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CAPE MAY WETLANDS WILDLIFE MANAGEMENT AREA HABITAT RESTORATION MONITORING & EVALUATION

Final Performance Report
Contract Number: FG19-057 (FAIN: F19AF00106)

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Project Summary and Objectives

The New Jersey coastline is highly vulnerable to impacts from sea level rise and increased frequency and intensity of coastal storms. In areas where marsh accretion rates are unable to keep pace with increasing sea levels, frequent inundation is reducing availability of quality marsh habitat for nesting bird species and other wildlife. Beneficially using dredged material has rapidly become an important tool to protect marsh function and enhance marsh elevations. Expanding the availability of nesting sites for avian species of concern through the beneficial use of dredged material is also a potential strategy to protect or create habitat in the marsh and increase higher quality habitat options that provide suitable nesting options for sensitive species in the state. Merging the needs for marsh enhancement and quality nesting habitat with the reoccurring availability of dredged material, we applied the concept of creating a complex of placement sites using beneficial placement of dredged material at select locations to monitor and evaluate the avian response, habitat quality, and management approaches.

In 2019, The Wetlands Institute (TWI) began a three-year project with Stockton University and the New Jersey Department of Environmental Protection (NJDEP) to monitor the response of flora and fauna at natural and habitat enhancement sites in the salt marsh and evaluate adaptive management approaches for maintenance of the sites to meet restoration objectives. The use of sandy, dredged material to create elevated nesting habitat for Black Skimmers in the Cape May Wetlands Wildlife Management Area in southern New Jersey was first trialed in 2014

with the construction of the Ring Island Elevated Nesting Habitat (ENH). Successful outcomes for nesting birds and other wildlife at the site, coupled with the increasing need for habitat management and availability of more dredged material, motivated the construction of a second site nearby, Great Flats ENH. The habitat objectives for each site was to provide open, sparsely vegetated areas with reduced flooding risk for nesting by Black Skimmers (*Rynchops niger*) and other coastal bird and wildlife species. Together, we anticipated the sites would function with nearby nesting areas as a complex of sites to ensure suitable habitat options for these species as site-specific conditions varied among and within years.

An underlying objective of this project was to evaluate an approach for merging the needs for marsh enhancement and nesting habitat with the availability of dredged material by also monitoring potential placement sites to consider for construction to add to the complex of placement sites with suitable habitat. We sought to determine baseline characteristics of marsh habitat to evaluate suitability and value of additional sites to meet comprehensive objectives of this complex of habitats approach. Over three years this project explored the response of bird species of conservation concern to changing habitat availability and conditions in the salt marshes, compared the response of vegetation over time following nesting habitat enhancement (i.e., dredged material placement), and developed recommendations for creating and maintaining successful nesting habitats in the salt marsh. The monitoring conducted during this project showed that created elevated nesting habitats can be suitable for both colonial and solitary nesting birds, adding opportunities for reproduction, rest, and foraging for 50 species of birds plus other coastal wildlife. The outcomes at the two ENH sites for avian use, reproductive success, and habitat changes demonstrated that achieving targeted objectives can vary by site and over time and require monitoring and adaptive management decisions and tools. Together, monitoring outcomes did not lead to addition of sites to the complex over the duration of this project but rather investment in management approaches to maintaining habitat of suitable quality at existing sites. Project activities conducted by TWI to meet project objectives for the full 2019-2021 project duration are summarized within.

Methods

Study area

The project focused on tidal saltmarsh sites located in the Cape May Wetlands Wildlife Management Area in New Jersey (Figure 1). These areas were selected as habitat enhancement sites, or potential habitat enhancement sites, because of their proximity to a key active nesting colony for Black Skimmers (Stone Harbor Point) and a sandy shoal in the New Jersey Intracoastal Waterway requiring repetitive dredging.

In August 2014, NJDEP, United States Army Corp of Engineers (USACE), and project partners, including TWI, piloted the creation of an Elevated Nesting Habitat (ENH) on Ring Island, Middle Township, New Jersey (hereafter, Ring Island ENH) with the goal of providing nesting habitat for Black Skimmers using sandy dredged materials. TWI monitored avian use and nesting activity at the site annually following its construction during projects funded through National Fish and Wildlife Foundation Hurricane Sandy Coastal Resiliency Program and a separate contract with NJDEP, and continued monitoring through 2021 through this project. During this time, several species of birds successfully nested on the Ring Island ENH, including Black Skimmers and Least Terns (*Sternula antillarum*), both New Jersey endangered species, as well as Common Terns (*Sterna hirundo*) and American Oystercatchers (*Haematopus palliatus*), both species identified as priority Species of Greatest Conservation Need in New Jersey.

In December 2018, USACE constructed a second elevated nesting habitat for birds approximately 2 km southwest of Ring Island ENH. This site, called Great Flats Elevated Nesting Habitat (ENH), was monitored by TWI staff for the 2019-2021 nesting seasons through this project. Renourishment of ENH sites with sandy dredged materials was conducted in February 2018 at Ring Island ENH and in February 2021 at Great Flats ENH to reestablish target elevations and increase the availability of open, sandy habitat by displacing vegetation (see Figure 2 for timeline of activities).

For monitoring purposes, we paired each ENH site with control sites in the surrounding marsh with no marsh enhancement. Ring Island ENH was constructed close to salt pannes and a separate area of high marsh and upland shrub habitat remaining from historic dredged material placement (approx. 1930s-1950s). We extended the nesting searching and monitoring area around Ring Island ENH to include these nearby habitats that provided foraging and nesting habitat for a variety of species (hereafter, search area). Great Flats ENH was constructed on a historic dredged material placement site that dates to the early 1900s. A small portion of the site retained elevation that supported high marsh and shrub vegetation at the time of ENH construction. The remnant high marsh and shrub habitat areas from earlier dredged material placement on Ring Island and Great Flats are hereafter referred to as 'historic placement areas'. Great Flats ENH was initially constructed adjacent to the historic placement area. Sediment from the 2018 placement shifted to join the ENH and historic placement area, and the latter was covered by dredged material during renourishment in 2021. We considered all nests within the historic placement area to be part of the Great Flats ENH site. We did not establish an extended search area for additional nest monitoring at Great Flats as the habitat surrounding the ENH site was fairly uniform, prone to flooding at high tide, and sparsely used by bird species over the project period.

Two additional sites (Bluefish and Ring West) were considered for possible future dredged material placement (hereafter, potential ENH sites). These sites received baseline vegetation monitoring to inform the potential construction of additional ENHs in the complex and for comparison with existing ENH and control sites within the study area. Nest searching and monitoring did not occur at potential ENH sites.

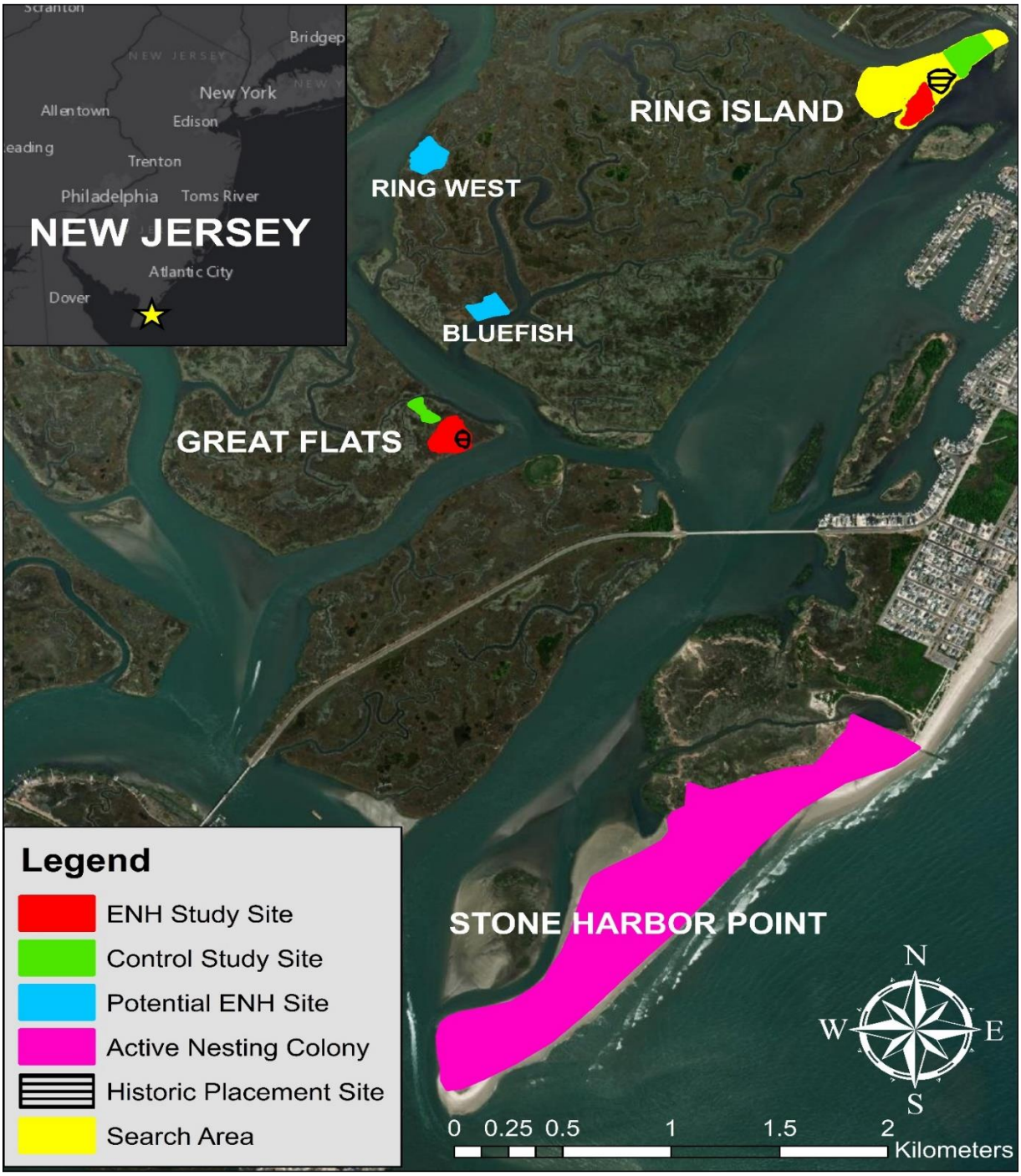

Figure 1. Study sites for avian monitoring efforts, April-August 2019-2021. Each focal Elevated Nesting Habitat (ENH) was paired with a Control site.

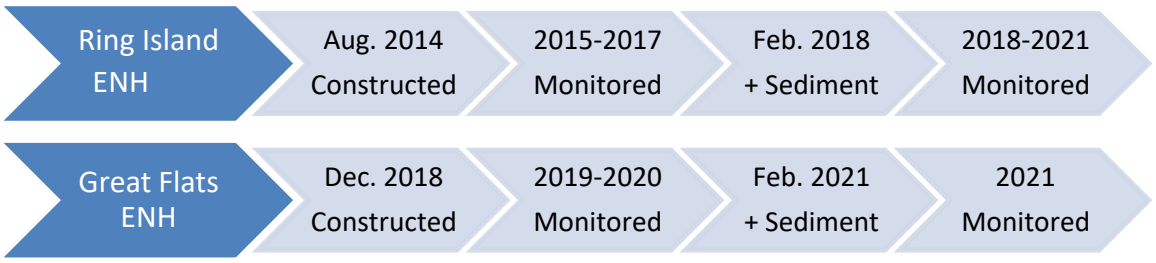

Figure 2. Timeline for construction, sediment addition (i.e. habitat renourishment), and monitoring efforts at two Elevated Nesting Habitats (ENHs) in the Cape May Wetlands Wildlife Management Area.

Avian Monitoring

Habitat Use

We monitored all ENH and control sites during the nesting season (April-August 2019-2021) to document avian species use, nesting success, and movements within available nesting habitat. We conducted habitat use surveys on all study sites 1-2 times per week through remote or direct checks and documented the number of birds observed, as well as species, age class and behavior (e.g. nesting, loafing, foraging) on ENH and control sites. During these surveys, we counted birds flying directly over study sites to account for individuals that flushed from the site or may be prospecting for nesting territories. Species richness was calculated as the total number of bird species counted from the ENH and control sites based on visual surveys. We recorded data on datasheets and transcribed all data into an Excel database.

Nest Site Selection and Reproductive Success

To monitor reproductive success, TWI staff used species- and site-specific approaches. We systematically searched study sites during each habitat use survey and opportunistically within the search area on Ring Island for nesting by all solitary and colonial-nesting avian species. We placed an array of Least Terns decoys on Ring Island and Great Flats ENH sites in May 2020 and 2021 to attract birds to the site. We conducted weekly direct or remote checks of active nests, as conditions (e.g. weather, nesting density, and disturbance or predation risks) permitted, to determine reproductive metrics. We considered all nests within the search area that were not located on the ENH or historic placement areas to be control habitat nests (i.e., nests located outside of the control study area were identified as control if they were not associated with placement sites).

We measured hatching and fledging success by tracking individual nests and chicks, whenever possible, or by estimating success based on the total number of nests or chicks observed. Due

to the difficulties of measuring fledging success in secretive rails and certain precocial species, we only monitored select nests until hatch. Within dense colonial nesting areas, we conducted walk-through or peripheral counts of all incubating birds and the total number of chicks for site surveys to produce estimates of reproductive success.

Disturbance and Predator Monitoring

We installed symbolic fencing around the perimeter of ENH sites before initiation of nesting activity (April) to protect areas from human disturbance. We recorded observations of other wildlife species or signs of disturbance or predation (e.g., avian predator presence, tracks, scat, eggshell remains, carcasses) during site surveys and nest checks, and photo documented whenever possible. Game cameras placed on ENH sites recorded other instances of wildlife use and disturbance or predation events not captured during site surveys. We collected and reviewed images from game cameras regularly throughout the season to inform adaptive management needs and respond to emerging issues. Based on predator observations and signs within any given year, we coordinated with state and federal partners to determine if additional management action was needed to reduce predation pressure for sensitive nesting species within ENH areas.

Banding Efforts and Resight Surveys

To document site fidelity, local movements during the nesting season, and gather information on statewide movements and survival, we banded target species of concern with color-encoded bands on ENH sites and near other active nesting areas in the region between June-September. Targeted species for banding efforts in 2019-2021 included Black Skimmer, American Oystercatcher, Common Tern, and Least Tern. TWI received state and federal permits to conduct all banding activities on targeted species, and followed protocols approved by Stockton University Institutional Animal Care and Use Committee. We coordinated all banding efforts with partners conducting avian monitoring on targeted species within the region. Experienced personnel captured and processed birds and followed established capture protocols. Capture methods implemented in 2019-2021 included hand captures and hand nets (pre-flighted young birds), bow nets (adults at nest), and noose carpets (adults and juveniles). We recorded observations and locations of banded birds during weekly surveys during the nesting season.

Following the nesting season, we conducted weekly resight surveys for Black Skimmers and American Oystercatchers on Stone Harbor Point while target species were staging for migration (August – October). Stone Harbor Point, an important staging and stopover site for migrating avian species, was a key location to resight banded individuals moving among the complex of nesting sites.

Vegetation Monitoring and Management

Vegetation Monitoring

We surveyed vegetation between 2019-2021 at Ring Island and Great Flats ENHs, ENH control sites, and potential ENH sites to monitor growth throughout the nesting season, make recommendations for adaptive solutions to manage vegetation composition and density to meet project objectives, and determine the succession of vegetation species following placement of dredged material. We established 1 m^2 monitoring plots along transects at each study site for annual vegetation surveys (Figure 3). We situated transects on all sites from a random starting point on the lengthwise axis. At control sites and potential ENH sites, we established transects in 2019 every 15 m perpendicular from the shoreline in 2019 and we monitored plots along these transects each year of the project. At Ring Island and Great Flats ENH sites, transect locations varied from 2019 (when treatment plots were used for an experimental vegetation control study, see Vegetation Management section below) to 2020/2021 (when fixed transects were used). In 2020 and 2021, we situated transects every 15 m parallel to the shoreline to reduce likelihood of overlapping with treatment plots used in 2019. At all sites, we placed the initial monitoring plot on each transect at a random location 1-5 m from the start of the transect and fixed monitoring plots every 25 m along the transect thereafter. In total, we monitored 27 plots at Ring Island ENH, 28 plots at Great Flats ENH, and 25 study plots at each ENH control and potential ENH site.

We collected vegetation metrics for monitoring plots at the end of the growing and nesting season (September 2019-2021). Within each plot, we recorded data on vegetation species, cover classes, height of dominant species, as well as Ribbed Mussel (*Geukensia demissa*) and Fiddler Crab (*Uca sp.*) abundance classes for control and potential ENH sites. We measured cover classes using Braun-Blanquet cover classes (hereafter, BB cover classes) and recorded the height of live vegetation for 15 stems of the dominant species, measured along the diagonal of the plot. We identified vegetation to the lowest order possible and each plot was photo-documented at the time of sampling.

Figure 3. Vegetation monitoring transects and plots established at Elevated Nesting Habitat (ENH) sites, Control sites, and Potential ENH sites in 2020-2021.

Vegetation Management

To further investigate vegetation growth during the nesting season and maintain open nesting habitat for Black Skimmers and terns on ENH sites, we developed and assessed methods to safely and effectively reduce vegetation growth and control ground cover. We focused most of the vegetation control on Ring Island ENH (2019-2021) compared to Great Flats ENH (2019) because our surveys throughout the project demonstrated greater vegetation cover and nesting activity, and hence need for vegetation control, there. Methods for vegetation control on Ring Island ENH following initial placement included additional placement of dredged material (with mechanical disruption of vegetation establishing on the habitat), prescribed burns, manual removal, application of concentrated salt solution spray, and direct placement of rock salt on the habitat (Figure 4). Methods for vegetation control on Great Flats ENH following initial placement included the application of a concentrated salt solution (May 2019) and additional placement of dredged materials with mechanical disruption of vegetation establishing on the habitat (February 2021).

Figure 4. Timeline for construction, renourishment, and adaptive vegetation management at Ring Island Elevated Nesting Habitat (ENH) in the Cape May Wetlands Wildlife Management Area.

Prior to nest initiation (March-April), the New Jersey Forest Fire Service conducted a prescribed burn on Ring Island ENH in 2019 and 2020. Based on vegetation succession and cover observed on the habitat at the end of the nesting season in 2019 and 2020, no prescribed burn was conducted prior to the nesting season in 2021. No burning was conducted at Great Flats ENH.

Additionally, to meet adaptive management recommendation objectives, we conducted a vegetation control study on Ring Island ENH and Great Flats ENH in 2019 and a modified study on Ring Island ENH in 2021 to assess the use of a concentrated salt solution spray treatment (hereafter, salt solution treatment) to control vegetation on these habitats while minimizing additional disturbance to birds during nesting. Methods for both sites in 2019 involved randomized assignment of salt solution treatment (~100 ppt/10% salinity; 1.5 cups of sodium chloride to 1 gallon of water) and control (no solution) within $1m^2$ plots along transects established across the ENH platform (above spring flood elevation). We established 6 transects and 48 plots on Ring Island ENH, and 8 transects and 67 plots on Great Flats ENH. We randomly assigned 23 treatment (salt solution) and 25 control (no salt solution) vegetation treatment plots on Ring Island ENH and 33 treatment and 34 control vegetation plots on the Great Flats ENH site. We manually removed any emergent vegetation on the ENH platform prior to the nesting season (March/April) and used battery-powered backpack sprayers to douse treatment plots with salt solution, specifically targeting any emerging vegetation (stems and leaves). Salt solution was applied on a weekly basis throughout the nesting season (April-July) and coincided with site visits. We collected vegetation characteristics (species identification, cover classes, height of dominant species) before and after the nesting season at both sites.

Limited vegetation control efforts occurred during 2020 because of restrictions associated with the COVID-19 pandemic. Instead, rock salt was spread directly across the Ring Island ENH platform prior to and during the nesting season (400lbs in February and 520lbs in April 2020) for ease of application. No vegetation treatment was conducted on Great Flats ENH in 2020 and we discontinued salt solution treatment after the 2019 nesting season.

With the apparent success of the salt solution treatment in 2019, we modified methods in 2021 to control vegetation and investigated vegetation succession on the habitat using salt solution to treat a larger area of habitat on the ENH platform to attract target nesting species. We established two 160m^2 treatment areas on the Ring Island ENH platform (Figure 5). Within these treatment areas, we established four transects and 24 vegetation treatment plots. We also established 25 control plots throughout the ENH platform using the random feature in ArcGIS to select plot locations. We manually removed vegetation in both areas prior to the nesting season (March/April). We selected one treatment area for application of the salt solution treatment (~100 ppt/10%) using battery-powered backpack sprayer or pump setup, specifically targeting any emerging vegetation (stems and leaves). Salt solution was applied approximately once every two weeks throughout the nesting season (April-July) and coincided with site visits. We collected standard vegetation metrics before and after the nesting season within 1 m^2 monitoring plots established along transects within the two treatment areas and within 1 m^2 monitoring plots randomly selected within the ENH area outside of the treatment area to better understand control efforts. We took photos of each plot and transect pre- and post-nesting season to document changes in vegetation species composition and growth.

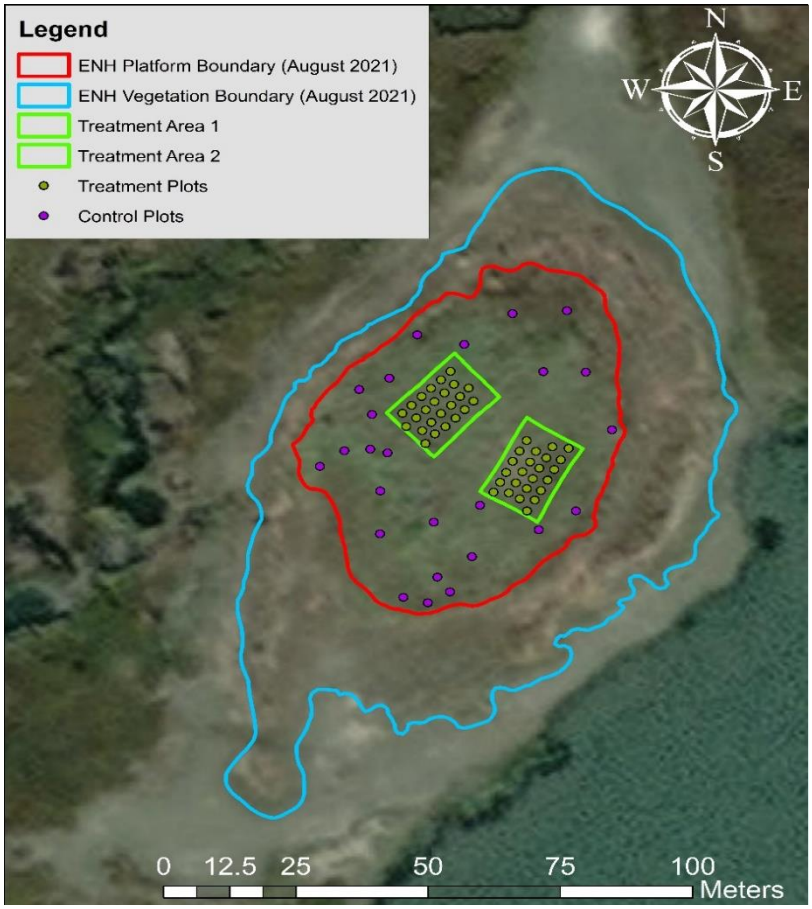

Figure 5. Vegetation treatment areas and monitoring plots on Ring Island Elevated Nesting Habitat in 2021.

Results

Avian Monitoring

Habitat Use

In all years, we initiated site surveys no earlier than 4 April and completed surveys by 17 August. In total, we counted 8,595 birds representing 50 species (Appendix 1) and eight guilds between 2019-2021. The overall number of birds and species varied for each site (3,788 birds/38 species at Ring Island ENH, 201 birds/29 species at Ring Island Control, 2,541 birds/22 species at Great Flats ENH, and 2,065 birds/10 species at Great Flats Control). Species composition also differed among sites and species diversity was lower at the Great Flats sites (A and B, Figure 6).

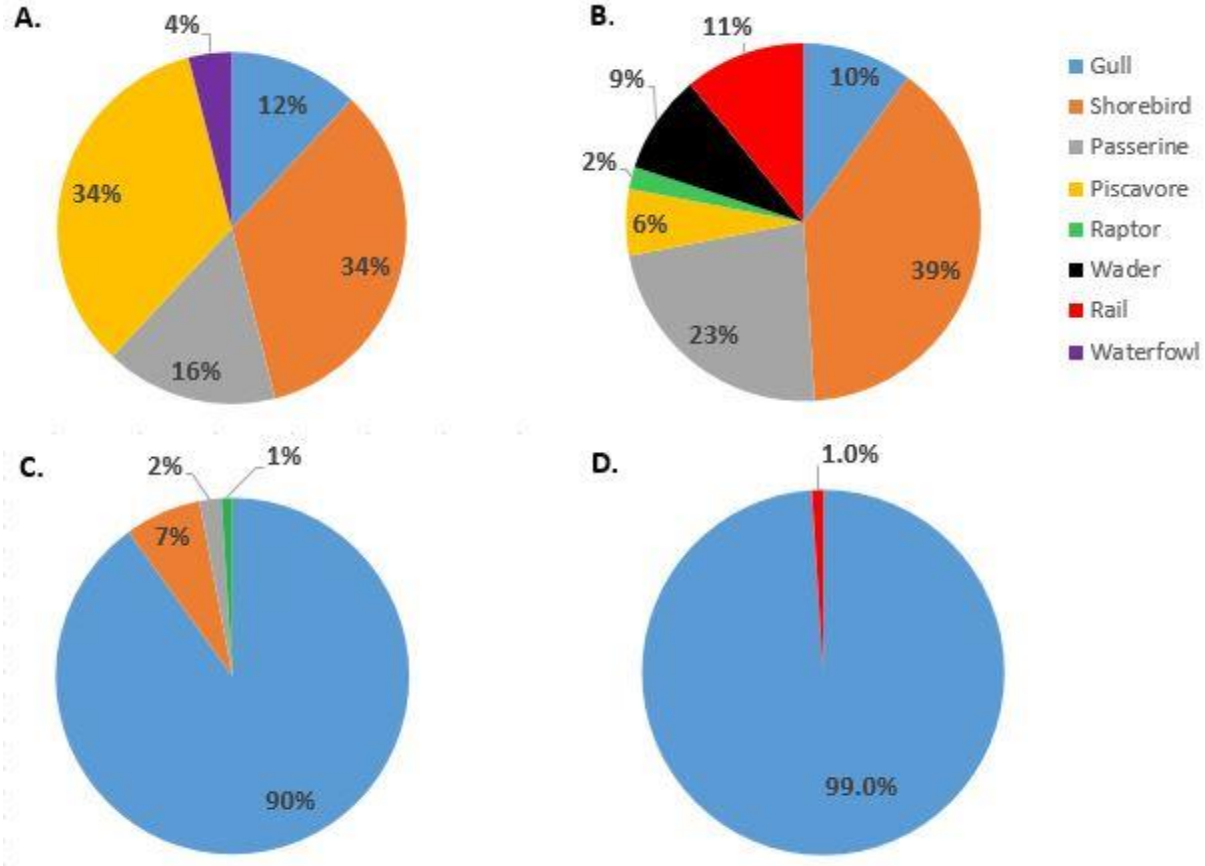

Figure 6. Percentage of birds recorded by guild within study areas at Ring Island Elevated Nesting Habitat (A), Ring Island Control (B), Great Flats Elevated Nesting Habitat (C), and Great Flats Control (D) sites during habitat use surveys conducted 2019-2021.

During each year of the project, we observed a higher number birds within ENH sites (n = 2,818 in 2019; n = 1,541 in 2020; n = 1,970 in 2021) compared to control sites (n = 607 in 2019; n = 873 in 2020; n = 790 in 2021). The number of all birds within ENH sites in 2021 was higher than

we observed in 2020 but lower than 2019 (Figure 7). We documented a high proportion of gulls and shorebirds within ENH sites during all three years of the project but observed an increase in the number and proportion of gulls each year of the project (n = 586, 21% in 2019; n = 766, 50% in 2020; n = 1,385, 70% in 2021). We observed a decrease in the number of shorebirds on ENH sites each year of the project and the proportion of shorebirds decreased in 2021 (n = 738, 26% in 2019; n = 444, 29% in 2020; n = 269, 14% in 2021). The number and proportion of piscivores (e.g. Black Skimmers, terns, and other species) observed at ENH sites was also much lower in 2021 (n = 72, 4%) and 2020 (n = 89, 6%) compared to 2019 (n = 1,149, 41%). We recorded similar proportions of gulls compared to total individual counts at control sites (91% in 2019, 94% in 2020, and 88% in 2021). A single species, Laughing Gull (*Leucophaeus atricilla*), on the Great Flats control site accounted for 98-99% of all gull observations on control sites for each year of the project. American Oystercatchers had among the highest species occurrence at ENH sites but were infrequently observed within control study areas in all years of the project (Appendix 2).

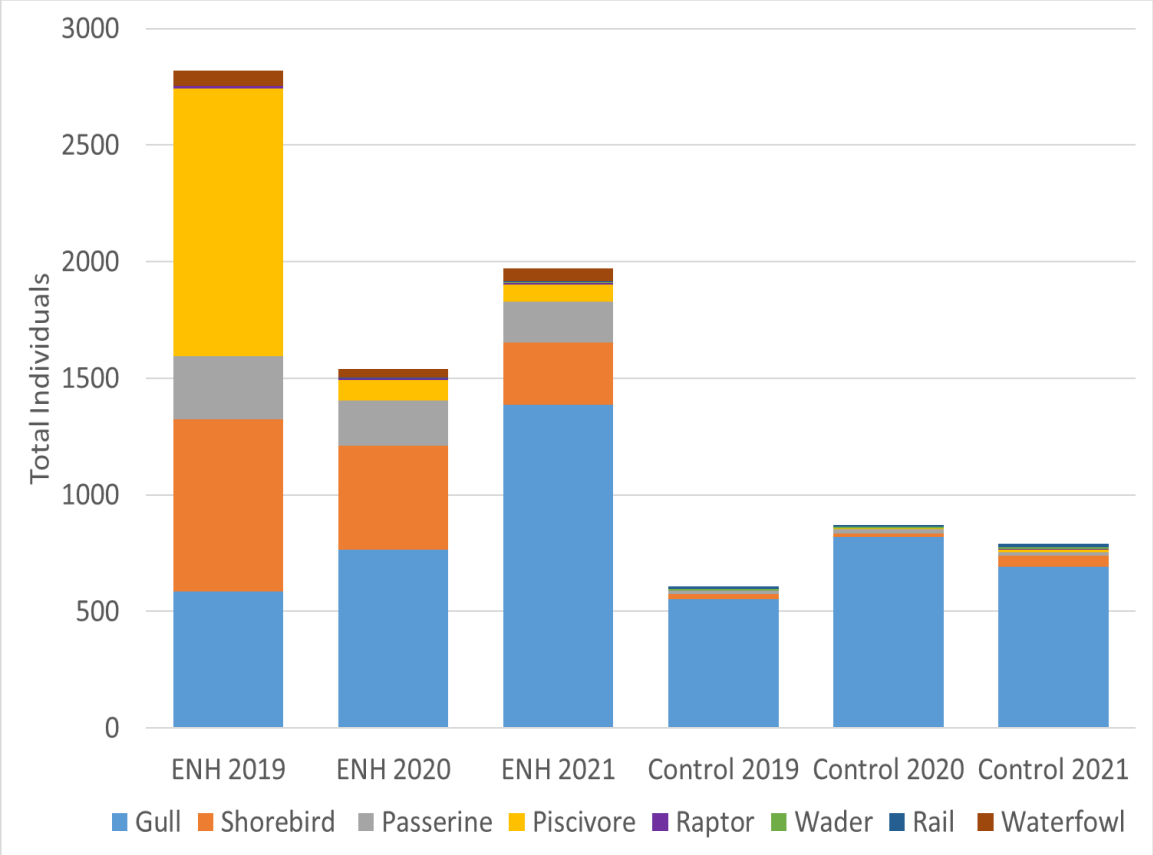

Figure 7. Total numbers of birds counted per guild during surveys conducted on Elevated Nesting Habitat (ENH) and Control sites, Ring Island and Great Flats combined, 2019-2021.

Using the Jaccard Index (SC_j), we calculated differences in avian species richness to compare avian use within ENH and control sites between years (Table 1). In 2021, SC_j ranged from the most similar (i.e. numbers approaching 1.0) between Ring Island sites (SC_j = 0.41, Ring Island ENH to Ring Island Control) and between ENH sites (SC_j = 0.32, Ring Island ENH to Great Flats ENH), to the least similar (i.e. numbers approaching 0) between ENH sites and Great Flats Control (SC_j = 0.09, Ring Island ENH to Great Flats Control and Great Flats ENH to Great Flats Control). We observed slight increases in similarity between the Ring Island and Great Flats ENH sites throughout the course of the project (SC_j = 0.27 in 2019, SC_j = 0.3 in 2020, and SCj = 0.32 in 2021). Pairwise comparisons also showed increases in similarity between Ring Island ENH and Ring Island Control and decreases in similarity between Great Flats ENH to Great Flats Control throughout the three years of the project.

Table 1. Pairwise comparisons of species richness (SC_j) at study sites to indicate relative degree of similarity (higher number; darker shades) or dissimilarity (lower number; lighter shades) for all species counted during site visits at ENH and Control sites 2019 - 2021. Color gradients compare across-year values.

Points	2019	2020	2021
Ring Island ENH to Great Flats ENH	0.27	0.3	0.32
Ring Island ENH to Ring Island Control	0.24	0.33	0.41
Ring Island ENH to Great Flats Control	0.13	0.14	0.09
Great Flats ENH to Great Flats Control	0.23	0.14	0.09
Great Flats ENH to Ring Island Control	0.08	0.29	0.23
Great Flats Control to Ring Island Control	0.18	0.17	0.17

In addition to birds, Diamondback Terrapins (*Malaclemys terrapin*) nested on both ENH sites. On Ring Island ENH, adult Diamondback Terrapins were directly observed nesting on the habitat on eight surveys in 2019 (4 April – 26 June), one survey in 2020 (7 July), and six surveys in 2021 (27 May - 11 July). We also documented a terrapin hatchling on Ring Island ENH at the start of the 2019 nesting season (8 April) but observed evidence of hatchlings and nesting activity on ENH sites in all years. During the 2021 season, game camera footage detected at least one Diamondback Terrapin on Ring Island ENH area on 14 occasions between 20 June – 11 July. We documented one observation of a Diamondback Terrapin on Great Flats ENH during a survey conducted in 2021 (21 June). We did not observe nesting adults on Great Flats ENH in 2019 or 2020 during site surveys or through game camera footage. One Diamondback Terrapin observed on Ring Island ENH during the 2021 nesting season, estimated to be over 30 years old based on microchip data, was originally captured in Bluefish Creek in 1997, and had been documented nesting on TWI property 2009-2019.

Horseshoe Crabs (*Limulus polyphemus*) were also observed spawning on the eastern edge of the Ring Island ENH site in high concentrations each year of the project, with highest concentrations occurring between 27 May – 1 July 2021. On Ring Island ENH, as many as 800 Horseshoe Crabs were documented spawning on the habitat during site surveys conducted in all years (4 June 2020). A tagged individual on the Ring Island ENH (5 July2019) was initially captured on Reeds Beach along the Delaware Bay one year prior (23 June 2018). Horseshoe Crabs were rarely observed along the mudflat at Great Flats ENH during the spawning season.

Nest Site Selection and Reproductive Success

We monitored nests of eleven species on Ring Island and nests of four species on Great Flats over the course of the project (Table 2). We monitored a total of 150 and 30 active nests on Ring Island ENH and Great Flats ENH, respectively. On control areas, we monitored a total of 56 and ~176 active nests on Ring Island and Great Flats, respectively. Additionally, we monitored 19 nests of five species within the historic placement area on Ring Island.

On Ring Island, nest site selection among nesting pairs and species composition on the ENH changed over the project period. Black Skimmer nesting pairs were observed regularly at ENH in 2019, but no nests were found. The number of nesting pairs at the site dropped in 2020 to just one pair, and no nests were found. In 2021, we observed skimmers loafing on the mudflat along the eastern edge of the ENH at the beginning of the nesting season (1 June) but no nesting pairs or nests were observed. In 2019, we documented Black Skimmer pairs among a colony of 110 Common Terns pairs, which initiate nesting earlier than skimmers. However, all tern nests failed during the time skimmers were initiating nesting activities. In 2020, we observed Common Terns at the ENH site regularly again in smaller numbers but we only documented one active nest, which subsequently failed. In 2021, we observed frequent occurrence of Common Terns between 18 June – 24 June and scraping on the ENH platform but did not observe any active nests during site visits. It is likely that skimmer and tern nests were initiated and lost between site visits in years with nesting pairs, particularly given evidence of depredated egg shells. Game camera footage also confirmed regular visits and nesting activities within each nesting season. Common Terns and Canada Goose (*Branta canadensis*) nested exclusively within the ENH, and American Oystercatchers and Willet (*Tringa semipalmata*) appeared to prefer nesting within the ENH or historic placement sites (Figure 8). The only Saltmarsh Sparrow (*Ammodramus caudacutus*) nest monitored during this project was located within the historic placement area on Ring Island in 2019.

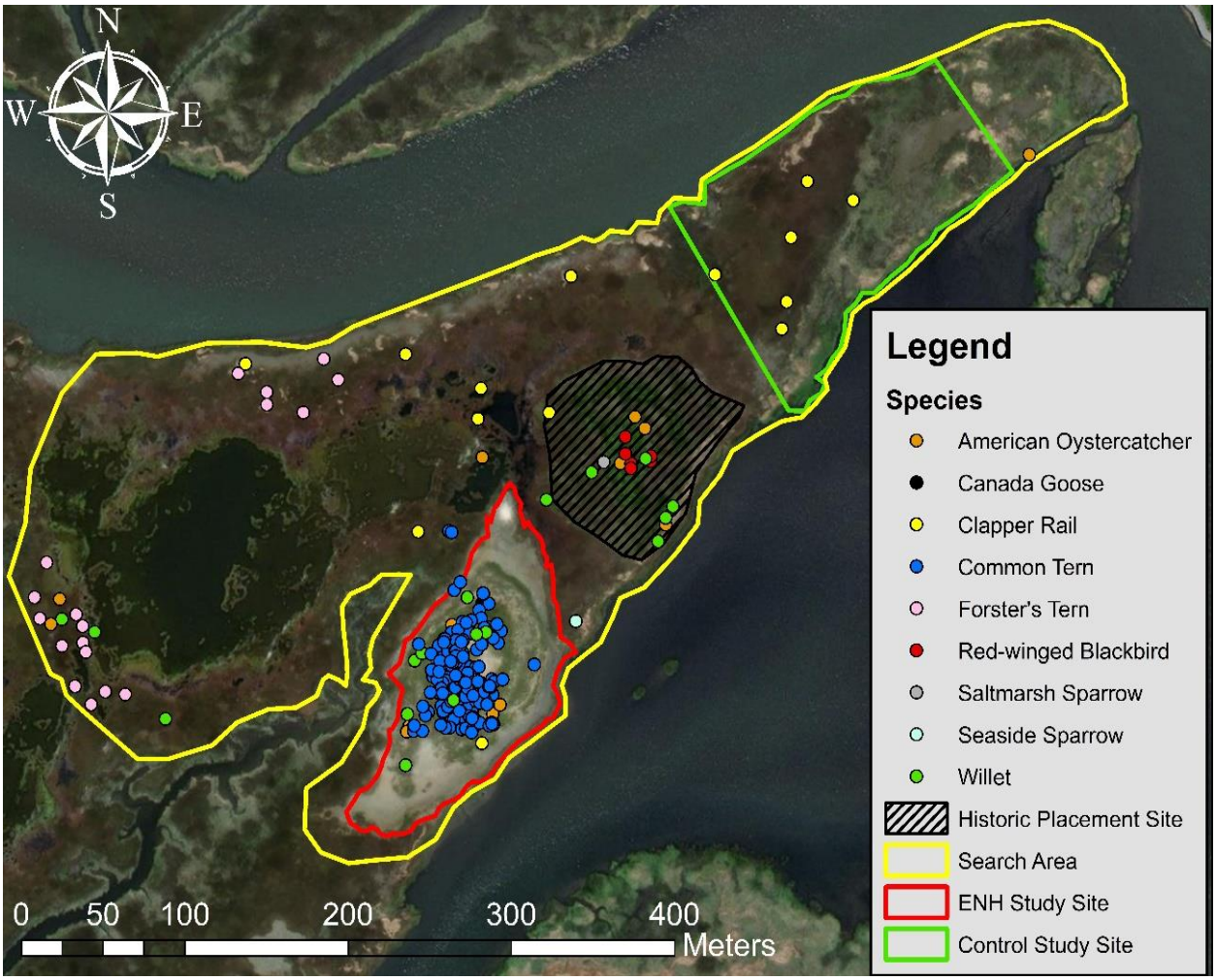

Figure 8. Survey areas and nest locations for monitored species on Ring Island 2019-2021. Not all nests are visible due to overlap in nest site selection.

On Great Flats, American Oystercatcher and Great Black-backed Gulls (*Larus marinus*) nested on the ENH site all years of the project (Figure 9). Great Black-backed Gulls nested within the historic placement area before and after habitat renourishment but we also located nests around the perimeter of the ENH in 2021. American Oystercatchers were the only species that nested on the ENH platform in 2019 and 2020 with one successful renest attempt in the historic placement area during the 2020 nesting season. Following habitat renourishment in 2021, the American Oystercatcher pair selected nest locations below the ENH platform near the perimeter. Clapper Rail (*Rallus crepitans*) nested within the historic dredge placement area prior to habitat renourishment in 2019 and around the perimeter of the ENH area during the 2021 nesting season. A small Laughing Gull colony formed around the perimeter of the ENH site following habitat renourishment in 2021. No Black Skimmers or tern species were observed nesting or prospecting at Great Flats ENH during the project.

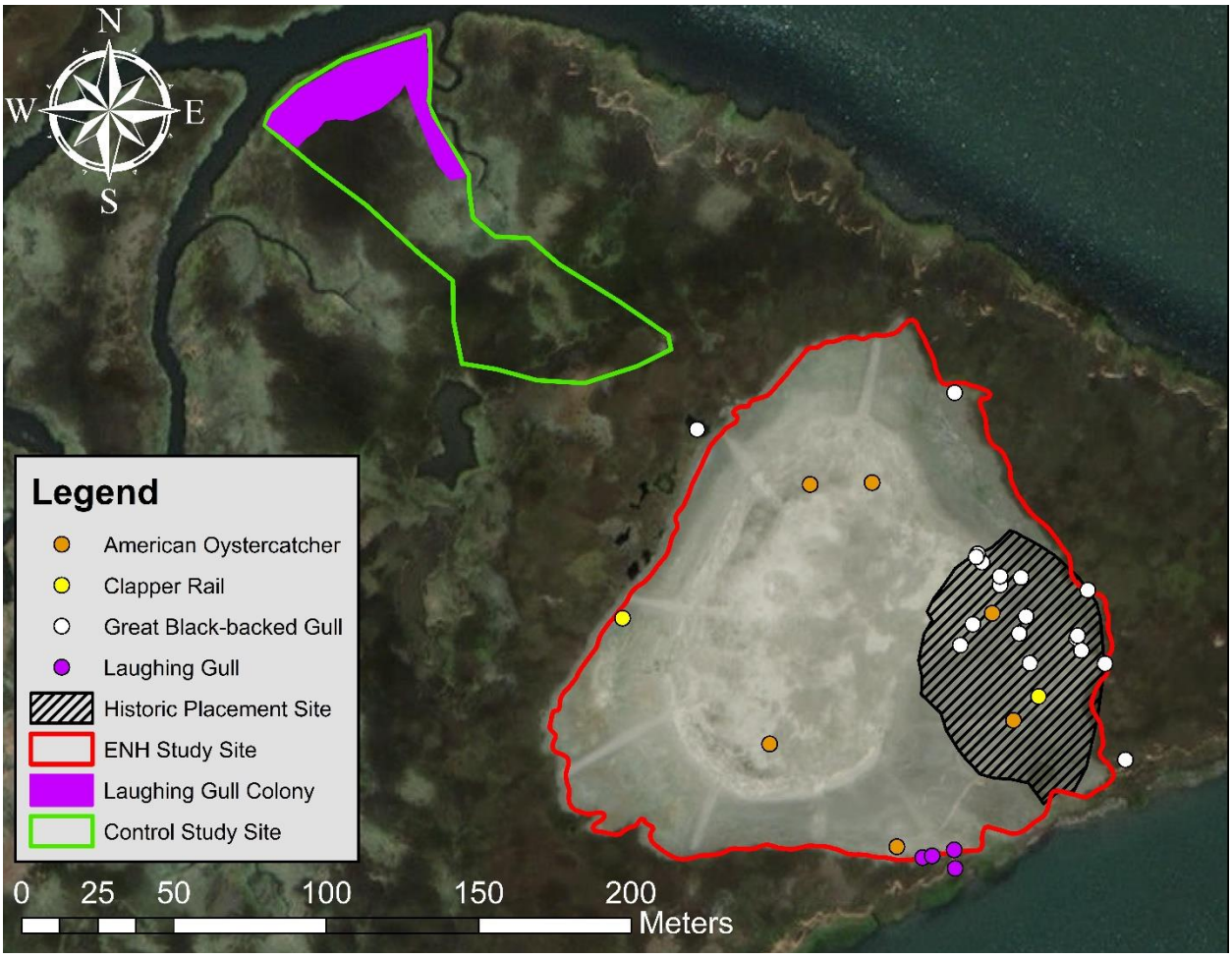

Figure 9. Survey areas and nest locations for monitored species on Great Flats 2019-2021. Not all nests are visible due to overlap in nest site selection.

Reproductive success for all nesting species was variable between locations and years of the project (Table 2). For all nests monitored, we documented lower hatch success during the 2019 season (12% hatch success for all species) compared to the 2020 and 2021 seasons (57% and 53%, respectively). We observed similar apparent hatch success for species that selected nest locations at both ENH and control sites (American Oystercatcher, Clapper Rail, Willet) with 38% hatch success for nests located in ENH or control sites for all years of the project. However, these species had higher hatch success (45%) for nests located within the Ring Island historic placement area. We documented no productivity (i.e., no chicks fledged) for American Oystercatcher pairs that nested within the control site at Ring Island but pairs nesting within both ENH sites and the Ring Island historic placement area in 2020 successfully fledged chicks. The Saltmarsh Sparrow nest located on the Ring Island historic placement site successfully hatched three chicks but failed shortly after hatching following a flooding event. At Great Flats, Great Black-backed Gulls nested on the ENH each year of the project but all nests failed before

hatch during the 2019 and 2021 nesting seasons. We estimated lower hatch success for Laughing Gulls nesting within the control site during the 2019 season (~33%) compared to 2020 and 2021 (~65 and ~70%, respectively).

Table 2. Reproductive success estimates for breeding pairs nesting within Ring Island and Great Flats survey areas in 2019 - 2021. Productivity not estimated for select species or pairs (NE).

		2019				2020				2021			
				Hatch				Hatch				Hatch	
Location	Species	Pairs	Nests	Succes	Productivity	Pairs	Nests	Succes	Productivity	Pairs	Nests	Succes	Productivity
Ring Island Elevated Nesting Habitat	Black Skimmer	10	0	-	-	1	0	-	-	0	-	-	-
	Common Tern	110	132	0%	-	3	1	0%	-	1	0	-	-
	American Oystercatcher	2	0	-	-	2	3	67%	1.0	2	3	33%	0.0
	Canada Goose	0	-	-	-	0	-	-	-	1	1	0%	-
	Clapper Rail	0	-	-	-	0	-	-	-	1	1	100%	NE
	Willet	3	3	0%	-	2	2	50%	NE	4	4	0%	-
Ring Island Historic Placement Area	American Oystercatcher	1	2	0%	0.0	1	1	100%	1.0	1	1	100%	0.0
	Willet	2	2	0%	0.0	1	1	0%	-	3	3	67%	NE
	Red-winged Blackbird	-	-	-	-	3	2	100%	NE	3	5	60%	1.0
	Clapper Rail	0	-	-	-	0	-	-	-	1	1	100%	NE
	Saltmarsh Sparrow	1	1	100%	0.0	0	-	-	-	0	-	-	-
Ring Island Control/ Search Area	American Oystercatcher	2	2	0%	0.0	1	2	0%	0.0	1	0	-	-
	Clapper Rail	7	7	57%	NE	10	10	57%	NE	2	2	100%	NE
	Forster's Tern	-	-	-	-	11	13	23%	NE	12	15	13%	NE
	Laughing Gull	-	-	-	-	-	-	-	-	1	1	100%	NE
	Willet	-	-	-	-	2	2	0%	-	1	1	0%	-
	Seaside Sparrow	1	1	0%	0.0	1	0	-	-	1	0	-	-
Great Flats Elevated Nesting Habitat	American Oystercatcher	1	2	50%	0.0	1	2	50%	1.0	1	2	0%	-
	Clapper Rail	1	1	100%	NE	0	-	-	-	1	1	100%	NE
	Great Black-backed Gull	11	11	0%	-	3	2	100%	2.0	6	6	0%	-
	Laughing Gull	0	-	-	-	0	-	-	-	4	4	75%	0.0
Great Flats Control	Laughing Gull	~50	~60	~33.3%	~0.6	~55	~65	~64.6%	~0.7	~40	~50	~70%	~0.33

Disturbance and Predator Monitoring

Within all years of the project, we rarely documented human disturbance within study sites during surveys or game camera footage. However, human disturbance was documented once at Ring Island ENH during the 2020 nesting season. During this incident, a stranded boat was observed on the mudflat located near an active American Oystercatcher nest, which subsequently failed. We did not document any evidence of human disturbance at the Great Flats ENH site during the project.

Direct observations and trap camera footage documented known avian nest predators (Fish Crow [*Corvus ossifragus*], Peregrine Falcon [*Falco peregrinus*], Herring Gulls [*Larus argentatus*], Great Black-backed Gulls [*Larus marinus*], and Laughing Gulls) on ENH sites. Fish Crows were regularly observed at both ENH sites during surveys conducted between late May – early August each year. However, we recorded a higher number of individuals at Ring Island ENH compared to Great Flats ENH, with as many as 18 individuals on Ring Island ENH (29 June 2020) and as many as three individuals on Great Flats ENH (26 May 2020 and 4 June 2021) during a single survey. During the 2021 season, game camera footage detected Fish Crows at least once each day for 30 days between 3 June – 27 July on Ring Island ENH and at least once each day for eight days between 16 June – 11 July on Great Flats ENH. Game camera footage of Fish Crow at both ENH sites documented egg depredation occurring during the nesting season (primarily depredation of Diamondback Terrapin eggs from nests). We did not quantify Fish Crow occurrence on ENH areas using game camera footage in 2019-2020 but site surveys indicate that species occurrence increased both on ENH sites since 2019 (Appendix 2). We rarely observed Fish Crows within the adjacent control study areas, with only one observation of two individuals within the Ring Island control site in 2021.

Gull species (Laughing, Herring, and Great Black-backed Gulls) were primarily observed flying over Ring Island ENH or loafing and foraging along the eastern edge mudflat and southern apron of the habitat rather than within the nesting area each year of the project. However, gull species were observed on Great Flats ENH during every survey and game camera footage showed that several individuals remained on the habitat near the location where Least Tern social attraction decoys were deployed. We observed an increase in the number of gulls on the Great Flats ENH area during the 2021 nesting season (n = 1,385) compared to the 2020 and 2019 nesting seasons (n = 766 and 586, respectively; Figure 7).

We documented a single Peregrine Falcon kill of a juvenile Laughing Gull on the south end of Ring Island ENH in 2020 (3 August) but did not observe the species using the habitat any other time during the project. On Great Flats ENH, we documented a single Peregrine Falcon present on the habitat in 2019 (19 June and 1 August), 2020 (1 June), and 2021 (10 August).

Known mammalian nest predators (Raccoon [*Procyon lotor*], Norway Rat [*Rattus norvegicus*], and Red Fox [*Vulpes vulpes*]) were documented at ENH sites throughout the project. In 2019, camera footage detected a Red Fox visiting Ring Island ENH at least 84 times (41 separate nights) between March 15 - August 26. We frequently observed mammal tracks (primarily fox) surrounding ENH sites and avian carcasses on and near ENH sites in 2019. We did not observe any evidence of fox activity during the 2020 season but we documented evidence of fox activity on Ring Island ENH in 2021 from tracks observed on one occasion (14 June).

Camera footage also documented occurrence of a raccoon on Ring Island ENH on one occasion in 2019 (June 9) and two occasions in 2021 (29 June and 11 July). We did not observe any evidence of raccoon on either of the ENH areas during the 2020 nesting season. We observed mammalian tracks, likely from Striped Skunk (*Mephitis mephitis*), on one occasion (12 July 2021) on Great Flats ENH. We also received a report of American Mink (*Neovision vison*) observed in the vicinity of Great Flats ENH during the 2021 nesting season but we did not document evidence of the species on the ENH site. Additionally, rat activity was documented on Ring island ENH almost every night from 20 June – 25 July in 2021. We have confirmed Norway Rats and Marsh Rice Rats (*Oryzomys palustris*) on the site in years following construction but we did not previously investigate activity using game camera footage.

Banding Efforts and Resight Surveys

We successfully captured both adult and juvenile Black Skimmers and American Oystercatchers for banding efforts at nesting and roosting locations throughout the project duration. We banded a total of 179 Black Skimmers (28 adults, 151 juveniles), 17 American Oystercatchers (4 adults, 13 juveniles), and one juvenile Common Tern within the complex of nesting sites between April – September 2019-2021. We limited capture and banding efforts for colonial nesting species on Ring Island ENH to minimize disturbance with mammalian activity (2019) and sparse nesting (2020 and 2021).

We confirmed previously banded American Oystercatcher adults on both Ring Island (ENH, control, and historic placement areas) and Great Flats (ENH only) with active nests for multiple years of the project. In addition, two chicks banded on Ring Island in 2016 and 2017 (A34 and A60) were resighted on Ring Island during the 2021 nesting season. One of these chicks (A34) was also resighted on both Ring Island and Great Flats ENH during the 2020 nesting season. Although we did not confirm active nests associated with these individuals, one bird (A60) was observed with a mate on two separate dates during the 2021 nesting season (13 April and 21 May) within the same territory. Due to low productivity within all nesting areas on Ring Island and Great Flats, no American Oystercatcher chicks were banded in 2021 and chicks were only banded at Stone Harbor Point in 2019.

We banded an adult Black Skimmer (C03) on its nest at the Ring Island ENH site prior to this project during the 2018 season. We observed this individual on the Ring Island ENH site again in 2019 and at the Stone Harbor Point colony during the 2019, 2020, and 2021 nesting seasons (Figure 10). In 2021, we confirmed this individual with chicks within the Stone Harbor Point colony. Another Black Skimmer (C02) banded as a chick on Ring Island ENH in 2017 was observed near an active colony located ~35 km North of Ring Island each subsequent nesting season (2018 - 2021). Both of these banded birds demonstrated linkages among the local complex of colony sites. With no Black Skimmer nesting on Ring Island ENH and Great Flats ENH in 2019 - 2021, capture and banding efforts for the species focused on individuals associated with the Stone Harbor Point colony. No previously banded Black Skimmers were observed on Ring Island in 2020 or 2021.

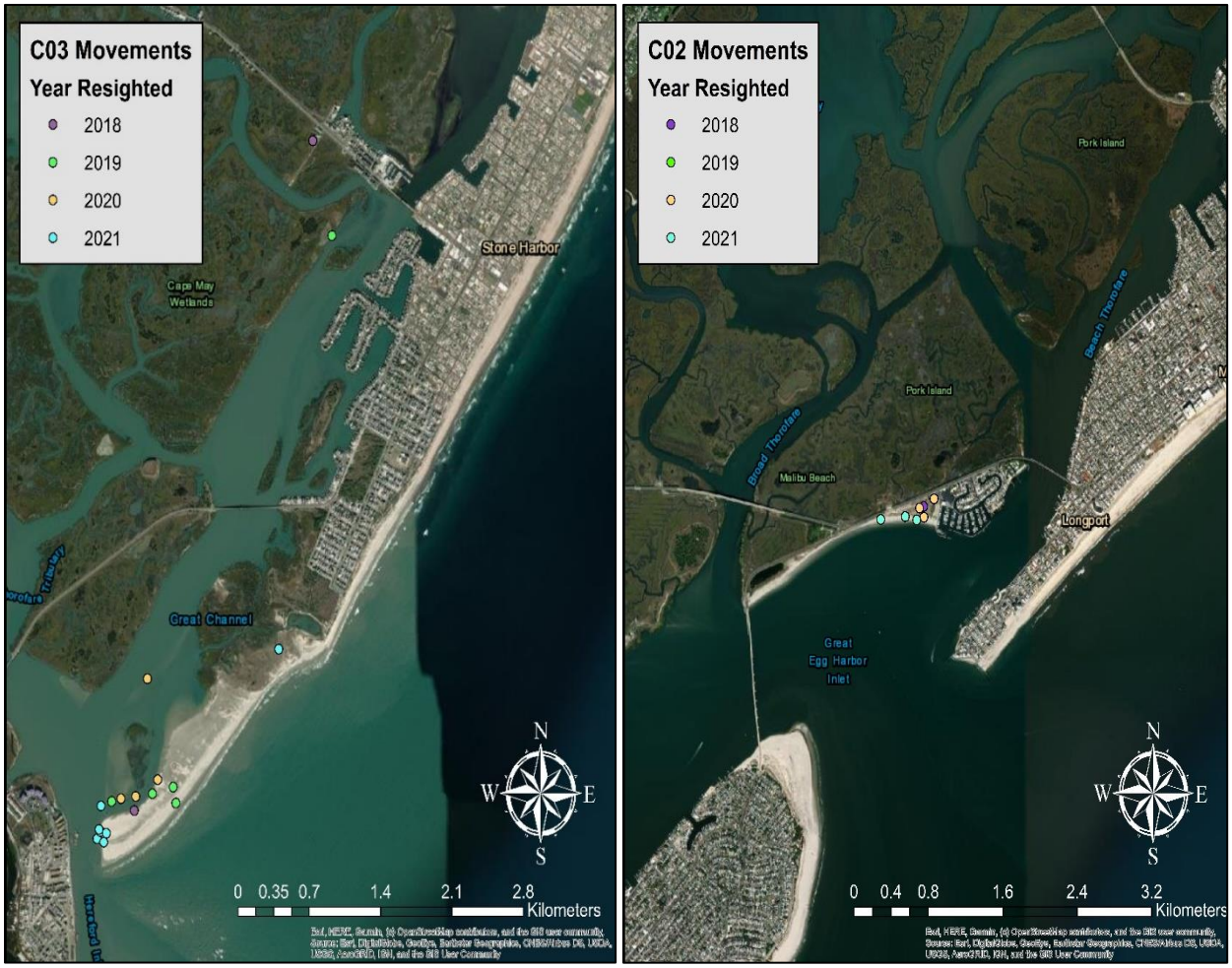

Figure 10. Local movements of an adult color banded Black Skimmer (C03; Left) and a juvenile color banded Black Skimmer (C02; Right) following capture on Ring Island Elevated Nesting Habitat in 2018.

We observed the highest number of banded birds at Stone Harbor Point in 2021 in late August for Black Skimmer and early to mid-September (American Oystercatcher) during resight surveys. Throughout this project, we resighted 55% (n = 12) of all American Oystercatchers previously banded on Ring Island or Great Flats (2015 – 2020) on Stone Harbor Point during fall resight surveys. We also resighted 37% (n = 67) of all Black Skimmers banded on Stone Harbor Point or Ring Island ENH 2019-2021 during resight surveys conducted in all years of the project.

Vegetation Monitoring

In 2020, we categorized 59% (n = 16) of plots on Ring Island ENH and 11% (n = 3) of plots on Great Flats ENH with live vegetation BB cover classes > 25% (Figure 11). In 2021, we observed fewer plots with BB cover classes > 25% at Ring Island ENH (n = 13; 50%) and a similar number at Great Flats ENH (n = 3; 11%). The average BB cover class on Ring Island ENH was similar between years (3.3 ± 2.4 in 2020 and 3.0 ± 2.0 in 2021). However, we observed an increase in average BB cover class on Great Flats ENH from 2020 to 2021 (0.8 ± 1.4 in 2020; 1.4 ± 1.6 in 2021).

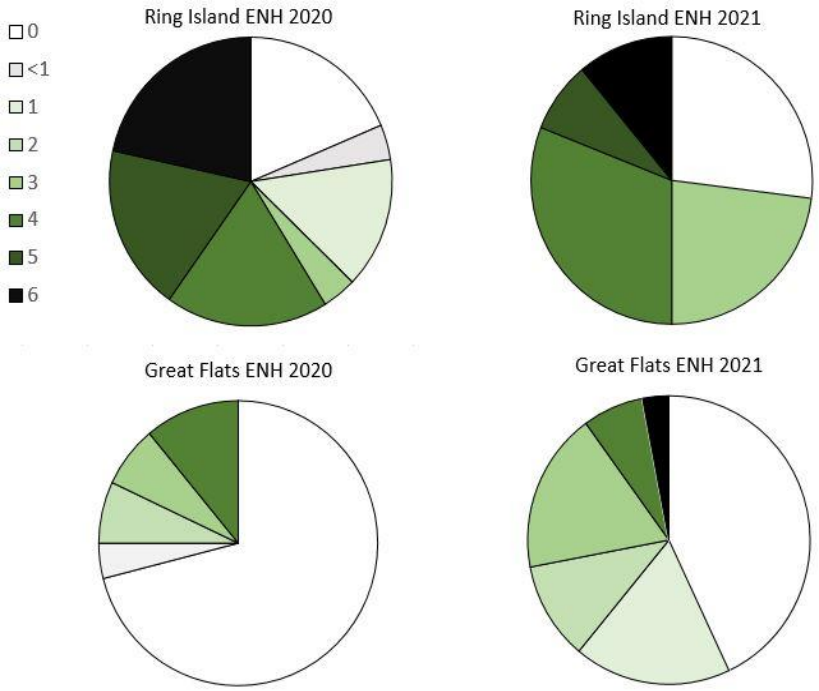

Figure 11. Live vegetation Braun-Blanquet cover classes on Ring Island Elevated Nesting Habitat and Great Flats Elevated Nesting Habitat in 2020 and 2021.0 = 0%, + = less than 1%, 1 = 1% to 5%, 2 = 6% to 10%, 3 = 11% to 25%, 4 = 26% to 50%, 5 = 51% to 75%, 6 = 76% to 100%.

Species richness was higher at Ring Island ENH (22 species) compared to Great Flats ENH (11 species) in 2020 and 2021 (Appendix 3). On Ring Island ENH, we documented American Beachgrass (*Ammophila breviligulata*), American Hog-peanut (*Amphicarpaea bracteata*), and Seaside Goldenrod (*Solidago sempervirens*) as the most abundant plant species observed for both years of the study (Figure 12). However, we observed a lower proportion of monitoring plots with these species present in 2021 compared to 2020.

On Great Flats ENH, we observed a higher proportion of plots with no vegetation (71% in 2020, 44% in 2021) compared to Ring Island ENH (19% in 2020, 27% in 2021). We also observed differences in plant communities on Great Flats ENH with American Searocket (*Cakile edentula*),

Common reed (*Phragmites australis*), Slender Crabgrass (*Digitaria filiformis*), and Smooth Cordgrass (*Spartina alterniflora*) having the highest abundance in 2020 and 2021 (Figure 13). Unlike Ring Island ENH, we observed a higher proportion of monitoring plots with these species present in 2021 compared to the 2020.

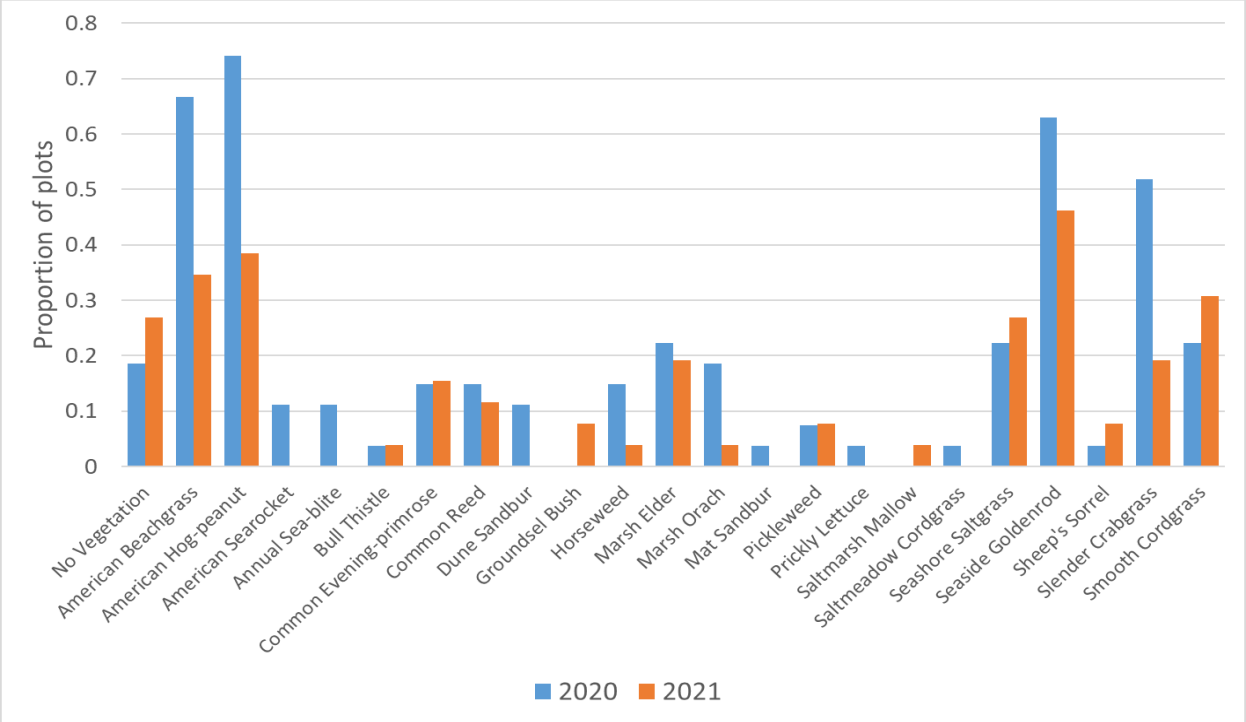

Figure 12. Vegetation species abundance within monitoring plots at the Ring Island Elevated Nesting Habitat in 2020 and 2021. See Appendix 3 for more detail.

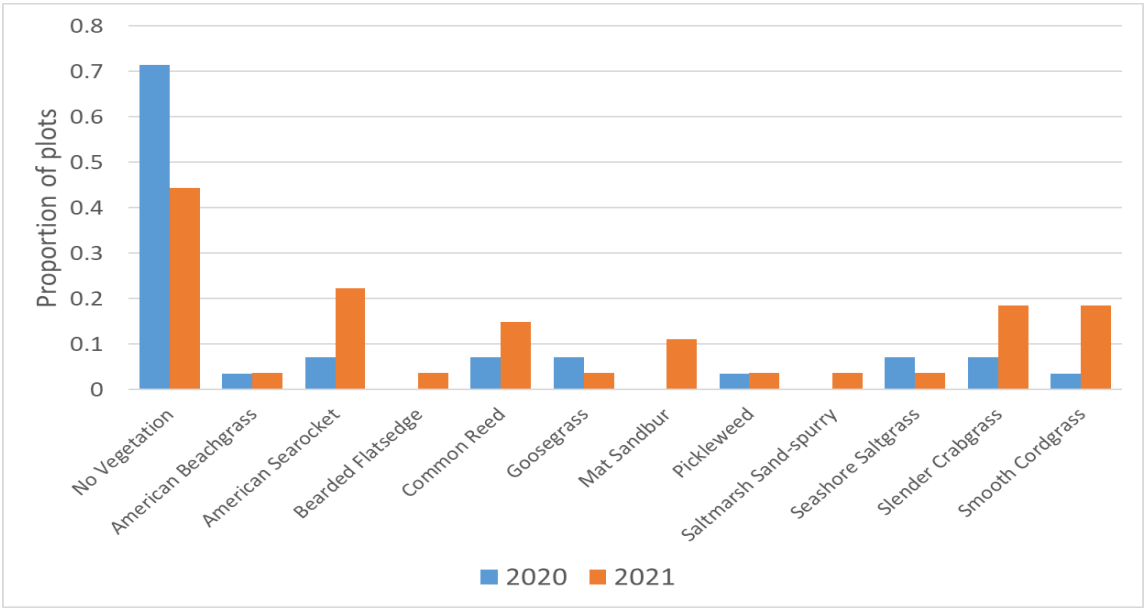

Figure 13. Vegetation species abundance within monitoring plots at the Great Flats Elevated Nesting Habitat in 2020 and 2021. See Appendix 3 for more detail.

Vegetation surveyed at study sites that did not receive placement of dredged material (i.e., control and potential ENH sites; Figure 3), exhibited lower species richness, higher cover classes, and different species composition than placement sites. Smooth Cordgrass was the dominant species for 100% of monitoring plots on ENH control sites (Great Flats, Ring Island) and potential ENH sites (Bluefish, Ring West), but differences in BB cover classes of Smooth Cordgrass were apparent among the sites in 2021 (Figure 14). The Bluefish potential ENH site had higher overall percent cover compared to other study sites. No study sites were observed with BB cover classes < 2 (range: 2 = 0-8%, 3 = 4-22%, 4 = 12-39%, 5 = 5-28%, 6 = 17-65%) within vegetation plots. We observed a lower proportion of plots with cover classes >50% in 2020 but a similar proportion between 2019 and 2021 (Figure 15). Stem height of Smooth Cordgrass varied among sites, with the highest average stems recorded at the Great Flats Control site and the lowest average stems at Bluefish potential ENH site (Figure 16). 48% of plots on the Ring Island Control site and the Bluefish potential ENH site (n = 12 and n = 10, respectively), as well as 8% (n = 2) of plots on Ring West potential ENH site, had other live vegetation species present in 2021, which included Pickleweed (*Salicornia maritima*) and Sea Lavender (*Limonium carolinianum*). Vegetation plots at the Great Flats Control site did not contain any live vegetation species other than Smooth Cordgrass in any year of the study. For all years of the project, Ribbed Mussel abundance was highest at the Great Flats Control site (60% of plots categorized as medium or high abundance) and lowest at the Bluefish potential ENH site (29% of plots categorized as medium or high abundance; Figure 17). Similarly, we also observed highest Fiddler Crab abundance at the Great Flats Control site (51% of plots categorized as medium or high abundance) and lowest abundance at the Bluefish potential ENH site (25% of plots categorized as medium or high abundance).

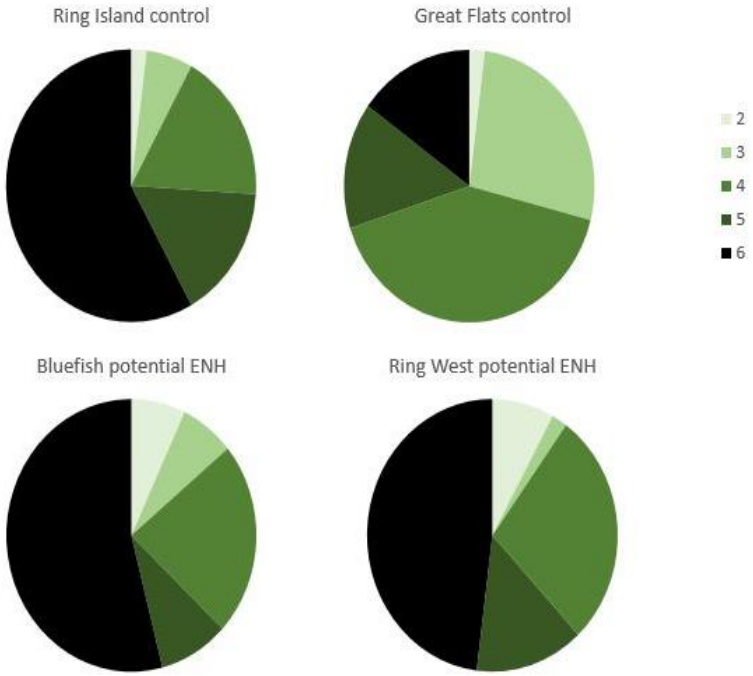

Figure 14. Live vegetation Braun-Blanquet cover classes for Smooth Cordgrass (Spartina alterniflora) *at control and potential Elevated Nesting Habitat (ENH) sites 2020-2021. Cover class categories: 2 = 6% to 10%, 3 = 11% to 25%, 4 = 26% to 50%, 5 = 51% to 75%, 6 = 76% to 100%.*

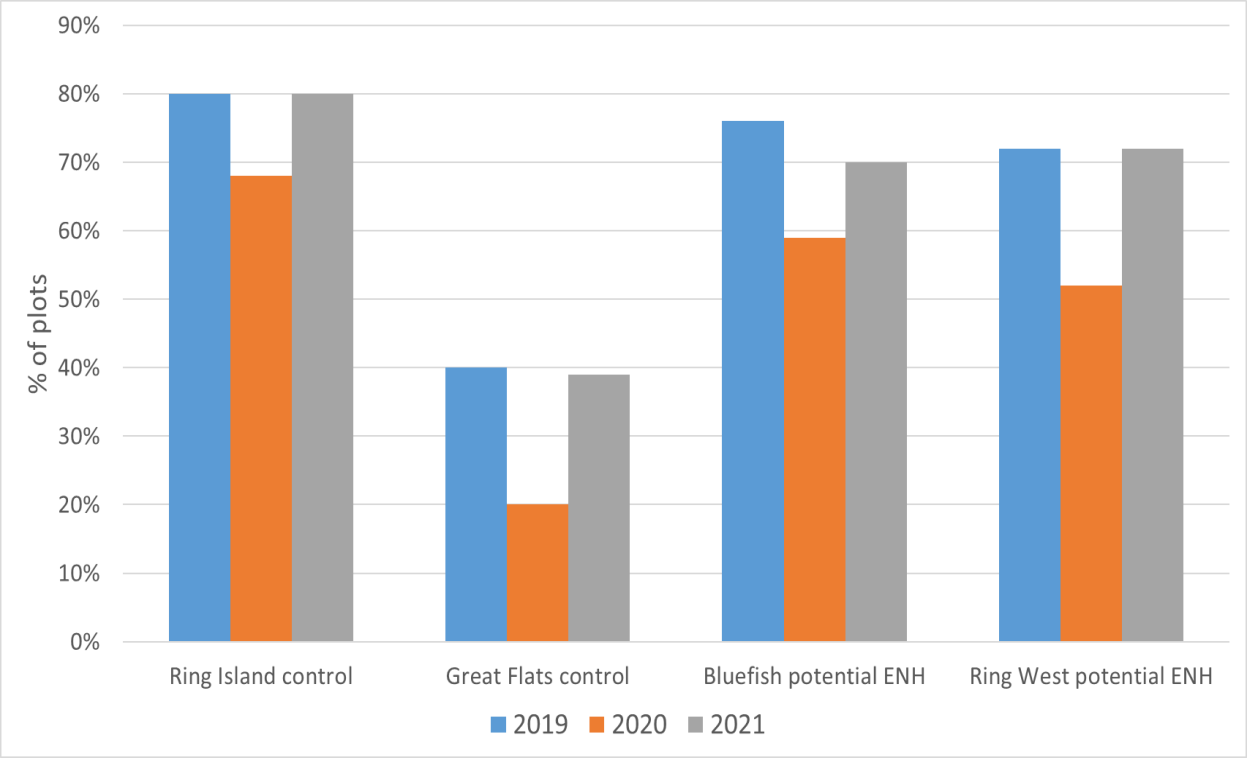

Figure 15. Percent of plots with live vegetation Braun-Blanquet cover classes >50% (cover class categories 5 or 6) for Smooth Cordgrass (Spartina alterniflora) *at control and potential Elevated Nesting Habitat (ENH) sites 2019-2021.*

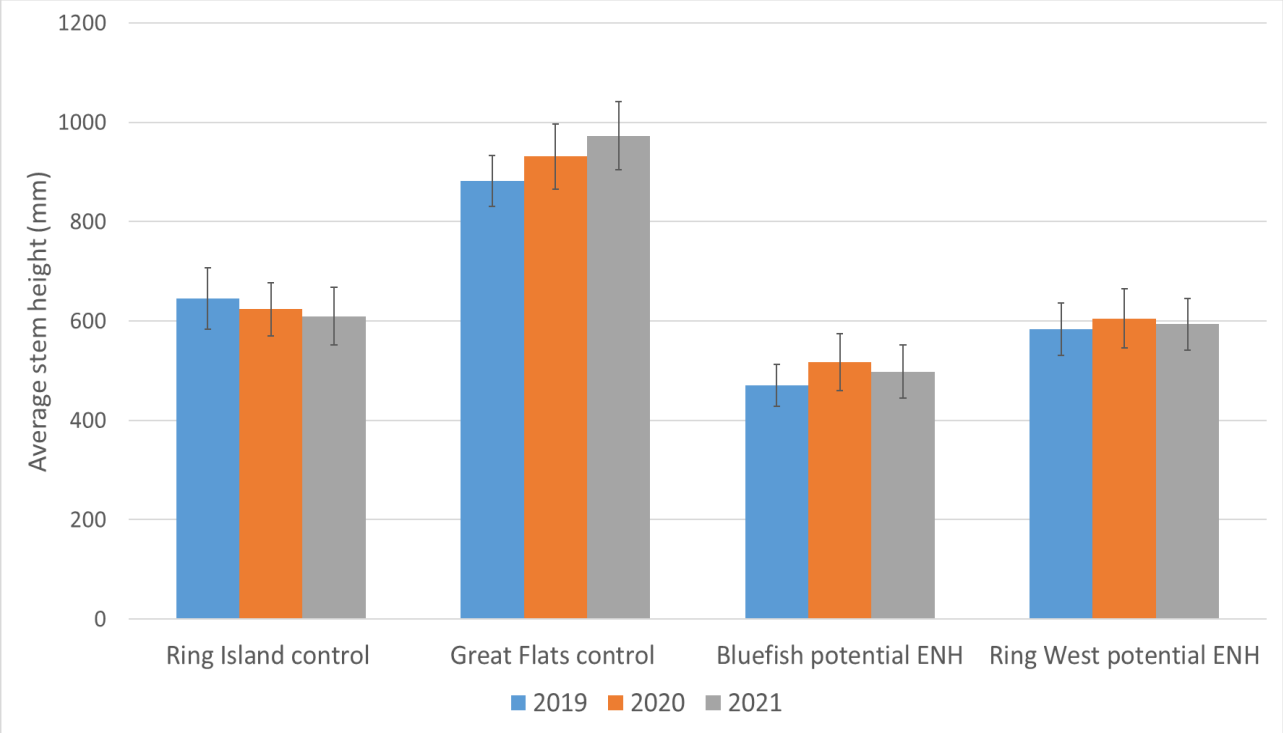

Figure 16. Mean (± SE) stem height of Smooth Cordgrass (Spartina alterniflora) *at control and potential Elevated Nesting Habitat (ENH) sites 2019-2021.*

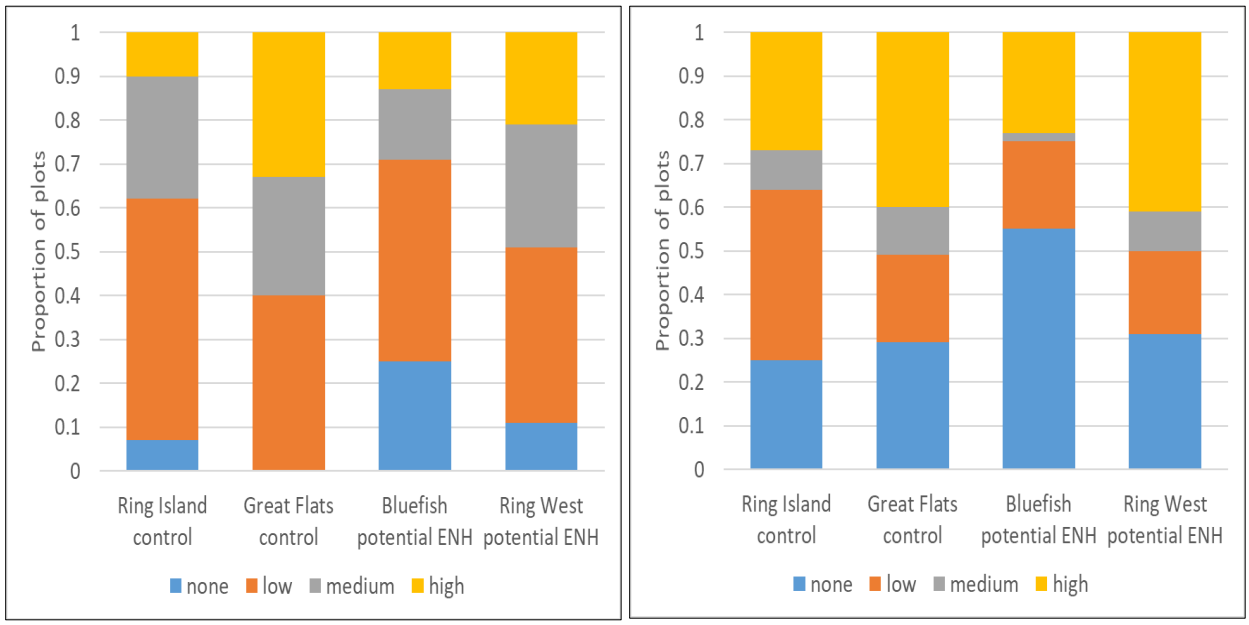

Figure 17. Abundance classes for Ribbed Mussels (left) and Fiddler Crabs (right) within plots at control and potential Elevated Nesting Habitat (ENH) sites 2019-2021. Individual count categories: Low (1-10), Medium (11-20), High (>20).

Vegetation Management

For the salt solution treatment study in 2019, manual removal of vegetation throughout the Ring Island ENH platform occurred between 13 March – 4 April. Vegetation was not present on the Great Flats ENH platform at the start of the 2019 nesting season. We surveyed all plots prior to salt solution treatment on 17 April at Ring Island ENH and 2 May and 6 May at Great Flats ENH. We surveyed all plots after the salt solution treatment on 24 July and 26 July at Ring Island ENH and 1 August at Great Flats ENH. We sprayed treatment plots 12 times (7.6 ± 2.5 d apart) on Ring Island ENH and four times (7.0 ± 1.2 d apart) on Great Flats ENH. The average duration of treatment (31 ± 2 min) was shorter than the duration of nest checks (41 ± 17 min). There was no vegetation present and no vegetation growth at the Great Flats ENH in either control or treatment plots during the treatment period.

Prior to the 2021 nesting season, manual removal of all vegetation within treatment areas on Ring Island ENH occurred between 17 March – 2 April. We surveyed salt solution treatment plots on 6 April prior to salt solution treatment and we surveyed control plots on 8 April at the start of the nesting season. We surveyed all plots again after the salt solution treatment between 11 – 13 August. We sprayed the entire salt solution treatment area five times (16.3 ± 2.9 d apart) throughout the nesting season between 20 April – 24 June 2021, approximately every two weeks. The average duration of the treatment using two backpack sprayers was approximately 45 minutes (44.5 ± 4.2 min).

For both years of the salt solution vegetation control study on Ring Island ENH (2019 and 2021), 100% of all control plots were documented having > 25% live vegetation cover by the end of the nesting season while only 36% of salt solution treated plots had > 25% live vegetation cover. We documented more vegetation species within control plots compared to salt spray treatment plots (Table 3). Presence of American Beachgrass occurred within the majority of all plots regardless of treatment type but American Hog-peanut had higher occurrence within control and manual removal only plots compared to plots treated with salt solution.

Table 3. Number and percentage (%) of 1 m^2 study plots with plant species on the Ring Island Elevated Nesting Habitat (ENH) following experimental vegetation control treatments in 2019 and 2021.

		2019		2021		
Common Name	*Scientific Name*	Salt Solution (n = 23 plots)	Control (n = 25 plots)	Salt Solution + Manual Removal (n = 24 plots)	Manual Removal Only (n = 24 plots)	Control (n = 25 plots)
American Beachgrass	*Ammophila brevigulata*	17 (74)	17 (68)	21 (88)	15 (63)	22 (88)
Crabgrass sp.	*Digitaria sp.*	0 (0)	24 (96)	22 (92)	7 (29)	4 (16)
Seaside Goldenrod	*Solidago sempervirens*	4 (17)	9 (36)	14 (58)	4 (17)	17 (68)
American Hog-peanut	*Amphicarpaea bracteata*	0 (0)	22 (88)	8 (33)	24 (100)	24 (96)
Common Evening-primrose	*Oenothera biennis*	0 (0)	12 (48)	0 (0)	13 (54)	17 (68)
Horseweed	*Erigeron canadensis*	0 (0)	0 (0)	0 (0)	11 (46)	13 (52)
Seashore Saltgrass	*Distichlis spicata*	11 (48)	6 (24)	0 (0)	0 (0)	0 (0)
Marsh Elder	*Iva fructescens*	2 (9)	5 (20)	0 (0)	0 (0)	2 (8)
Marsh Orach	*Atriplex patula*	2 (9)	1 (4)	0 (0)	0 (0)	1 (4)
Mat Sandbur	*Cenchrus longispinus*	1 (4)	2 (8)	0 (0)	0 (0)	0 (0)
Common Reed	*Phragmites australis*	3 (13)	3 (12)	1 (4)	0 (0)	4 (16)
Prickly Saltwort	*Salsola kali*	7 (30)	4 (16)	0 (0)	0 (0)	0 (0)
Sand Dune Sandspur	*Chenchrus tribuloides*	2 (9)	5 (20)	4 (17)	0 (0)	0 (0)
Sea Rocket	*Cakile edentula*	2 (9)	1 (4)	4 (17)	2 (8)	0 (0)
Seaside Sandmat	*Euphorbia polygonifolia*	0 (0)	4 (16)	4 (17)	0 (0)	0 (0)
Pickleweed	*Salicornia virginica*	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Sea Lavender	*Limonium carolinianum*	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Prickly Lettuce	*Lactuca serriola*	0 (0)	0 (0)	0 (0)	2 (8)	0 (0)
Saltmarsh Aster	*Symphyotrichum subulatum*	0 (0)	0 (0)	0 (0)	9 (38)	0 (0)
Virginia Pepperweed	*Lepidium virginicum*	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)

On Ring Island ENH in 2021, pre-season live vegetation BB cover classes were similar between the salt solution and manual removal only treatment plots (1.3 ± 0.6 and 1.0 ± 0.2, respectively) and significantly lower than control plots (3.3 ± 0.6). At the end of the nesting season, we observed lower BB cover classes in salt solution treatment plots compared to control and manual removal only plots (Figure 18). We found that 4% (n = 1) of salt solution treatment plots had > 50% live vegetation cover while 100% (n = 24) of manual removal only plots and 96% (n = 24) of control plots had > 50% live vegetation cover. Species richness was lowest within the

manual removal only treatment area at the start of the nesting season but vegetation species richness was similar between treatment areas by the end of the nesting season (Figure 19). Control plots had a higher number of species compared to treatment areas at both the start and end of the nesting season. American Beachgrass was the dominant vegetation species within the majority of all treatment and control plots on Ring Island ENH pre-season (77% of all plots) in 2021. At the end of the nesting season, American Beachgrass was the dominant species for the majority of plots within the salt solution treatment area (88% of plots), while American hog-peanut was the dominant species for the majority of manual removal only plots (100% of plots) at the end of the nesting season. Within control plots, American Beachgrass was identified as the dominant species for 28% of plots (n = 7) and American Hog-peanut was identified as the dominant species for 24% of plots (n = 6) at the end of the nesting season. Average stem heights of American Beachgrass were similar between treatment areas at the start of the nesting season following manual removal but were lower within the salt solution treatment plots at the end of the nesting season in 2021 compared to the manual removal only plots (Figure 20). We observed higher stem heights within control plots were compared to treatment areas by the end of the 2021 nesting season (931.7 ± 158.3mm and 728.5 ± 122.7mm, respectively).

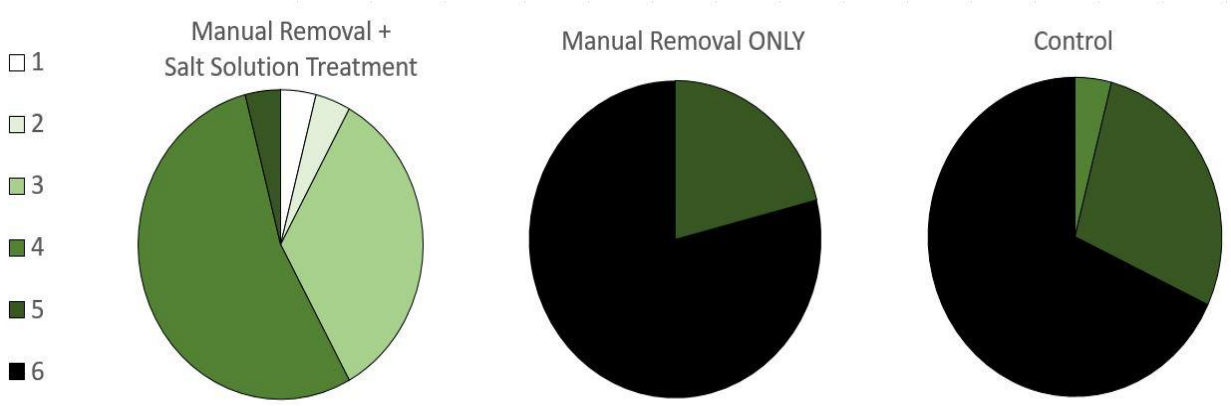

Figure 18. Live vegetation Braun-Blanquet cover classes for monitoring plots within treatment and control areas on Ring Island Elevated Nesting Habitat at the end of the 2021 nesting season. Cover class categories: 1 = 1% to 5%, 2 = 6% to 10%, 3 = 11% to 25%, 4 = 26% to 50%, 5 = 51% to 75%, 6 = 76% to 100%.

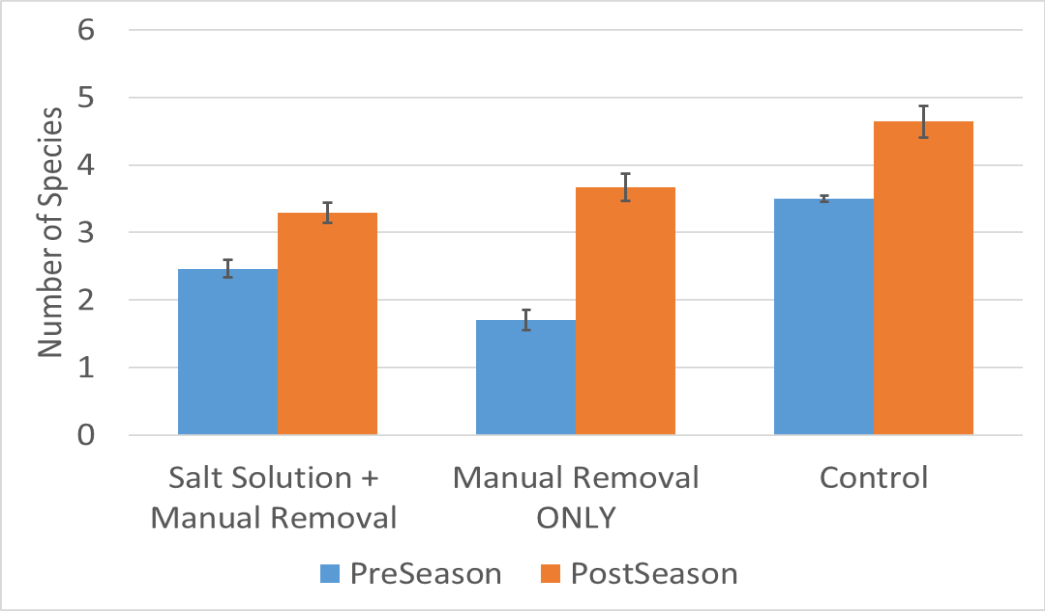

Figure 19. Live vegetation species richness within treatment and control plots on Ring Island Elevated Nesting Habitat at the start and end of the nesting season in 2021.

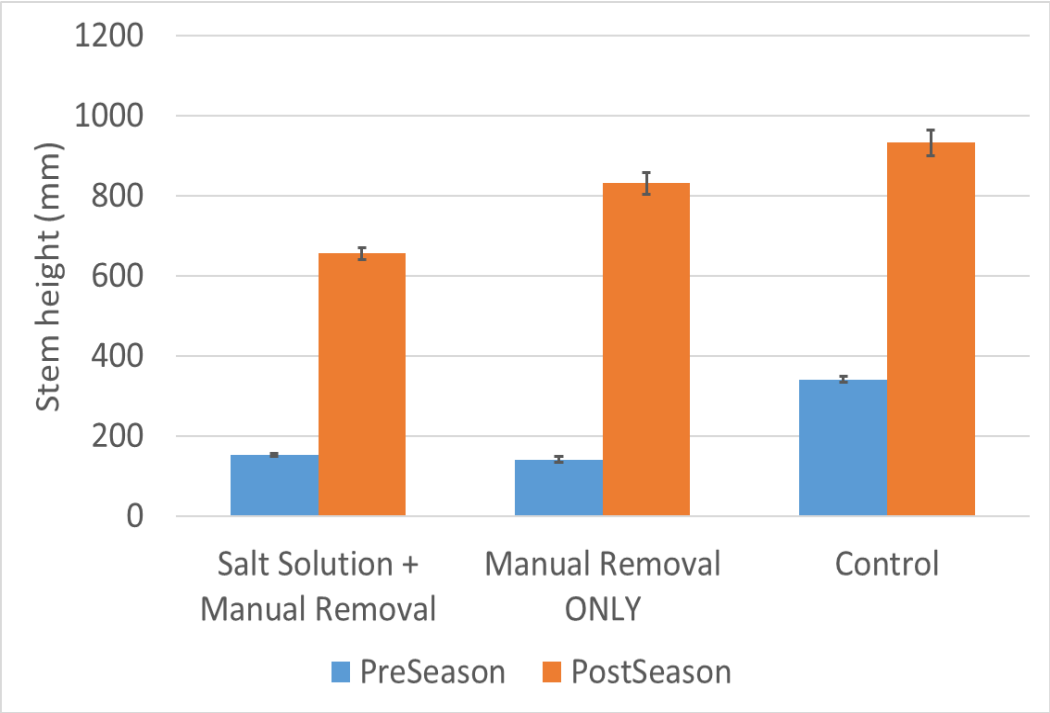

Figure 20. Stem heights of American Beachgrass (Ammophila breviligulata) *within control and treatment areas on Ring Island Elevated Nesting Habitat at the start and end of the nesting season in 2021.*

Discussion

During this project, elevated nesting habitats created for sensitive nesting birds provided areas for reproduction, rest, and foraging for 50 avian species and other coastal wildlife. The outcomes at the two ENH sites demonstrated that achieving targeted outcomes for avian use and reproductive success can vary by site and over time. Species richness was higher for ENH sites compared to their respective control sites, varied among all sites, and was highest on Ring Island ENH (Appendix 1 and 2). Though there was little similarity between any two sites during the project, we observed increasing similarity in species richness between ENH sites for each year of the project. We also observed the most similarity in species richness between the Ring Island ENH and Ring Island control sites, which increased over time, while Great Flats ENH showed less similarity to the adjacent control habitat during the project. We suspect that the continued establishment of vegetation on the Ring Island ENH promoted avian use for different species (e.g., passerine species) that were present within the Ring Island control area near the historic dredged placement area. Great Flats ENH, which was constructed four years after Ring Island ENH, may follow a similar trend as the site and vegetation community mature. Comparisons of species richness between control sites was nearly stable throughout the project. These results suggest that the maturity of the site and changes in habitat features may be related to avian site selection and use of placement sites.

Monitoring at Ring Island ENH prior to this project, and at Great Flats during this project, illustrates that it may take some time for many bird and other species to locate and select nesting areas on these habitats or for conditions to become suitable. Some species, like the American Oystercatcher which regularly nest in the surrounding marsh, nested on both ENH sites the first season following construction, selected nesting territories that included the sites all years, and successfully produced young during the project at both ENH sites. Other species, like the Black Skimmer and tern species which less regularly nest in the surrounding marsh, took time to begin nesting at the sites and only nested on Ring ENH. On Ring Island ENH, a mixed species colony (Black Skimmer, Common Tern, Least Tern) established on the ENH platform by the third nesting season (2017) following initial construction of the site but began to decline starting in 2019. The limited amount of open, non-vegetated space on the habitat preferred by these colonial nesting species, as well as increased presence of potential avian and mammalian nest predators (e.g., Red Fox, Fish Crows, Norway Rats), reduced the suitability of the site for nesting. Comparatively, no colonial nesting species established on Great Flats ENH by the third nesting season (2021) following initial construction of the site. It is not clear whether colonial nesting species will eventually nest on Great Flats ENH, though many habitat conditions (elevation, open habitat, location) there were similar to conditions when the colony first formed on Ring Island ENH. It is possible that other factors not considered in or known

during the site design (presence of loafing gulls, increased predator presence) will preclude the site from meeting this objective.

Nest site selection for target species may be driven by site elevation, presence of mammalian or avian predators, inter- or intra- specific competition, as well as vegetation cover at the site, flooding, and other factors. For example, pairs nesting along the perimeter of the nesting platform, below spring flood elevations, at both ENH sites experienced nest failure following flooding events. Great Black-backed Gulls, Laughing Gulls, and American Oystercatchers experienced no productivity in 2019 and 2021, attributed to flooding and predation (both mammalian and avian). We also estimated low hatch success in 2019 and low productivity in 2021 for the Laughing Gull colony located within the Great Flats control site, likely due to increased flooding during incubation and while broods were present. Nest success may be limited by flooding occurring below the ENH nesting platform, as well as increased presence of potential avian nest predators (gulls, crows) and mammalian activity on the ENH habitat. Differences in nest success within and between years is an expected result at most established nesting sites and may be related to annual changes in the presence of nest predators within nesting areas, nest site elevation, and flooding occurrences. It is apparent from this project that habitat suitability varied among years and sites at ENH and control sites.

Banded birds provided information about nest site selection and fidelity, as well as movement among sites. Previous banding efforts helped us confirm nest site fidelity of American Oystercatcher pairs on study sites throughout this project. Although there was not an active Black Skimmer colony on either ENH site for the 2020 or 2021 nesting seasons, we resighted Ring Island ENH banded birds near local colonies both years (Figure 21). Resights of newly banded birds provided information on survival, natal and nest site persistence, as well as habitat use and movement patterns after leaving the colony. Resighting surveys of banded birds, and opportunistic observations of marked terrapins and horseshoe crabs show the connectivity of the placement sites in the broader coastal habitat (Figure 21). Continued banding and resight survey efforts will make ongoing contributions to our understanding of nest site tenacity, habitat use and movements within and between seasons, and nest site selection among these sites to provide insight on the suitability of habitat over time.

Figure 21. Previously banded Black Skimmer (C03; top) and tagged Horseshoe Crab (bottom left) and Diamondback Terrapin (bottom right) observed on and near the Ring Island Elevated Nesting Habitat 2019 - 2021.

Throughout the project period, Ring Island ENH and Great Flats ENH provided important areas for nesting habitat for a variety of species. Migratory birds, including state and federally listed species, spawning Horseshoe Crabs, and nesting Diamondback Terrapins utilized the higher elevation and sandy substrates these ENH features provided. Species composition and nesting activity for avian species varied between ENH, control, and historic placement sites because many marsh-nesting species, such as Clapper Rail, Willet, and Seaside Sparrow, prefer to nest in dense vegetation, while others, such as Black Skimmers, Least Terns, and American Oystercatchers, prefer open areas with limited vegetation for nesting. Annual variation in reproductive success related to flooding events, predation pressure, and changes in habitat features on study sites demonstrates the importance of having multiple nesting sites available as conditions change within and between years.

We documented evidence of potential nest predators on both ENH sites each year of the project, but the frequency of occurrence and impact on nesting outcomes varied by year and site. In 2021, we documented both avian nest predators (Fish Crow) and mammalian nest predators (Norway Rats and Raccoon) on Ring Island ENH near nest sites and depredating eggs (Figure 22). We documented variable site visitation and impacts for different mammalian mesopredators (Red Fox, Raccoon, Striped Skunk, and American Mink) within and between nesting seasons on ENH sites. We observed high activity for Red Fox on both ENH sites during the 2019 season through game camera footage and visible signs. Game camera footage also captured Red Fox depredating American Oystercatcher chicks at Great Flats ENH shortly after hatch (Figure 22). Complete colony failure for ~110 pairs of Common Terns nesting on Ring Island ENH in 2019 also suggests that fox had a direct impact on reproductive success. Further, Black Skimmers (the target species for Ring Island ENH) abandoned the site in 2019 prior to nesting, likely due largely to mammalian activity. In 2020, we observed few pairs of Common Terns (~3 pairs) and no Black Skimmers establish nesting territories on Ring Island ENH. As the

colony size was reduced and less equipped to defend itself in numbers, Fish Crow made regular visits and contributed to the colony failure. Fish Crows were active on the Ring Island ENH habitat each year of the project but the frequency of occurrence and the total number of Fish Crows observed was much lower on the Great Flats ENH site. We did not observe any evidence of mesopredators on ENH sites during the 2020 season. Norway Rats and Marsh Rice Rats were also very active on the Ring Island ENH site during the peak of the nesting season throughout the project, but the degree of impact to nesting success was unclear. However, it is likely that rat activity affected nesting activity and contributed to nest failure for avian species.

Figure 22. Game camera footage documenting a Red Fox depredating American Oystercatcher chicks on Great Flats Elevated Nesting Habitat (ENH) during the 2019 nesting season (left) and a Fish Crow (middle) and Norway Rat (right) depredating Diamondback Terrapin eggs on the Ring Island ENH during the 2021 nesting season.

Great Flats ENH was a regular roosting and loafing site for large gull species (primarily Herring Gull and Great Black-backed Gulls). Groups of large gulls were frequently observed on the habitat during site surveys and in diurnal and nocturnal camera trap footage of the habitat in 2020 and 2021. The frequency of occurrence and total number of large gulls was much higher at Great Flats ENH compared to Ring Island ENH. We observed an increase in the number of large gulls on the Great Flats ENH site each year of the project, with highest abundance observed following habitat renourishment in 2021 (Appendix 1 and 2). It is likely that the number and regular presence of large gulls at Great Flats ENH contributed to the site not being selected for nesting by colonial species (Black Skimmer, Common Tern, Least Tern).

Both ENH sites received little human disturbance throughout the project. We established symbolic fencing to reduce the boater visitation to these sites during the nesting season but we rarely observed any evidence of human recreation at these ENH sites. Symbolic fencing did not appear necessary at these ENH sites and may have even promoted visitation of nest predators (e.g. Fish Crows) that used fence posts to scan for food sources (e.g. terrapin nests).

This project and continued monitoring of the ENH sites illustrate that conditions at the sites for target species can degrade or vary with time and there are differences in vegetation

communities between and within sites and years. Results from this project showed that vegetation did not grow at the same rate or intensity between ENH sites. Vegetation was very limited at Great Flats ENH in 2019 and over half of the monitoring plots had vegetation present by the end of the 2021 nesting season. Conversely, at the older Ring Island ENH, the majority of monitoring plots were observed with vegetation by the end of the nesting season throughout the duration of the project (73 – 81 % in 2020-2021). As a result, we observed few target species nesting on the Ring Island ENH platform during the 2020 and 2021 nesting season. Though vegetation succession on the Ring Island ENH did not lend to successful nesting of original target species, the condition of the site may become valuable for other at-risk marsh-dependent species, like Seaside and Saltmarsh Sparrows, as it matures.

We observed differences in vegetation communities between ENH sites and control or potential ENH sites, as expected due to increased elevation with sediment additions and shift from tidal saltmarsh to sandy transitional upland areas. Control and potential ENH sites showed little change in vegetation communities and cover classes between years. Compared to ENH sites, we observed higher vegetation cover classes on control and potential ENH sites and Smooth Cordgrass was the dominant plant species observed in all plots for these sites. We observed differences in vegetation cover classes and stem heights, as well as mussel and crab abundance between control and potential ENH sites. These results provide a better understanding of pre-placement features to assess suitability for potential future placement and evaluate change following placement of dredged materials if the site is selected as a location for creation of an elevated nesting habitat.

Species composition, cover classes, and stem height of dominant species of vegetation also differed between ENH sites. The more mature site, Ring Island ENH, had higher vegetation species richness compared to Great Flats ENH throughout the project. We also observed differences in dominant plant species present in monitoring plots on ENH sites and changes in abundance of vegetation species between years. We saw an overall decrease in the proportion of plots with dominant plant species present on Ring Island ENH between 2020 and 2021 but observed a higher proportion of plots with dominant plant species between 2020 and 2021 at Great Flats ENH. Differences in vegetation communities between ENH sites may be a result of their location, currents, local seed banks, or differences in management strategies at each site (Appendix 3). For example, prescribed burning can promote growth of some vegetation species, so varying use of this strategy between sites and years may have contributed to differences in vegetation species abundance. Results from this project indicate the need for site-specific adaptive management decisions and regular evaluation of best approaches to meet habitat objectives for target species. The ENH sites provide two examples of how vegetation communities may develop and, together with other drivers in the system (i.e. predator communities), affect the overall quality of habitat for avian other wildlife species over time.

Without continued vegetation management, ENH sites may become undesirable nesting areas for target species like terns and skimmers that prefer open, sparsely vegetated areas for nesting. The establishment and cover of vegetation at Ring Island ENH shifted habitat management focus to vegetation control efforts over the course of this project. Without natural control from regular tidal or storm flooding, vegetation on the higher nesting platform at Ring Island ENH grew densely vegetated. Nutrients from bird colonies can also promote vegetation control. Given these factors, we tested the use of a salt solution to reduce ground cover and eliminate or reduce growth of many emergent species during the nesting season. We limited significant additional disturbance to nesting species by applying treatment during nest checks. Prescribed burns or manual removal, as conducted during this project, alone were not effective at reducing vegetation succession and growth to maintain open nesting habitat for target species over the duration of the nesting season. These methods also cannot be implemented during the nesting season, when emergent vegetation can reduce habitat quality and reproductive success. In 2021, manual removal was initially effective in reducing vegetation cover but the salt solution treatment area on Ring Island ENH was the only area with limited vegetation cover by the end of the nesting season (Figure 23). Further, stem heights of the dominant vegetation species (American Beachgrass) were lower within salt spray plots. Vegetation cover classes and stem heights of American beachgrass within the manual removal only plots in 2021 were similar to control plots at the end of the nesting season but we observed lower species diversity within these plots compared to control areas. We documented salt solution treated plots with more crabgrass, Seaside Goldenrod, and American Hog-peanut in 2021 compared to 2019 treatment plots, which may be due to differences in frequency and duration of spray treatments or size of plots between the two seasons.

To keep additive disturbance to a minimum, we established treatment areas and salt solution spray techniques so they would be compatible with the length of nest check visits. The duration of the salt solution treatment was similar or within the time it would take to check nests and survey the habitat if there were an active colony. The duration of the salt solution treatment (~30-45 min) was similar to or within the time it would take to check nests and survey the habitat when there were an active colony in 2019 (~40 min). Therefore, salt solution treatment using two or more battery-powered backpack sprayers could be an effective way to reduce vegetation growth and succession for smaller, targeted areas (160 m^2 in this study) on the habitat throughout the nesting season, without risk of using herbicides around active nests. Vegetation around the lower elevation perimeter of the ENH was not controlled so it could provide cover for young chicks to hide or find shelter and habitat for other species of interest that nest or feed in vegetated patches. Vegetation management practices (e.g., manual removal, salt solution treatment) to benefit habitat for Black Skimmers and terns at ENH sites with similar vegetation communities will likely need to be limited to a small section on the

nesting platform unless other methods to control vegetation over the duration of the nesting season are found. The rest of the site should be monitored and could be left unmanaged to allow for continued succession of vegetation with the objective of attracting a different suite of sensitive nesting species (e.g. wading birds).

Figure 23. Vegetation cover on Ring Island Elevated Nesting Habitat at the start of the 2021 nesting season (left; imagery date: 27 May; source: ESRI) and at end of the 2021 nesting season (right; imagery date: August 27; source: University of Pennsylvania). The 160 m^2 salt solution treatment area is visible in both images (the less densely vegetated, sandy rectangle on right) while the 160 m^2 manual removal only treatment area is only apparent in the left image.

Great Flats ENH was included in the salt solution treatment testing in 2019 immediately following placement to provide another test scenario. Our monitoring that season, however, indicated that vegetation control was not necessary on Great Flats ENH to maintain suitable nesting habitat because vegetation did not establish on the platform. Though vegetation emerged on the ENH platform during the 2020 nesting season and following habitat renourishment in 2021, it has occurred at a lesser rate with lower coverage intensity and species composition compared to Ring Island ENH. The site was renourished with sandy dredged material in early 2021 to restore elevation to target levels and enlarge the nesting habitat which resulted in more open habitat for nesting species. However, the number of gulls using the habitat to roost increased and may have prevented target species from selecting the

site to nest. Further, renourishment may have altered vegetation succession on some areas of the habitat and we observed dense vegetation forming around the perimeter of the habitat by the end of the nesting season in 2021. Site location, currents, and local seed bank may be contributing to difference in elevation and vegetation succession on ENH sites, and it is possible Great Flats ENH will require similar vegetation control efforts as Ring Island ENH in the near future if it is to provide suitable habitat for target avian nesting species.

It is important to understand that habitat suitability, avian use, and reproductive success may change from year to year based on site-specific conditions including elevation changes, flooding incidences, predation pressure, and vegetation succession following management efforts. Results from this project illustrate that conditions at ENH sites for target species can degrade or change with time. ENH sites that successfully attract birds and provide nesting habitat can also attract predators, creating limits to reproductive success. Increased efforts to minimize avian and mammalian predators, such as live trapping of small mammals, removal of fence posts that serve as perches for avian predators, and quick response for predator control during the nesting season could enhance nest site selection and reproductive outcomes if there is open, suitable habitat at these sites. Elevation reductions occur though compaction, dewatering and sediment transport over time following placement especially on unvegetated sites that may lead to increased risk of flooding. While increased vegetation cover can help reduce elevation losses by trapping sediments it can be undesirable for target nesting species. Continued monitoring is needed to fully understand the changes to the habitat and species responses within and between seasons to inform management needs and maximize conservation efforts and restoration potential. Ideally, in a complex of nesting habitats, sites and management needs will be staggered so that newer or recently renourished placement sites (e.g. Great Flats ENH) can provide open nesting habitat for target species as habitat quality at more mature sites declines or requires management.

This project provided an important opportunity to advance approaches to provide elevated habitat using dredged material placement in tidal salt marshes through annual monitoring and evaluation. Previously recorded and new species documented within the study area have the potential for successful nesting on the site in future years with predator and vegetation control management. Continued monitoring will be necessary to assess the response of avian and vegetation communities to habitat changes over time and evaluate species response to restoration and management activities. These ongoing monitoring efforts can help inform managers on future restoration and habitat management actions that can enhance the suitability of areas for sensitive avian species and other wildlife.

Appendix 1. Total number of individuals counted from each placement (Elevated Nesting Habitat, ENH) and control site during weekly surveys April-August, 2019-2021.

**Denotes surveys we were unable to accurately distinguish between gull species.*

Species		Ring Island ENH			Ring Island Control			Great Flats ENH			Great Flats Control		
Common Name	*Scientific Name*	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
American Black Duck	*Anas rubripes*	9	0	0	0	0	0	0	0	0	0	0	0
American Kestrel	*Falco sparverius*	0	0	0	0	0	1	0	0	0	0	0	0
American Oystercatcher	*Haematopus palliatus*	83	117	78	1	6	3	46	65	42	1	0	0
Barn Swallow	*Hirundo rustica*	2	8	14	1	4	0	0	1	0	0	0	0
Black-bellied Plover	*Pluvialis squatarola*	32	51	0	0	0	1	0	0	0	0	0	0
Black-crowned Night-heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0	1	0
Black Skimmer	*Rynchops niger*	179	10	10	0	0	0	0	0	2	0	0	0
Boat-tailed Grackle	*Quiscalus major*	4	5	1	1	2	1	0	1	0	0	0	0
Brant	*Branta bernicla*	53	38	43	0	0	0	0	0	5	0	0	0
Canada Goose	*Branta canadensis*	0	0	5	0	0	0	0	0	0	0	0	0
Clapper Rail	*Rallus crepitans*	0	2	4	8	4	11	0	0	0	3	4	3
Common Grackle	*Quiscalus quiscula*	0	0	0	2	0	0	0	0	0	0	0	0
Common Tern	*Sterna hirundo*	956	68	32	0	2	0	3	2	0	0	0	0
Double-crested Cormorant	*Phalacrocorax auritus*	0	2	3	0	0	1	0	0	1	0	0	0
Dunlin	*Calidris alpina*	131	7	10	0	0	0	0	0	0	0	0	0
European Starling	*Sturnus vulgaris*	150	119	63	3	1	1	0	0	0	0	0	0
Fish Crow	*Corvus ossifragus*	26	44	48	0	0	2	5	10	17	0	0	0
Forster's Tern	*Sterna forsteri*	7	1	22	0	1	8	0	0	0	2	0	0
Great Black-backed Gull	*Larus marinus*	4	6	5	0	0	0	187	258	277	0	0	0
Gull-billed Tern	*Gelochelidon nilotica*	2	1	0	0	0	0	0	0	0	0	0	0
*Gull sp.		0	0	0	0	0	0	0	0	544	0	0	0
Great Blue Heron	*Ardea herodias*	0	0	0	1	0	1	0	0	1	0	0	0
Great Egret	*Ardea alba*	0	0	0	2	5	3	1	0	2	0	0	1
Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	0	1	0	0	0	0	0	0	0
Green Heron	*Butorides virescens*	0	0	0	1	0	0	0	0	0	0	0	0
Herring Gull	*Larus argentatus*	1	13	26	0	2	1	89	173	314	0	0	0
House Finch	*Haemorhous mexicanus*	0	0	2	0	0	0	0	0	0	0	0	0
Laughing Gull	*Leucophaeus atricilla*	122	198	70	6	6	5	179	79	150	548	811	680
Least Sandpiper	*Calidris minutilla*	74	15	11	1	0	0	0	5	8	0	0	0
Least Tern	*Sternula antillarum*	6	5	4	0	0	0	0	0	0	0	0	0
Mallard	*Anas platyrhynchos*	2	0	2	0	0	0	0	0	0	0	0	0
Mourning Dove	*Zenaida macroura*	0	0	1	0	0	0	0	0	0	0	0	0
Osprey	*Pandion haliaetus*	1	2	3	0	0	3	3	0	2	0	0	0
Peregrine Falcon	*Falco peregrinus*	0	1	0	0	0	0	2	1	1	0	0	0
Red-winged Blackbird	*Agelaius phoeniceus*	8	4	28	6	8	10	0	1	2	0	1	1
Ruddy Turnstone	*Arenaria interpres*	10	29	8	0	0	16	1	0	0	0	0	0
Sanderling	*Calidris alba*	15	0	4	0	0	0	0	0	0	0	0	0
Savannah Sparrow	*Passerculus sandwichensis*	11	0	3	1	0	0	0	0	0	0	0	0
Seaside Sparrow	*Ammodramus maritimus*	1	0	0	3	0	1	0	0	0	0	0	0
Semipalmated Plover	*Charadrius semipalmatus*	7	7	0	0	0	0	3	0	1	1	0	0
Semipalmated Sandpiper	*Calidris pusilla*	100	89	16	1	0	1	0	0	0	0	1	0
Short-billed Dowitcher	*Limnodromus griseus*	189	19	62	0	0	5	0	0	0	0	0	0
Snowy Egret	*Egretta thula*	0	2	0	1	1	1	0	0	0	0	0	0
Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	1
Spotted Sandpiper	*Actitis macularius*	0	0	0	0	1	0	0	0	1	0	0	0
Tree Swallow	*Tachycineta bicolor*	1	0	0	0	0	0	0	0	0	0	0	0
Turkey Vulture	*Cathartes aura*	0	0	0	0	0	0	4	1	2	0	0	0
Western Sandpiper	*Calidris mauri*	0	1	0	0	0	0	0	0	0	0	0	0
Willet	*Tringa semipalmata*	31	31	28	17	8	15	0	0	0	0	0	0
Yellow-crowned Night-heron	*Nyctanassa violacea*	0	0	0	0	1	2	0	0	0	0	0	0

*Appendix 2. Species occurrence observed during weekly site surveys on each placement (Elevated Nesting Habitat, ENH) and control site during weekly surveys April-August, 2019-2021. * Denotes surveys we were unable to accurately distinguish between gull species.*

Species		Ring Island ENH			Ring Island Control			Great Flats ENH			Great Flats Control		
Common Name	*Scientific Name*	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
American Black Duck	*Anas rubripes*	1	0	0	0	0	0	0	0	0	0	0	0
American Kestrel	*Falco sparverius*	0	0	0	0	0	1	0	0	0	0	0	0
American Oystercatcher	*Haematopus palliatus*	27	35	32	1	5	3	21	32	24	1	0	0
Barn Swallow	*Hirundo rustica*	1	4	9	1	3	0	0	1	0	0	0	0
Black-bellied Plover	*Pluvialis squatarola*	3	2	0	0	0	1	0	0	0	0	0	0
Black-crowned Night-heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0	1	0
Black Skimmer	*Rynchops niger*	10	3	3	0	0	0	0	0	1	0	0	0
Boat-tailed Grackle	*Quiscalus major*	2	2	1	1	2	1	0	1	0	0	0	0
Brant	*Branta bernicla*	4	4	3	0	0	0	0	0	1	0	0	0
Canada Goose	*Branta canadensis*	0	0	3	0	0	0	0	0	0	0	0	0
Clapper Rail	*Rallus crepitans*	0	1	4	8	4	8	0	0	0	2	3	2
Common Grackle	*Quiscalus quiscula*	0	0	0	1	0	0	0	0	0	0	0	0
Common Tern	*Sterna hirundo*	23	21	15	0	1	0	2	2	0	0	0	0
Double-crested Cormorant	*Phalacrocorax auritus*	0	1	1	0	0	1	0	0	1	0	0	0
Dunlin	*Calidris alpina*	4	1	1	0	0	0	0	0	0	0	0	0
European Starling	*Sturnus vulgaris*	4	7	9	0	1	1	0	0	0	0	0	0
Fish Crow	*Corvus ossifragus*	9	12	19	0	0	1	4	7	8	0	0	0
Forster's Tern	*Sterna forsteri*	2	1	8	0	1	5	0	0	0	1	0	0
Great Black-backed Gull	*Larus marinus*	2	3	2	0	0	0	22	35	30	0	0	0
Great Blue Heron	*Ardea herodias*	0	0	0	1	0	1	0	0	1	0	0	0
Great Egret	*Ardea alba*	0	0	0	2	5	3	1	0	2	0	0	1
Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	0	1	0	0	0	0	0	0	0
Green Heron	*Butorides virescens*	0	0	0	1	0	0	0	0	0	0	0	0
Gull-billed Tern	*Gelochelidon nilotica*	1	1	0	0	0	0	0	0	0	0	0	0
*Gull sp.		0	0	0	0	0	0	0	0	5	0	0	0
Herring Gull	*Larus argentatus*	3	9	9	0	1	1	16	22	19	0	0	0
House Finch	*Haemorhous mexicanus*	0	0	1	0	0	0	0	0	0	0	0	0
Laughing Gull	*Leucophaeus atricilla*	9	16	18	4	6	5	13	8	17	12	15	17
Least Sandpiper	*Calidris minutilla*	5	3	2	1	0	0	0	2	1	0	0	0
Least Tern	*Sternula antillarum*	2	3	4	0	0	0	0	0	0	0	0	0
Mallard	*Anas platyrhynchos*	1	0	2	0	0	0	0	0	0	0	0	0
Mourning Dove	*Zenaida macroura*	0	0	1	0	0	0	0	0	0	0	0	0
Osprey	*Pandion haliaetus*	1	2	3	0	0	2	3	0	1	0	0	0
Peregrine Falcon	*Falco peregrinus*	0	1	0	0	0	0	2	1	1	0	0	0
Red-winged Blackbird	*Agelaius phoeniceus*	5	3	13	6	6	7	0	1	2	0	1	1
Ruddy Turnstone	*Arenaria interpres*	3	4	3	0	0	2	1	0	0	0	0	0
Sanderling	*Calidris alba*	1	0	2	0	0	0	0	0	0	0	0	0
Savannah Sparrow	*Passerculus sandwichensis*	3	0	1	1	0	0	0	0	0	0	0	0
Seaside Sparrow	*Ammodramus maritimus*	1	0	0	1	0	1	0	0	0	0	0	0
Semipalmated Plover	*Charadrius semipalmatus*	3	2	0	0	0	0	1	0	1	1	0	0
Semipalmated Sandpiper	*Calidris pusilla*	7	5	2	1	0	1	0	0	0	0	1	0
Short-billed Dowitcher	*Limnodromus griseus*	8	6	5	0	0	1	0	0	0	0	0	0
Snowy Egret	*Egretta thula*	0	2	0	1	1	1	0	0	0	0	0	0
Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	1
Spotted Sandpiper	*Actitis macularius*	0	0	0	0	1	0	0	0	1	0	0	0
Tree Swallow	*Tachycineta bicolor*	1	0	0	0	0	0	0	0	0	0	0	0
Turkey Vulture	*Cathartes aura*	0	0	0	0	0	0	2	1	2	0	0	0
Western Sandpiper	*Calidris mauri*	0	1	0	0	0	0	0	0	0	0	0	0
Willet	*Tringa semipalmata*	17	15	14	9	6	11	0	0	0	0	0	0
Yellow-crowned Night-heron	*Nyctanassa violacea*	0	0	0	0	1	1	0	0	0	0	0	0

Appendix 3. Total number of monitoring plots where vegetation species were observed on Ring Island and Great Flats Elevated Nesting Habitat (ENH) at the end of the nesting season (July-August), 2020-2021.

Species		Ring Island ENH		Great Flats ENH	
Common Name	*Scientific Name*	2020	2021	2020	2021
American Beachgrass	*Ammophila breviligulata*	18	9	1	1
American Hog-peanut	*Amphicarpaea bracteata*	20	10	0	0
American Searocket	*Cakile edentula*	3	0	2	6
Annual Sea-blite	*Suaeda linearis*	3	0	0	0
Bearded Flatsedge	*Cyperus squarrosus*	0	0	0	1
Bull Thistle	*Cirsium vulgare*	1	1	0	0
Common Evening-primrose	*Oenothera biennis*	4	4	0	0
Common Reed	*Phragmites australis*	4	3	2	4
Dune Sandbur	*Cenchrus longispinus*	1	0	0	0
Goosegrass	*Eleusine indica*	0	0	2	1
Groundsel Bush	*Baccharis halimifolia*	0	2	0	0
Horseweed	*Erigeron canadensis*	4	1	0	0
Marsh Elder	*Iva fructescens*	6	5	0	0
Marsh Orach	*Atriplex patula*	5	1	0	0
Mat Sandbur	*Cenchrus longispinus*	1	0	0	3
Pickleweed	*Salicornia virginica*	8	3	1	1
Prickly Lettuce	*Latuca serriola*	1	0	0	0
Saltmarsh Mallow	*Kosteletzkya virginica*	0	1	0	0
Saltmarsh Sand-spurry	*Spergularia marina*	0	0	0	1
Saltmeadow Cordgrass	*Spartina patens*	1	0	0	0
Seashore Saltgrass	*Distichlis spicata*	6	7	2	1
Seaside Goldenrod	*Solidago sempervirens*	17	12	0	0
Sheep's Sorrel	*Rumex acetosella*	1	2	0	0
Slender Crabgrass	*Digitaria filiformis*	14	5	2	5
Smooth Cordgrass	*Spartina alterniflora*	6	8	1	5