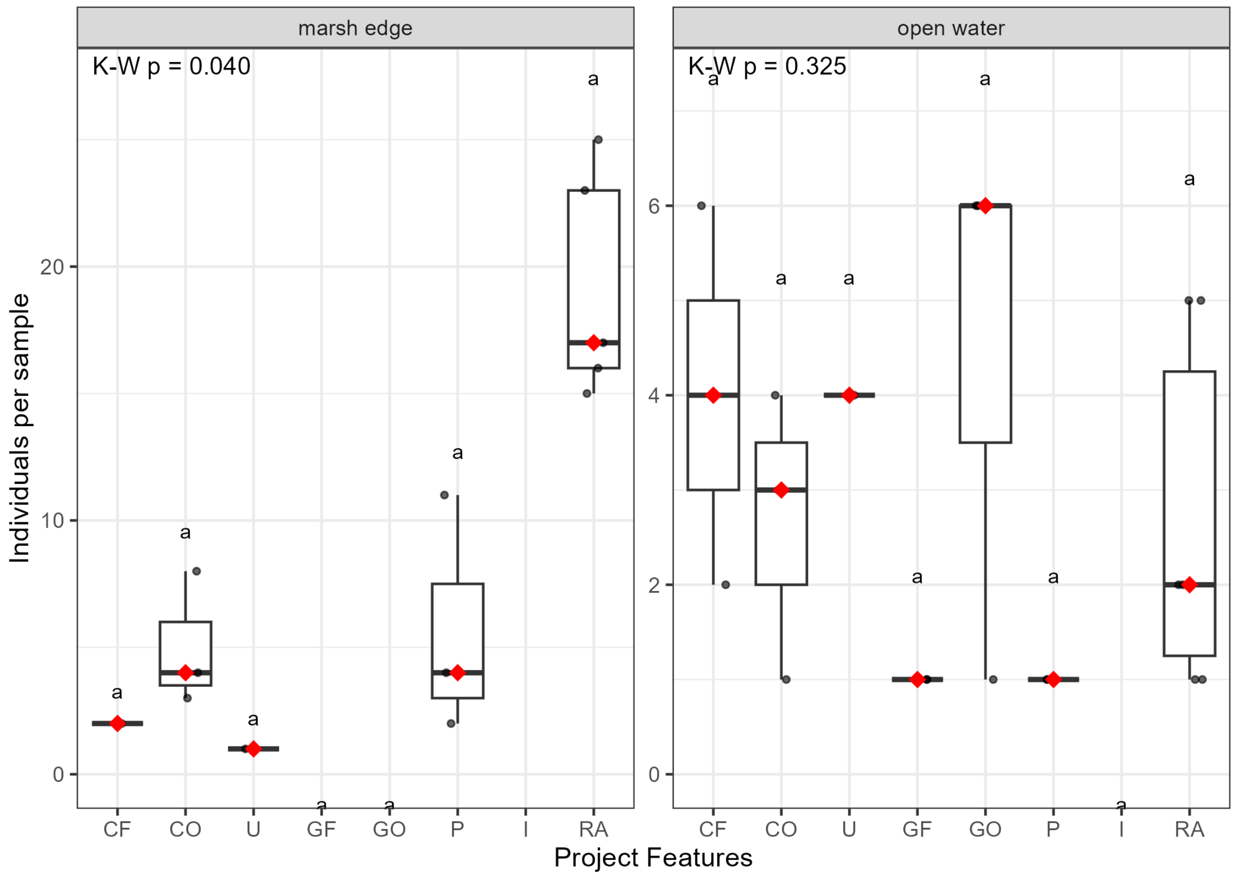


*Figure 69. Boxplots (median and IQR) of White Shrimp density in marsh edge and open water habitat at fixed-area stations in Project Year 1 (2024). Red diamonds represent medians; upper and lower bounds of the box represent Q3 and Q1, respectively; vertical bars represent the largest/smallest values no further than 1.5*IQR; black dots represent raw data; groups that do not share a letter are significantly different based on a post-hoc Dunn's test with a Benjamini-Hochberg correction (α = 0.05). Acronyms: CF = confined edges along a flow pathway; CO = confined edges along an open bayou; U = unconfined edges; GF = gaps along a flow pathway; GO = gaps along an open bayou; P = pond; K-W = Kruskal-Wallis (omnibus). All samples collected by drop sampler gear type except for Interior which was sampled using throw trap gear.*

Across the target nekton in marsh edge habitats, Cliff's *d* mean effect size for density ranged from -1 (White Shrimp) to 0.4 (Killifish spp.; Figure 70). Negative Cliff's *d* values were observed White Shrimp (-0.71) and Other Shrimps (-0.32) indicating higher density of these taxa in the Reference Area than in the Project Area. Statistically significantly lower effect size was observed for White Shrimp (-1 [-1, 0.9]]) in marsh edge habitats. Killifish spp. (0.38) were the only taxa with indications of higher density in the Project Area than in the Reference area, although not statistically significant. For open water habitats, Cliff's *d* of target nekton ranged from 0.75 (Other Shrimps) to -0.75 (Blue Crabs), with no significant effect sizes were observed. Killifish spp. collected in open water habitat was not analyzed for effect size due to insufficient sample size. Interior samples collected using throw trap gear type were removed from the effect size analysis due to no comparable throw trap sampling in the Reference Area.

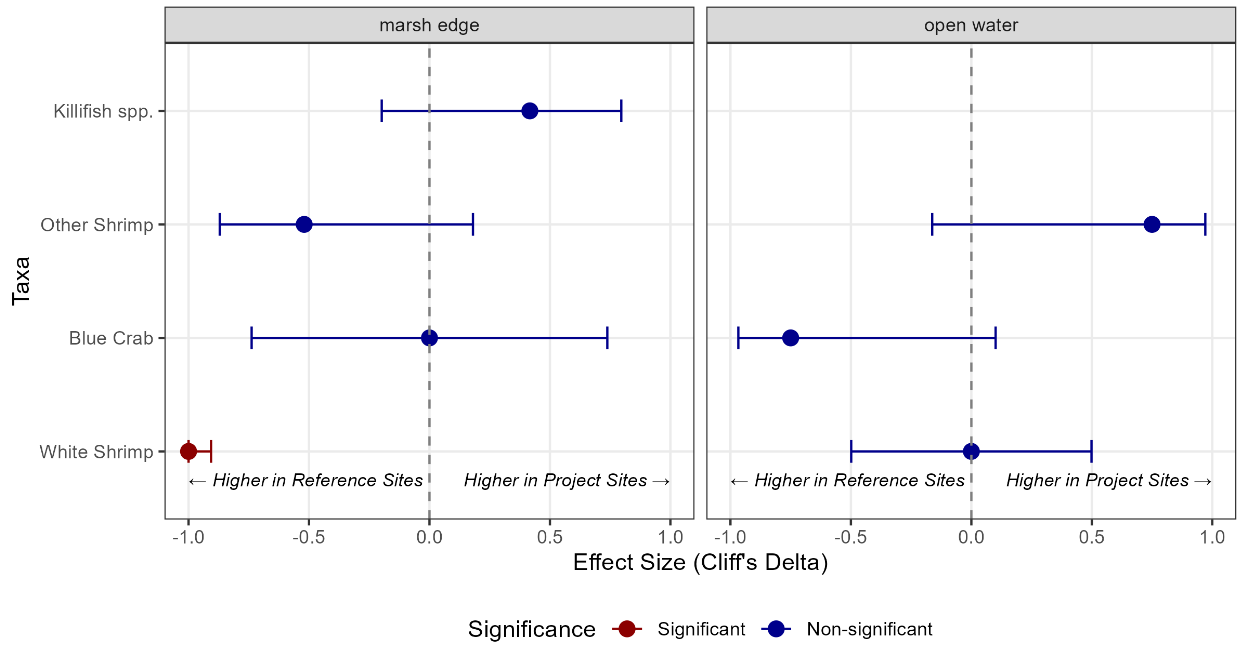


*Figure 70. Effect size (Cliff's D) of target nekton species density at the Project Area compared with the Reference Area. Circles represent the mean effect sizes; horizontal bars represent 95% CI; vertical dotted line represents no difference between Reference and Project area. Effect sizes are not considered significant (blue) if the 95% CI overlaps zero. Data from interior samples collected by throw trap were omitted from analysis of Cliff's D.*

**Results – Biomass: Project Year 1 (2024):** In 2024 the median biomass (g) of target nekton taxa varied widely, but no significant differences were observed between Project and Reference areas in marsh edge nor open water habitat types (Figure 71, Table 39). The biomass (g sample$^{-1}$) of most target nekton species was generally higher in marsh edge habitat (range: 0-12.71 g sample$^{-1}$) over biomass observed in open water habitat (range: 0–3.24 g sample$^{-1}$), but not significantly.

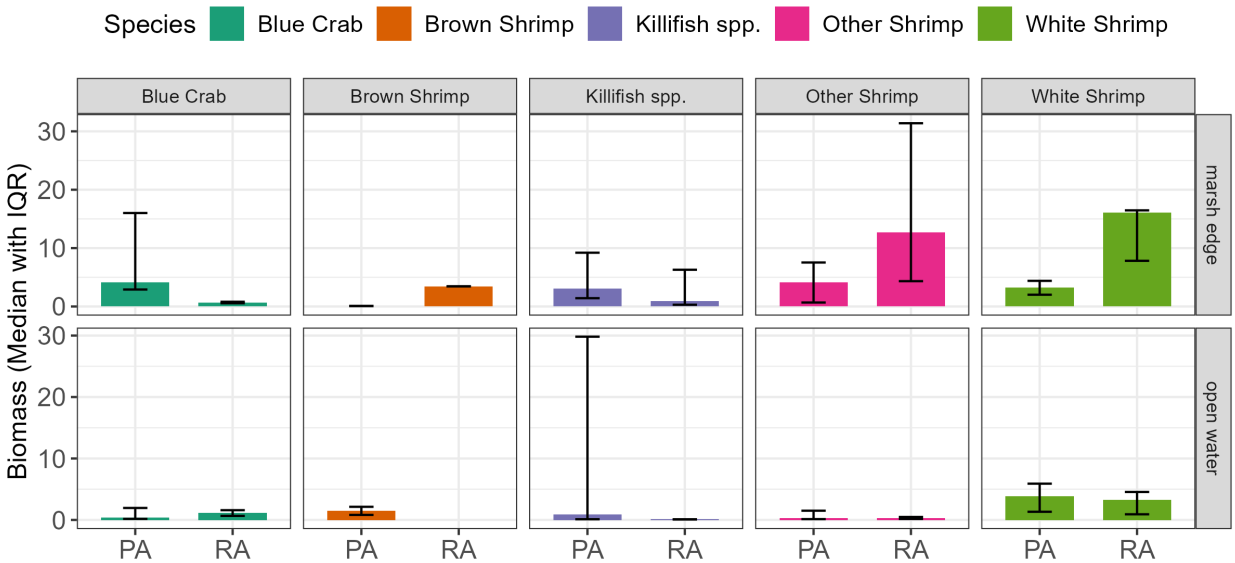


*Figure 71. Biomass (in grams) of target nekton taxa in marsh edge and open water habitats sampled by fixed-area gear types in 2024. Bars represent median and vertical lines represent IQR. Abbreviations: PA = Project Area; RA = Reference Area. See table below for statistical significance.*

*Table 39. Median target nekton biomass (in grams sample$^{-1}$) in marsh edge and open water habitats observed at the Project and Reference areas by fixed-area gear types in 2024. Values provided as median [IQR]. Asterisk (*) indicates statistically significant Mann-Whitney U Test with α = 0.05. Acronyms: p = p value, NA = statistical tests were not conducted due to low catch values.*

| **Common Name** | **Marsh edge** | | | **Open Water** | | |
|---|---|---|---|---|---|---|
| | **Reference** | **Project** | ***p*** | **Reference** | **Project** | ***p*** |
| Blue Crab | 0.69 [0.56–0.81] | 4.16 [2.91–16.01] | 0.40 | 1.11 [0.66–1.59] | 0.39 [0.17–1.95] | 0.66 |
| Brown Shrimp | 3.44 | 0.08 | 1.00 | 0 | 1.48 [0.82–2.14] | NA |
| Killifish spp. | 0.94 [0.29–6.29] | 3.05 [1.42–9.21] | 0.50 | 0.09 | 0.88 [0.12–29.82] | 0.33 |
| Other Shrimps | 12.71 [4.34–31.39] | 4.10 [0.68–7.53] | 0.15 | 0.32 [0.16–0.48] | 0.33 [0.14–1.5] | 0.48 |
| White Shrimp | 16.11 [7.82–16.46] | 3.28 [2.01–4.39] | 0.07 | 3.24 [0.92–4.55] | 3.89 [1.33–5.9] | 0.55 |

Cliff's *d* mean effect size for target nekton biomass (g) ranged from -0.65 (White Shrimp) to 0.5 (Blue Crab) in marsh edge habitat, with Killifish spp. and Blue Crab having a larger biomass in marsh edge habitat within the Project Area and White Shrimp and Other Shrimps having larger biomass in the Reference Area; however, differences were not statistically significant (Figure 72). In open water, Cliff's *d* mean effect size ranged from -0.5 (Blue Crab) to 0.4 (Other Shrimps), but no statistically significant differences were identified. Killifish spp. collected in open water habitat was not analyzed for effect size due to insufficient sample size.

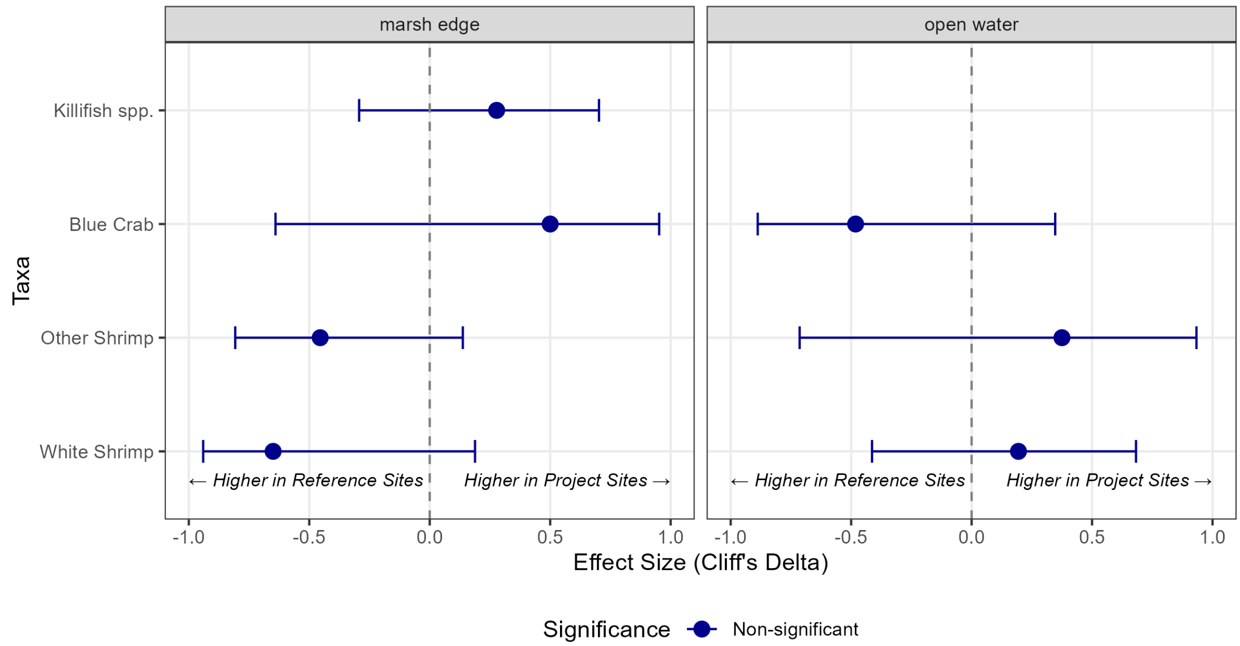


*Figure 72. Effect size (Cliff's* d*) of target nekton species biomass at the Project Area compared with the Reference Area and collected by fixed-area gear types in 2024. Circles represent the mean effect sizes; horizontal bars represent 95% CI; vertical dotted line represents no difference between Reference and Project area. Effect sizes are not considered significant (blue) if the 95% CI overlaps zero. Data from interior samples collected by throw trap were omitted from analysis of Cliff's* d*.*

**Results – Size: Project Year 1 (2024):** Significantly larger Blue Crabs, Killifish spp., and White Shrimp were observed from open water habitat types of the Project Area compared to the Reference Area (Figure 73, Table 40). However, no differences were observed for Brown Shrimp (for which no comparisons could be made due to a lack of data) and Other Shrimps collected from the open water habitat type. In marsh edge habitat, significantly larger White Shrimp were observed in the Project Area compared to the Reference Area, however no other significant differences were observed for the other target nekton sampled from marsh edge habitat.


*Figure 73. Size (TL or CW in mm) of target nekton taxa in marsh edge and open water habitats sampled by fixed-area gear types in 2024. Bars represent median and vertical lines represent IQR. Abbreviations: PA = Project Area; RA = Reference Area.*

*Table 40. Median target nekton size (TL or CW in mm) in marsh edge and open water habitats observed at the Project area and Reference area by fixed-area gear types in 2024. Values provided as median [IQR]. Asterisk (*) indicates statistically significant Mann-Whitney U Test with α = 0.05. Acronyms: p = p value; NA = calculation was not possible due to lack of data.*

| Common Name | Marsh edge | | | Open Water | | |
|---|---|---|---|---|---|---|
| | Reference | Project | p | Reference | Project | p |
| Blue Crab | 16.39 [13.14–19.91] | 24.77 [13.61–39.62] | 0.44 | 10.55 [9.8–12.29] | 13.88 [12.86–20.64] | 0* |
| Brown Shrimp | 94.12 | 43.98 | 1.00 | 0 | 49.51 | NA |
| Killifish spp. | 21.79 [19.26–29.59] | 21.66 [12.73–28.8] | 0.13 | 13.25 [12.79–13.71] | 30.04 [25.28–34.58] | 0.02* |
| Other Shrimps | 19.59 [16.16–24.26] | 20.66 [15.61–25.1] | 0.38 | 8.2 | 17.81 [8.84–23.08] | 0.39 |
| White Shrimp | 37.72 [28.11–48.34] | 49.12 [41.89–55.81] | 0* | 24.92 [14.49–44.08] | 49.12 [41.47–52.83] | 0.01* |

Cliff's *d* mean effect size for target nekton size ranged from -0.2 (Killifish spp.) to 0.4 (White Shrimp) in marsh edge habitat and 0.5 (White Shrimp) to 1.0 (Killifish spp.) in open water (Figure 74). Statistically significant effects were observed in White Shrimp in both marsh edge and open water habitats (0.4 [0.2, 0.6] and 0.5 [0.03, 0.8], respectively), and for Blue Crab (0.6 [0.2, 0.8]) and Killifish spp. (0.9 [0.6–1]) in open water habitats. These results indicate that the size distributions of these taxa were significantly different between the Project and Reference areas, with larger sizes occurring in the Project Area. Low sample sizes of Other Shrimps restricted effect size analysis to only marsh edge habitat and no analysis was possible for Brown Shrimp in either habitat type.

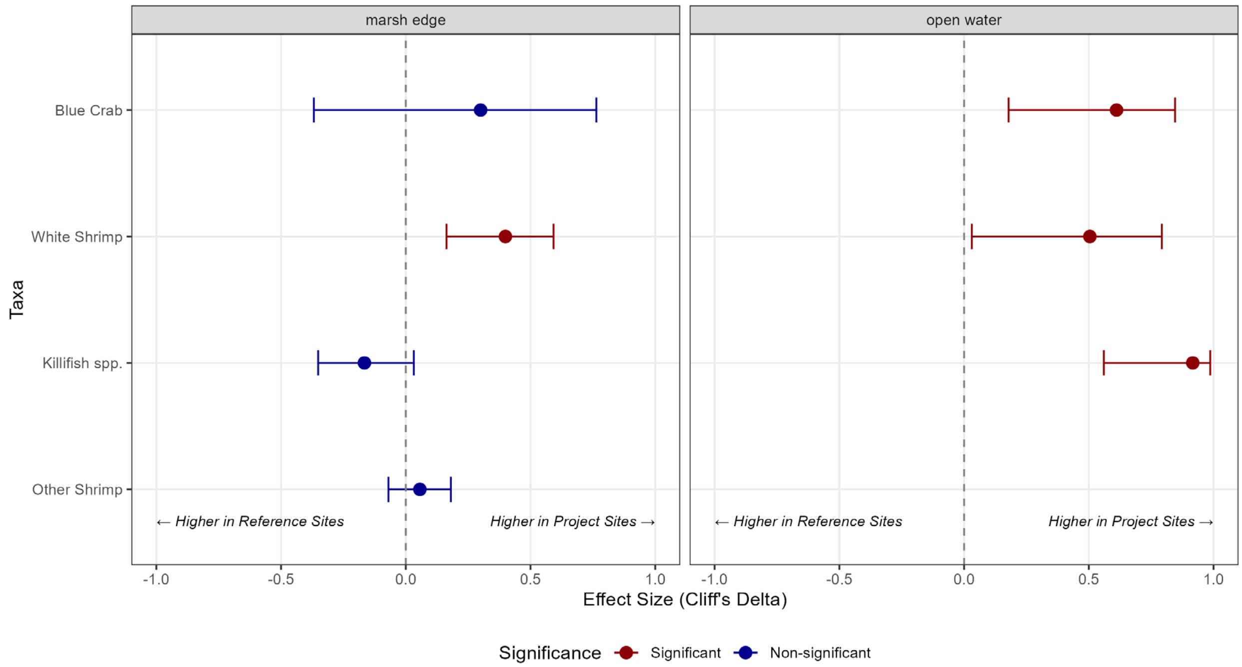


*Figure 74. Effect size (Cliff's D) of target nekton species size at the Project Area compared with the Reference Area in 2024. Circles represent the mean effect sizes; horizontal bars represent 95% CI; vertical dotted line represents no difference between Reference and Project Area. Effect sizes are not considered significant (blue) if the 95% CI overlaps zero. Data from interior samples collected by throw trap were omitted from analysis of Cliff's* d.

## Project Performance Assessment:

- ***Performance Criteria:*** *Density (abundance), size distribution, and biomass of target nekton species within the Project Area sampled using fixed-area gear types are not significantly lower than values of the same metrics at the reference site by Year 8.*
  - **Project Year 1 (2024):** ***Performance Criteria Not Yet Met***
    - **Density:** No significant differences in target nekton densities were observed between Project and Reference fixed-area stations.
    - **Size and Biomass**: No significant differences in target nekton biomasses were observed between Project and Reference fixed-area stations. Significantly larger Blue Crabs, Killifish spp., and White Shrimp were observed in open water habitats of the Project Area compared to the Reference Area, and significantly larger White Shrimp were observed in marsh edge habitats of the Project Area compared to the Reference Area. No other significant differences in size were detected for the target taxa analyzed.

#### 2.3.3.3 Secondary productivity by overall production

No monitoring activities were conducted to inform this parameter pre-construction or during Year 1 (2024). Secondary productivity analyses are anticipated to be completed in future Upper Barataria Project MAM Synthesis reports.

**Project Performance Assessment:**

- ***Performance Criteria:*** *Secondary productivity of target species is enhanced by marsh creation/restoration of the Project Area.*
    - **Project Year 1 (2024):** ***Performance Criteria Not Evaluated.*** Analyses of this performance criterion was not completed.

#### 2.3.3.4 Secondary productivity by habitat resource index

**Methods:** Spatially explicit energetic resource maps (E-scapes; James et al., 2022) were developed using land:water delineated imagery of the Upper Barataria Project footprint (see Section 2.1.1) to visualize species-specific resource use information onto the landscape to classify areas based on energetic importance to the target species. Raster math was employed in ArcGIS to create habitat rasters for the main basal dietary resources for the target nekton species for each year of delineated imagery (2018 Figure 75, and 2022 Figure 76): (1) emergent vegetation (*Spartina* spp. and mangrove combined), (2) algae (suitable habitat for benthic algal production is assumed to be within 1 m landward and seaward of emergent marsh edge), and (3) particulate organic matter (POM; open water). Static input values for each target species' home range and dietary contributions are provided in Table 41. Following methodology developed by James et al. (2022), the index of energetic importance (IEI) and the habitat resource index (HRI) were first calculated. HRI values were then projected on the landscape to create an e-scape map for each taxon where higher values indicate the target species could receive more optimal energetic resources based on Barataria-specific stable isotope mixing models, home ranges, and habitat information (Nelson et al., 2019).

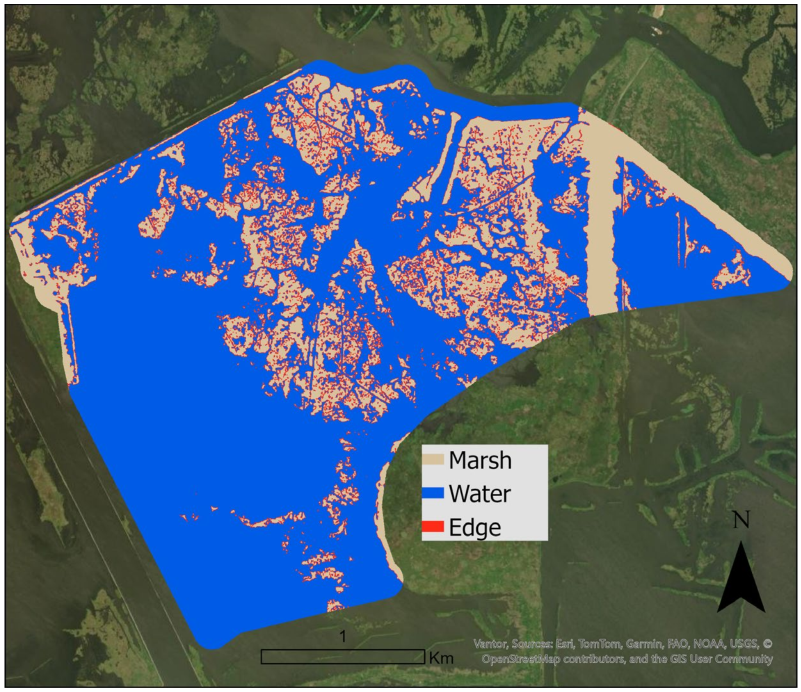


*Figure 75. Map of dietary resources based on habitat types in the Project Area based on 2018 land:water delineated imagery. Habitat types of marsh (emergent vegetation), water (particulate organic matter), and edge (algae) are shown.*

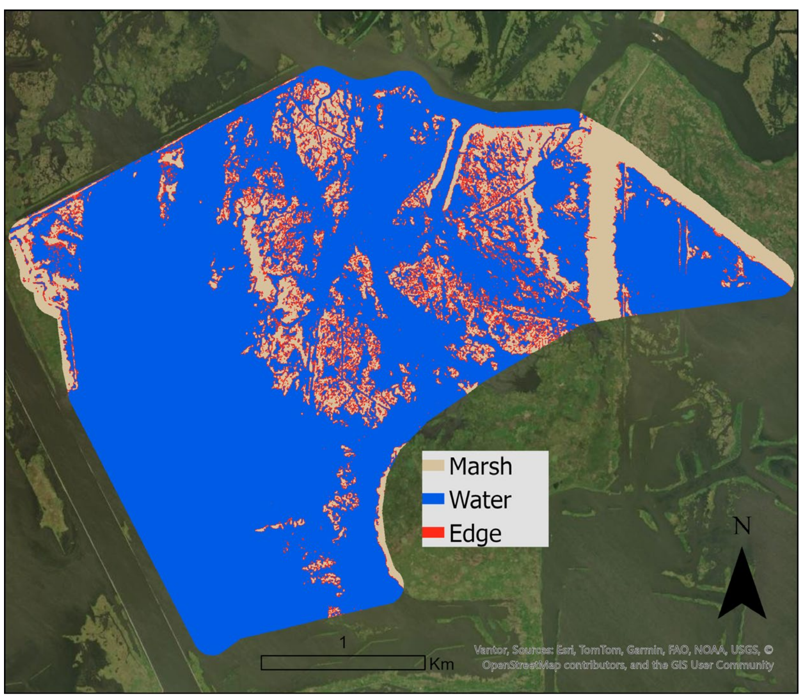


*Figure 76. Map of dietary resources based on habitat types in the Project Area based on 2021 land:water delineated imagery. Habitat types of marsh (emergent vegetation), water (particulate organic matter), and edge (algae) are shown.*

*Table 41. E-scape parameters for target nekton species. Species-specific data inputs were based on methodology outlined in James et al.,(2022). Abbreviations: EV = Emergent Vegetation (Sporobolus + Mangrove); POM = Particulate Organic Matter.*

| Species | Home range (m) | Dietary Contributions of Basal Resources to Consumer (%) | | | Citation |
|---|---|---|---|---|---|
| | | EV | Algae | POM | |
| **Blue crab** | 500 (range: 10 to over 1000) | 15 | 57 | 28 | (Hines, 2007; Nelson et al., 2019) |
| **White shrimp** | 200 | 13 | 49 | 38 | (Nelson et al., 2019; Rozas & Minello, 1997; Webb & Kneib, 2004) |
| **Brown shrimp** | 100 | 9 | 46 | 45 | (Haas et al., 2004; Nelson et al., 2019) |
| **Killifish spp.*** | 100 | 17 | 49 | 34 | (Jensen et al., 2019; Nelson et al., 2019) |

*The Gulf killifish species is used as a representative of the broader killifish guild due to a lack of available data to complete this analysis for other species.

E-scapes were created for each year of land:water delineation of the Project Area (2018 and 2021). HRI values in 2018 and 2021 were summarized for each timepoint. Due to a lack of post-construction data at the time of writing, no statistical analyses were conducted to compare pre- and post-construction HRI values.

**Results:** Results in this section are separated by target taxon. Summary data tables for the range in HRI values and the amount of area (%) where HRI values >1 are provided at the end of this section in Table 42.

*Blue Crab:* The HRI values for Blue Crabs pre-construction (2021) in the Project Area ranged from 0.30 to 2.05. The amount of area (%) with HRI values greater than 1 did not change between 2018 and 2021 and remained 25%.

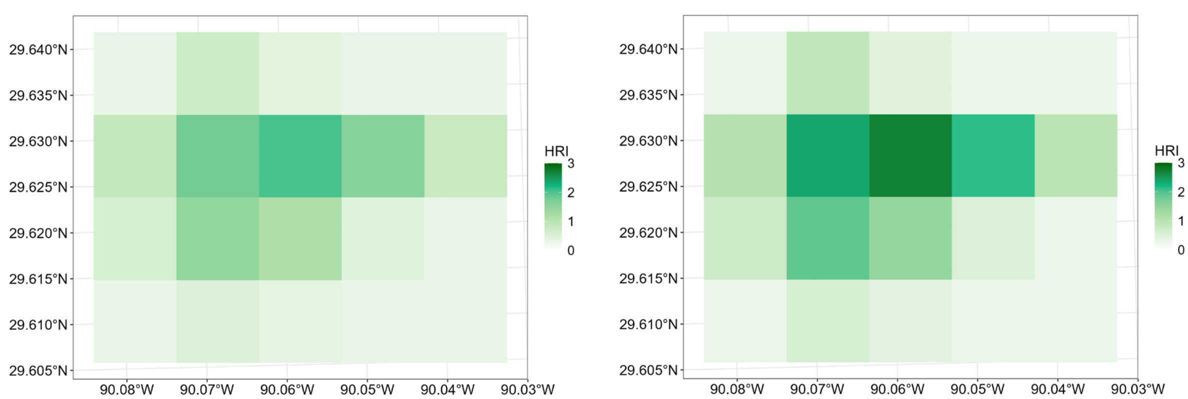


*Figure 77. Habitat resource index (HRI) values of the Project Area for Blue Crab. Imagery available for pre-construction years 2018 (left) and 2021 (right). Darker shades of green represent more area from habitats producing resources being used by Blue Crab, and lighter colors contain less amount of these habitats.*

*Brown Shrimp:* The HRI values for Brown Shrimp pre-construction (2021) in the Project Area ranged from 0.45–3.31, with a notable increase from 2018 (max HRI = 2.17) to 2021 (max HRI = 3.31). The amount of area (%) with HRI values greater than 1 also increased from 17% to 19% between 2018 and 2021, particularly near the center of the Project Area where land loss was high. This observed increase in HRI value was likely due to an increase in open water habitat and edge habitat which offers greater potential access to particulate organic matter (POM)—a dietary source comprising an estimated 45% of the diet of Brown Shrimp.

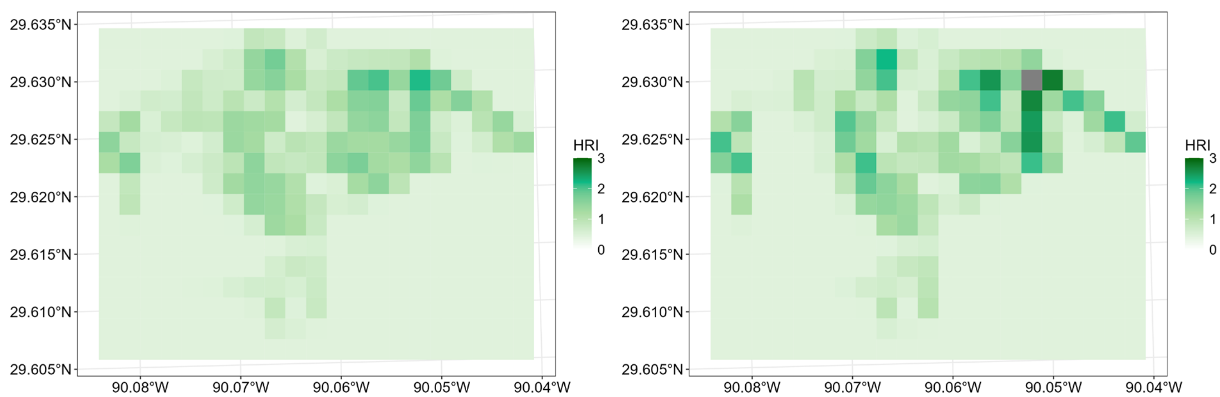


*Figure 78. Habitat resource index (HRI) values of the Project Area for Brown Shrimp. Imagery available for pre-construction years 2018 (left) and 2021 (right). Darker shades of green represent more area from habitats producing resources being used by Brown Shrimp, and lighter colors contain less amount of these habitats. Grey areas denote HRI values greater than 3.0.*

*Killifish spp. (Gulf Killifish):* The HRI values for Killifish spp. pre-construction (2021) in the Project area ranged from 0.34 to 3.47 with a slight increase from 2018 to 2021. The amount of area (%) with HRI values greater than 1 did not change between 2018 and 2021 and remained 20%.

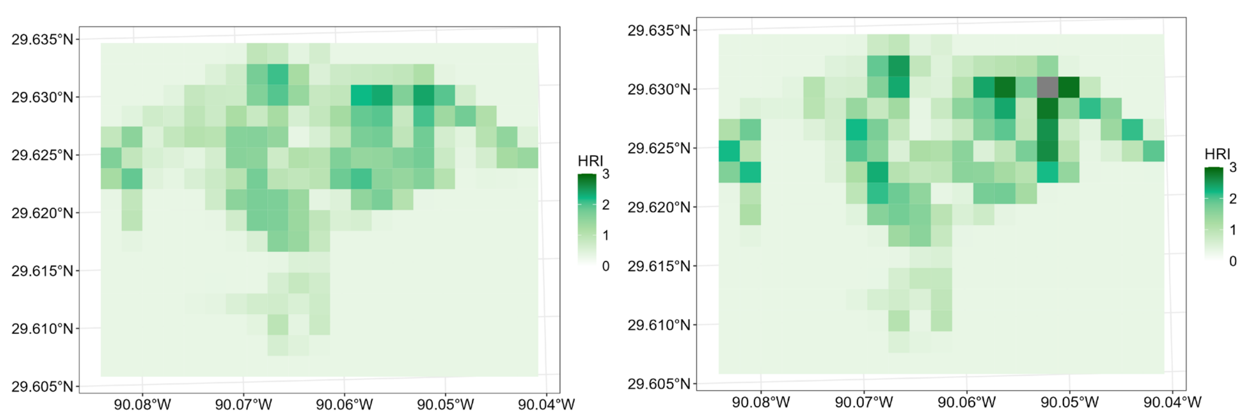


*Figure 79. Habitat resource index (HRI) values of the Project Area for Killifish spp. Imagery available for pre-construction years 2018 (left) and 2021 (right). Darker shades of green represent more area from habitats producing resources being used by Killifish spp., and lighter colors contain less amount of these habitats. Grey areas denote HRI values greater than 3.0.*

*White Shrimp:* The HRI values for White Shrimp pre-construction (2021) in the Project area ranged from 0.38 to 2.78, and minimal change was observed between 2018 to 2021. Although the maximum HRI value increased slightly from 2.48 in 2018 to 2.78 in 2021, the amount of area (%) with HRI values greater than 1 decreased slightly (~28% in 2018; ~25% in 2021).

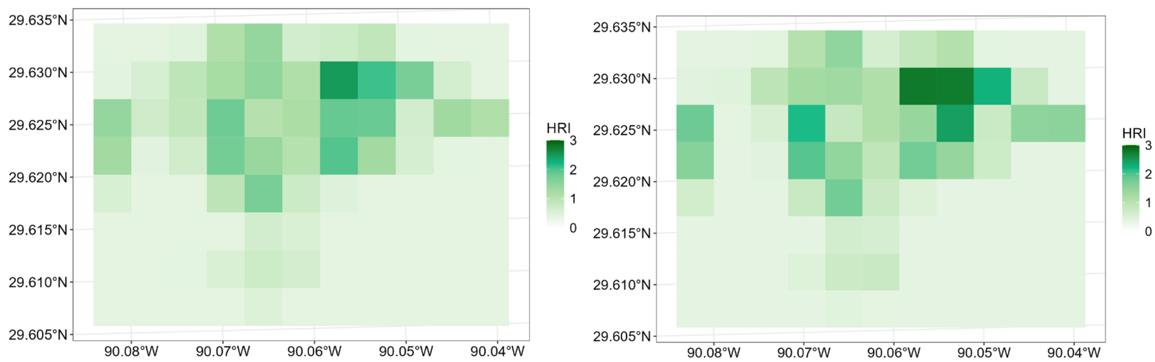


*Figure 80. Habitat resource index (HRI) values of the Project Area for White Shrimp. Imagery available for pre-construction years 2018 (left) and 2021 (right). Darker shades of green represent more area from habitats producing resources being used by White Shrimp, and lighter colors contain less amount of these habitats.*

*Table 42. Summary of habitat resource index (HRI) values by target nekton taxa over time. Data summarized as HRI ranges and proportions (%) of the Upper Barataria Project footprint where HRI values >1 for each target taxa based on 2018 and 2021 aerial imagery.*

| Target Taxa | 2018 | 2021 |
|---|---|---|
| White shrimp | Total: 28.14% (Range: 0.39–2.48) | Total: 25.00% (Range: 0.38–2.78) |
| Brown shrimp | Total: 17.00% (Range: 0.45–2.17) | Total: 19.00% (Range: 0.45–3.31) |
| Blue crab | Total: 25.00% (Range: 0.31–2.02) | Total: 25.00% (Range: 0.30–2.05) |
| Gulf Killifish | Total: 20.00% (Range: 0.34–2.39) | Total: 20.00% (Range:0.34–3.47) |

**Project Performance Assessment:**

- ***Performance Criteria:*** *With respect to target species, the habitat value of the Project Area evaluated by energetic landscapes is improved by marsh creation/restoration of the Project Area.*
    - **Project Year 1 (2024): *Performance Criteria Not Evaluated.*** Post-construction delineated imagery for the Project Area were not available at the time of writing and thus this performance criterion could not be evaluated.

# 3.0 EVALUATION AND SYNTHESIS

The stated monitoring objectives set for Upper Barataria Project indicate early success in meeting most of its objective parameters, although more years of monitoring data are required to strengthen project assessment. A summary of project performance assessment is provided in Table 43 appearing at the end of this section.

*Objective #1: Marsh Creation*

Early successes regarding marsh creation are highlighted by the significant increase in total land created by the Upper Barataria Project, which created a total of 1,259 acres of wetland and water features including 1,170 acres of tidal marsh habitat, exceeding the performance criteria by 76 acres. This significant increase in total land is notable in an area experiencing severe rates of land loss exacerbated by the passage of hurricanes (i.e. Hurricane Ida in 2021) and lasting impacts from oiling events. At the time of writing, only pre-construction (2018-2021) data were available to determine land loss rates, and therefore statistical differences between the Project and Reference areas could not be determined at this time and the associated performance criterion could not be assessed.

After dredge fill placement to build the marsh platforms was completed, post-construction surveys indicated that none of the Project Area MCAs met the minimum as-built design elevation of +2.5 ft NAVD88, therefore no MCAs met the associated performance criterion. Variable rates of settlement were present across individual MCAs, which may have been influenced by differing sediment properties and dredge fill completion dates—MCA1A in 10/31/2023, MCA1B in 1/16/2023, MCA2B in 2/27/2023, MCA3A in 3/9/2023, and MCA2A in 4/7/2023. As the sediments of the created marsh platform continue to settle over time, land loss rates calculated from changes in land:water area will be better understood throughout the life of the project and will inform its sustainability into the future. Future measurements of marsh fragmentation will also provide context to better understand landscape patterns and changes within the Project Area and will be used to better understand the Upper Barataria Project's habitat creation services for nekton.

*Objective #2: Basin Connectivity*

Connectivity of water around, within, between, and through the Project Area and surrounding bayou was also used to assess the performance of the Upper Barataria Project. These connections provide nekton access to the created marsh habitat for foraging and protection as well as facilitate the transportation of nutrients and energetic resources to adjacent habitats. While water movement around the marsh is important for regional connectivity, water movement and exchange with the marsh surface is a primary driver of marsh health and determines what plant species may thrive there (Pennings et al., 2005). It is expected that the created marsh platforms of the Project Area will be inundated more than 10 % but less than 90 % of the time per year of the project's 20-year life. Initial assessments based on data collected at construction completion were relatively simple and based only on average elevations of each MCA. Initial findings suggest that the inundation performance criteria of 10 to 90% frequency of the surface inundation assessed using water levels recorded during 2024 was only met by two of the five MCAs (MCA1B and MCA2B). The three MCAs that did not meet the performance criteria were reported with the highest average elevations at the time of surveying, and a notably low settlement rate at MCA1A was recorded. Surprisingly, the only MCA constructed using completely unconfined dredge fill placement (MCA3A) was estimated to experience inundation for just ~5 % of the year based on 2024 water levels. Future work to model the more dynamic elevations of the created marsh surface are necessary to better understand water movement and flooding regimes within the MCAs. Finally, environmental factors also likely impacted the inundation and salination in the Project Area, including the passage of Hurricane Ida in 2021, a "flash drought" in 2023 (Miller & Hiatt, 2024), and the passage of Hurricane Francine in 2024.

Despite not meeting inundation targets at each MCA, the presence of nearly all target nekton taxa (Brown Shrimp, White Shrimp, Other Shrimps, Blue Crab, Killifish spp., and Red Drum) within and adjacent to the Project Area serves as evidence of intact hydrologic connectivity in Project Year 1. Select nekton species were assessed based on their commercial and economic importance (Blue Crabs, Brown Shrimp, and White Shrimp), recreational importance (Red Drum), and trophic importance (Other Shrimps, Killifish spp.) in supporting the broader food web. Some of these economically important species, such as White Shrimp and Blue Crab, have generated a total of ~$397 million and ~$380 million USD, respectively, within the last 5 years, proving invaluable to Louisiana's fisheries economy (NOAA, 2025a) and highlighting the importance of restoring lost and degraded coastal nekton habitats. Hydrologic connectivity will continue to improve as the MCAs continue to settle and a greater diversity of nekton gain access to the interiors of MCAs.

Based on FIMP seine and trawl monitoring data, the Upper Barataria Project met the performance criteria for nekton presence in Project Year 1. Similarly, results of fixed-area nekton monitoring further confirm that all target taxa were detected in the Project Area using drop sampler gear with the exception of Brown Shrimp in the Reference Area. Only Blue Crabs, Killifish spp., and Other Shrimps were detected using throw trap gear, which aligns with the life history of these marsh-resident species utilizing interior ponds (Peterson & Turner, 1994). These findings suggest that nekton species have moved from the surrounding areas in the basin to the project area. Achieving this nekton performance criteria even at this early stage post-construction is promising. Over time, hydrologic connectivity should continue to improve as the elevation of MCAs settle and the duration of inundation of the marsh platform increases.

*Objective #3: Productivity*

In addition to land-building and connectivity, evaluating contributions of the Upper Barataria Project to the primary and secondary productivity of the Basin is the third major component of the Project's performance assessment. In Project Year 1 post-construction, no differences were noted in vegetation height of dominant species, Species Richness, Pielou Evenness, and VVI in the Project Area compared to the Reference Area. However, significantly lower vegetation cover and Shannon Diversity were observed. In terms of dominant vegetation taxa, a notable lack of *S. patens* and *S. alterniflora*, and a greater cover of *P. australis* was observed in the Project Area and compared to the Reference Area. The establishment of vegetation in the Project Area was likely influenced by the local vegetation communities that recolonized the area naturally, with the only plantings being cypress tree saplings in MCA 1A. It is expected that the vegetation cover, composition, and vigor in the Project Area will meet the performance criteria by Year 6 and Year 3, respectively.

Soils in the Project Area evaluated alongside vegetation were characterized by significantly lower soil specific conductance, significantly lower soil organic matter, and significantly higher soil bulk density (high compaction and low porosity). These soil properties can contribute to decreased vegetation growth and cover in typical low marsh vegetation species and contribute to the early colonization and establishment of disturbance tolerant species such as *P. australis* that can thrive in extreme abiotic conditions such as drought, anoxia, and high salinity (Stanton, 2004). Sand content also varied widely across MCAs which may provide opportunities for sand-tolerant species such as *P. vaginatum* and *P. repens* to colonize the Project Area; however, sand content was not significantly different between the Project and Reference areas. A delayed response of typical marsh vegetation colonization observed in Year 1 in the Project Area aligns with other marsh restoration projects in Louisiana and is expected to evolve over time as elevation shifts (Edwards & Proffitt, 2003).

Secondary productivity of the Project Area was assessed at FIMP seine and trawl monitoring stations as well as fixed-area stations positioned adjacent to and within the Project and Reference areas. It is expected that the target nekton CPUE/density, size distribution, and biomass in the Project Area will not be significantly lower than the Reference Area by Year 8. In Project Year 1, significantly higher CPUE of Blue Crab collected by FIMP trawls and higher biomass and individual sizes of White and Brown Shrimp collected by FIMP seines within the Project Area were observed. No other significant differences in CPUE for the other target species between the Project and Reference areas were identified, although future years of FIMP monitoring data may illustrate changing trends.

Fixed-area sampling efforts revealed significantly larger individuals of Blue Crabs, Killifish spp., and White Shrimp in open water habitats of the Project Area compared to the Reference. Additionally, significantly larger White Shrimp were observed in the marsh edge habitats of the Project Area, but significantly fewer individuals were observed. The presence of these larger individuals in the Project Area could point to the lack of available refuge for smaller individuals to hide that is typically provided by a flooded marsh platform (Yaeger & Hovel, 2017).

Overall, individual nekton secondary productivity criteria for both FIMP and fixed-area monitoring did not meet the performance criteria at this time, but secondary productivity by these metrics is expected to meet performance criteria by Year 8. It is known that nekton use of microhabitats in Barataria Bay demonstrates a complex relationship between abundance and stem density, depending on individual size and life history (Baltz et al., 1993). For instance, juvenile Red Drum abundance demonstrates a positive relationship with shallow water and high stem density in fall when juvenile Red Drum are at their highest abundance in this area (Baltz et al., 1993). As the marsh platform continues to settle and vegetation communities establish, target nekton species in the Project Area should converge with the Reference Area and more closely resemble a natural marsh over time (Hollweg et al., 2020).

*Table 43. Summary of project performance for Project Year 0 (as-built) and Project Year 1 (2024). Values of "Yes" indicate that the associated performance criterion was fully met based on data collected within the relevant Project Year, whereas values of "No" indicate the associated performance criterion was not fully met. Metrics not evaluated by data collected within a given Project Year are shown as "Not evaluated". Evaluation was not conducted for context metrics.*

| Parameter | Metric | Performance Criteria | Year 0 2023 | Year 1 2024 |
|---|---|---|---|---|
| **Objective 1: Marsh Creation** | | | | |
| #1 Spatial extent (Acres) of created tidal marsh platform | Total land area | The total created wetland (marsh, created water features) built in the Project Area is equal to or greater than 1,183 acres (per final approved construction design) | Yes | Not evaluated |
| | Land area change | The total marsh platform area within the Project Area 20 years post-construction does not exhibit a higher rate of proportional land loss than the reference marsh at CRMS0248. | Not evaluated | Not evaluated |
| | Marsh area elevation | The mean constructed marsh elevation for each MCA is +2.5-3.0 ft NAVD88 immediately following construction (as-built surveys) | No | Not evaluated |
| | Marsh area settlement | The constructed marsh for each MCA maintains a mean elevation of +1 ft NAVD88 at the end of the Project life | Not evaluated | Not evaluated |
| #2 Marsh fragmentation | Marsh fragmentation | N/A context variable | | |
| **Objective 2: Basin Connectivity** | | | | |
| #3 Water levels & salinity | Tidal signal | N/A context variable | | |
| | Inundation | The modeled post-settlement marsh surface inundation in each MCA will have a 10 to 90 percent exceedance frequency for the 20-year project life | Not evaluated | No |
| #4 Presence of target nekton | Nekton sampling (50 ft seine) | Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab are present in the habitat types sampled by 50 ft seines (marsh edge) at FIMP sites adjacent to the Project Area | Not evaluated | Yes |
| | Nekton sampling (6 ft trawl) | Brown Shrimp, White Shrimp, Other Shrimps, and Blue Crab are present in the habitat types sampled by 6 ft trawls | Not evaluated | Yes |
| | Nekton sampling (fixed area) | Brown Shrimp, White Shrimp, Other Shrimps, Killifish spp., and Blue Crab are present in the habitat types sampled by fixed-area samplers (marsh edge: open water, marsh edge: vegetated, and marsh interior) at the Project Area | Not evaluated | No |
| | Red drum telemetry | Target nekton (Red Drum) are detected in tidal channels, tidal ponds, and at the entrance choke points to the Project Area | Not evaluated | Not evaluated |
| **Objective 3: Productivity** | | | | |
| #5 Vegetation cover | | Within 6 years of construction, marsh cover is not significantly less than reference marshes at CRMS0248. | Not evaluated | Not yet |

<table>
<tr><th>Parameter</th><th>Metric</th><th>Performance Criteria</th><th>Year 0 2023</th><th>Year 1 2024</th></tr>
<tr><td rowspan="3"></td><td>Vegetation (primary productivity)</td><td>The marsh vegetation composition and vigor is typical of a healthy intertidal marsh with respect to inundation and salinity regime (reference marsh at CRMS0248 after 3 years)</td><td>Not evaluated</td><td>Not yet</td></tr>
<tr><td>Vegetation (porewater)</td><td colspan="3">N/A context variable</td></tr>
<tr><td>Soil</td><td colspan="3">N/A context variable</td></tr>
<tr><td rowspan="4">#6: Secondary productivity</td><td rowspan="3">Secondary productivity assessment (based on nekton sampling)</td><td>CPUE, size distribution, and biomass of target nekton species adjacent to the Project Area sampled using seine and trawl gear types are not significantly lower than values of the same metrics at surrounding reference sites by Year 8</td><td>Not evaluated</td><td>Not yet</td></tr>
<tr><td>Density, size distribution, and biomass of target nekton species within the Project Area sampled using fixed-area gear types are not significantly lower than values of the same metrics at the reference site by Year 8</td><td>Not evaluated</td><td>Not yet</td></tr>
<tr><td>Secondary productivity of target species is enhanced by marsh creation/restoration of the Project Area</td><td>Not evaluated</td><td>Not evaluated</td></tr>
<tr><td>Secondary productivity assessment (based on land:water delineation)</td><td>With respect to target species, the habitat value of the Project Area evaluated by energetic landscapes is improved by marsh creation/restoration of the Project Area</td><td>Not evaluated</td><td>Not evaluated</td></tr>
</table>

## 3.1 EVALUATION OF LEARNING GOALS

At the time of writing, insufficient data were available to accurately and robustly address the stated learning goals of this project (given below). Evaluation of learning goals is expected to occur in subsequent synthesis reports.

- Killifish spp. proximity to the tidal channels will be evaluated to determine whether connectivity increases density.
    - At Project Year 1 (2024), no statistically significant differences in Killifish spp. densities for either open water or marsh edge habitats were observed between any project design features (see Section 2.3.3.2 above). However, sample sizes at the time of analysis were very small and any conclusions should be made with caution.
- Blue Crab density along the constructed unconfined marsh edge will be compared to the density along the diked marsh edge to determine whether density is correlated to edge habitat type.
    - At Project Year 1 (2024), no statistically significant differences in Blue Crab densities for either open water or marsh edge habitats were observed between any project design features (see Section 2.3.3.2 above). However, sample sizes at the time of analysis were very small and any conclusions should be made with caution.
- White Shrimp, Brown Shrimp, and Other Shrimps density along the unconfined edge will be compared to the density along the diked marsh edge to determine whether density is correlated to edge habitat type.
    - At Project Year 1 (2024), no statistically significant differences in White Shrimp nor Other Shrimps densities for either open water or marsh edge habitats were observed between any project design features (see Section 2.3.3.2 above). No analyses were possible for Brown Shrimp due to small sample sizes and low catch.
- Primary productivity in the MCAs will be compared to primary productivity at the Reference Station (CRMS0248) to determine whether project size and tidal flow are correlated with vegetation composition, abundance, and primary productivity. Changes in soil properties (organic content and grain size distribution) during the project life will be quantified to increase understanding of how constructed marsh soils evolve.
- When the Mid-Barataria Sediment Diversion is constructed, changes in soil properties (organic content and grain size distribution) will be quantified to describe how the constructed marsh responds to changes in salinity and sediment availability. **Note:** Construction of the Mid-Barataria Sediment Diversion has ceased and the project has been terminated (NOAA, 2025b). *Therefore, this learning objective will not be assessed.*

# 4.0 RECOMMENDATIONS AND LESSONS LEARNED

Spatial Extent and Elevation Monitoring

- Future project monitoring efforts may consider expanding the size of the Reference Area (CRMS0248) delineated for land:water such that comparisons of land loss rates and fragmentation between the Reference and Project Areas can be more directly assessed. Considerations of scale at which fragmentation is calculated should also be reviewed.
- Future monitoring efforts could consider augmenting or adjusting the elevation transects originally established by the construction contractor to ensure that the spatial resolution of elevation data is sufficient for addressing the identified monitoring goals and objectives. Light detection and ranging (LiDAR) overflight data collection techniques may provide finer scale spatial resolution elevation data. Such data may enhance inundation models by incorporating barriers to flow such as containment dikes that are not adequately sampled during RTK elevation surveys as originally designed.

Vegetation and Soils Sampling

- The current sample location and replication method allows for flexibility as the vegetation changes over time. No changes are recommended.
- Due to the compact nature of soils at the restored sites, it was not possible to collect porewater samples. In the future, attempts will be made to collect porewater. If it is not possible, soil will be collected to measure soil specific conductance, as was done in Year 1 (2024). Soil-specific conductance is an appropriate proxy for porewater-specific conductance.
- The use of the McCaulley Corer was appropriate for soil sample collection. However, it was still very difficult to collect soils in the restored sites due to compaction. In the future, a small portable vibracore may be a good alternative.

FIMP Nekton Sampling

- Counting and measuring of all organisms, not only penaeid shrimp, collected by Reference FIMP 6 ft trawls would enable community composition, including other specified target species, comparisons between Reference and Project stations.
- Project-related seine and trawl FIMP stations may be relocated into the Project Area footprint to provide a dataset that is more closely tied (spatially) to the Project.
- Catches of rare/lower abundance organisms (e.g., Red Drum) requires a higher sample size in order to obtain sufficient statistical power for further analysis at this time. More data over the time series will likely make further analyses possible during the next reporting cycle. For other restoration projects with shorter post-construction monitoring periods, higher sample sizes are required for assessing these species.
- Additional multivariate analyses of community composition and presence/absence data alongside environmental metrics collected by FIMP program are recommended during the next reporting

cycle. These analyses are better suited to larger datasets and were only attempted at a basal level for this initial synthesis.

Fixed-Area Nekton Sampling

- At a minimum, three additional interior throw trap stations should be established at the Reference Area for comparison to Project Area interior stations. A greater number of throw trap stations should be established to develop a more robust dataset. Marsh edge and open water habitat types should be sampled with the throw trap.
- In future monitoring efforts, the fixed-area sampling should be adjusted to occur in the fall so the prime recruitment period for newly hatched red drum is captured.

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