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Relationships of Nest-Site Selection and Nest Success of Saltmarsh Sparrows (*Ammospiza caudacuta*) in Upper Narragansett Bay, Rhode Island

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Abstract

This report summarizes results after 4 years (2017–2020) of a 5-year, comprehensive field study of Saltmarsh Sparrow breeding ecology and reproductive success in a 10-ha salt marsh in upper Narragansett Bay. We found 153 active nests and documented outcomes for 152: 55 (36%) failed due to flooding, and 42 (28%) failed due to predation. Nest success (as defined by at least one chick fledging from a nest) averaged 28% over four years, with a range of 24% (2020) to 38% (2017). We banded 316 Saltmarsh Sparrows, 48% of which were adults. As is typical for the species, most Saltmarsh Sparrows nested in marsh habitats dominated by grasses: 59% of nests were placed at sites dominated by stands or mixtures of the "salt meadow" grasses (*Spartina patens, Distichlis spicata, Juncus gerardii*), and 18% of nests were placed in salt meadow grasses mixed with *Spartina alterniflora*. Sparrows selected nest sites in *S. patens* more frequently than would be expected based on that species' abundance on the marsh. Unlike findings from other published studies, Saltmarsh Sparrows at our study site nested regularly (24%) at the base of, or within 15 cm of, the erect, woody stems of *Iva frutescens*, and nest success in that microhabitat (38%) was significantly greater than at sites lacking *I. frutescens* plants (22%). Based on these findings, we suggest that on salt marshes targeted for management activities to combat the negative impacts of sea-level rise, sparrow biologists work in concert with marsh-restoration specialists to strategically place spoils from restoration operations so as to promote the growth of patches of *I. frutescens* for use by nesting sparrows.

Introduction

The Saltmarsh Sparrow (*Ammospiza caudacuta*, Fig. 1) breeds in patches of healthy salt marsh from Virginia to Maine—and nowhere else on the globe (Greenlaw et al. 2020). Its reliance on low-lying coastal habitats renders it vulnerable to the impacts of sea-level rise by two fundamental mechanisms: (1) sea-level rise is driving increased tidal inundation and erosion of saltmarsh (Donnelly and Bertness 2001, Raposa et al. 2017, Eckberg et al. 2017, Watson et al. 2017, Adamowicz et al. 2020), as well as changes to vegetation, specifically replacement of the Saltmarsh Sparrow's favored high-marsh nesting vegetation types (*Spartina patens, Distichlis spicata, Juncus gerardii*) with *Spartina alterniflora*—the dominant low-marsh grass; and (2) increased frequency of nest-flooding events (DiQuinzio et al. 2002, Bayard and Elphick 2011, Ruskin et al. 2017). These two factors have decimated Saltmarsh Sparrow populations during the past two-plus decades. Field et al. (2017) conducted Saltmarsh Sparrow

Figure 1. Adult Saltmarsh Sparrow perched in a high-tide bush at the Jacob's Point study site. Note the aluminum federal band and three plastic color-bands (photo by Deirdre Robinson).

population simulations focusing on the frequency of marsh-flooding tides in conjunction with sea-level rise. Their models estimated species extinction as soon as 2035. Roberts et al. (2019) simulated sea-level-rise scenarios at their New Jersey study sites and predicted that Saltmarsh Sparrows are likely to become extinct there by 2050. Towards saving the species, the Atlantic Coast Joint Venture's (ACJV; www.acjv.org) Salt Marsh Bird Conservation Plan (Hartley and Weldon 2020) calls for teams of marsh managers and biologists to implement marsh restoration actions to improve habitat conditions for Saltmarsh Sparrows. Here, we (Saltmarsh Sparrow Research Initiative [SSRI]; www.SALSri.org) present results after 4 years of our intensive 5-year study of Saltmarsh Sparrow breeding ecology in a 10-ha (25-acre) salt-marsh study site in upper Narragansett Bay, Rhode Island. In this preliminary report, we focus on the habitat characteristics associated with successful nests, and discuss the management implications of those findings. In particular, we build on the proposal of Adamowicz et al. (2020) to mound spoils (excavated from runnel construction and ditch-clearing operations) over high-marsh grasses to create elevated marsh habitat for use by nesting Saltmarsh Sparrows. Subsequent reports, following the collection of our fifth year of field data in 2021, will address the population density, nesting success, and inter-annual survival of the sparrows in our study population.

Figure 2. Aerial view of the Jacob's Point salt marsh during a "king tide" in October 2020. Tides of this magnitude, which would inundate every Saltmarsh Sparrow nest on the marsh, will occur with greater frequency as sea levels rise in the years ahead (drone photo by Butch Lombardi).

Study Site Description

Jacob's Point (41°42′45″ N, 71°17′18″ W) is a 16-ha estuarine wetland bordering the east shore of the Warren River on upper Narragansett Bay (Fig. 2). A narrow sand/upland-barrier ridge separates the marsh from the bay. Tidal waters enter the marsh via two channels that breach the ridge and flow east and south respectively, into the marsh interior. The extreme southern segment of the marsh is separated from the larger wetland by an elevated roadbed. Tidal flow is maintained to this southern tract via three 1.5-m culverts running north-south beneath the road-bed along the courses of the original marsh channels. The marsh is dominated by "salt meadow" communities of the high marsh—stands or mixed communities of *Spartina patens* (salt marsh hay), *Distichlis spicata* (spike grass), and *Juncus gerardii* (black grass) (Fig. 3). In the eastern half of the marsh that is south of the road-bed, the salt meadow community intergrades with the shrubby high-tide bush (*Iva frutescens*) in areas of relatively high marsh-surface elevation. High-tide bush occurs in dense patches bordering higher-elevation habitats (back-dune shrub and *Phragmites australis*, common reed) at the marsh edge, as "islands" of various sizes (~10–100 m^2) within expanses of salt-meadow habitat, or as scattered plants and clumps interspersed among the salt-meadow grasses. Salt-marsh cordgrass *(Spartina alterniflora)* occurs in two forms at Jacob's Point: (1) a tall form (>1 m) that grows within the regularly flooded intertidal zone along the upper elevations of creek and ditch banks ("low marsh"); and (2) a shorter form (<1 m), "high-marsh cordgrass", which grows in monotypic patches on the high marsh, or mixes with salt meadow grasses. Our study area encompassed 10.04 ha of the larger 16-ha wetland complex, as we excluded brackish-marsh stands dominated by *P. australis* and *Typha latifolia*

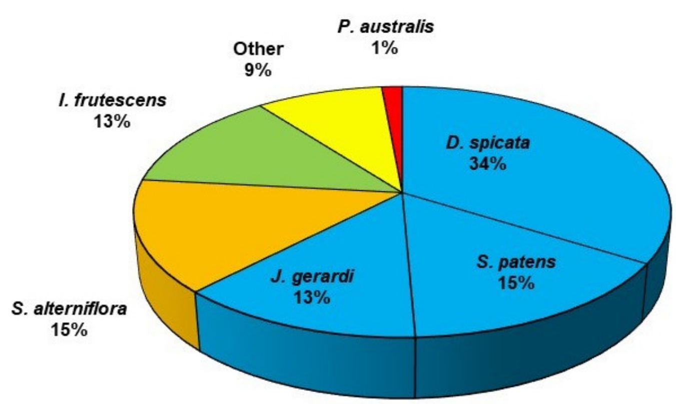

Figure 3. Relative abundance of the principal habitat types at Jacob's Point study marsh. Blue slices (*D. spicata*, *S. patens*, and *J. gerardii)* represent high-marsh short-grass habitats that combine to form the Saltmarsh Sparrow's preferred "salt meadow" nesting habitat. Data are from 1-m^2 plots placed at 68 random points during 2020.

(common cattail), which were not used by Saltmarsh Sparrows.

Methods

During 2017–2020 we captured adult and free-flying juvenile sparrows using mist nets (four to seven nets, 6-m and 12-m sizes). We set nets in arrays to capture roaming adults, primarily (1) perpendicular to tidal channels where they often foraged, and (2) near nests to capture attending females. We set mist-nets during 19 days between 23 May and 7 August 2017, 17 days between 25 May and 11 August 2018, 22 days between 22 May and 12 August 2019, and 26 days between 20 May and 12 August 2020. To allow resighting of individuals via binoculars or photography, we used plastic color-bands (XCSD Darvic leg bands, 2.8-mm inside diameter) to individually mark birds. We marked all adult Saltmarsh Sparrows with a federal metal band plus a unique combination of three color-bands. During 2019 and 2020, we marked nestling sparrows between nest-days 5 and 8 in like fashion; however, in 2017 and 2018 nestlings were equipped with one metal band only, or one metal band and one color-band.

Nests were located by flushing females off them, or by observing female sparrows as they fed nestlings or removed fecal sacs from nests. Nests were marked with small, low-set flags 1 m to the east and west. Nests were typically checked every other day, with nest contents and evidence of flooding or depredation recorded. During lunar-driven flood-tide cycles, however, we monitored nests daily so that we could accurately associate nest fates with tidal amplitude as measured at a local tide gauge. During every day of our field season, team members resighted and photographed banded sparrows to estimate return rates and population size, and such efforts continued through October during 2018 and 2020.

To limit disturbance to nesting females, we assessed nest-site vegetation after a nest was no longer active. In the 2017–2019 seasons, we visually estimated the percent cover of each vegetative species within a circular 0.125-m^2 (40-cm diameter) plot centered over each nest—at 150 of 153 nests during the 4 years. Beginning with the 2020 breeding season, we added standardized Saltmarsh Habitat and Avian Research Program (SHARP) protocol for nest-vegetation sampling within 1-m^2 plots at each of the 68 nests found, and at a paired, randomly located point for each nest, following Kocek et al. (2019). Within each plot, we estimated the percent cover of each species of vegetation (noting the percentage of dead and living stems per species), and the percent cover of wrack, bare substrate, and standing water. We also measured structural characteristics of the nest (within 3 days of a nest being found to minimize error associated with nest monitoring), including height of the lip of the nest from the substrate, the distance between the substrate and the bottom of the nest, and a quantitative assessment of the vegetative cover over the nest. To quantify the extent of cover over the nest, we placed a 6-cm diameter white disk above the eggs within the nest-bowl, then estimated the percent of the disc viewable from directly above the nest. Finally, we measured the distance from the nest perimeter to the nearest erect stem of *I. frutescens* for all nests in the sample.

Statistical methods

We used the independent-samples t-test (with adjustment for unequal variances where appropriate) to compare (1) percent-cover values of vegetation types between nest sites and randomly placed plots, (2) distance to nearest *Iva frutescens* between successful and unsuccessful nests, and (3) percent-cover values of vegetation types between successful and unsuccessful nests. We used the Chi-square test to compare the frequencies of occurrence of vegetation types between nests and random plots and successful and unsuccessful nests. Based on the number of statistical tests assessed in this paper (19 tests), we use $\alpha = 0.03$ as the threshold for statistical significance.

Results

Saltmarsh Sparrows arrived at our Narragansett Bay study site in mid-May. Nesting began in late May and continued into mid- to late August each year. During 2020, the year during which we compiled the most complete nesting record, the earliest first-egg date was 22 May, and the latest was 9 August (79 days); that nest fledged young on 31 August. Banded adult males remained on the marsh as late as 15 October during fall monitoring in 2018, and two fledglings banded in the nest during 2020 remained on the marsh as late as 17 October and 21 October of the same year.

We banded 316 Saltmarsh Sparrows in four years, 49% of which were adults. The sex ratio of captured adults was 1.6 males:1 female (62% male), ranging from 57% male captures in 2019 to 69% in 2018. Based on the numbers of banded adult sparrows at our site, we have a high degree of confidence in estimating that 40–45 females occupy our 10-ha study plot, and that 50–60 males are at least part-time breeding-season residents.

Nest habitat selection

Only two of the four vegetation types showed significant differences in percent cover between nest sites and random plots (Fig. 4). *S. patens* occurred in significantly greater abundance at nests ($\bar{x}$ = 33.3%) than in random plots ($\bar{x}$ = 16.4%) (Table 1). *J. gerardii* occurred in a significantly higher proportion of nest plots (41.3%) than randomly placed plots (25.0%). No other nest vs. random-point comparisons exhibited statistical significance (Table 1). Atypically, sparrows placed 37 (24%) of 152 nests within 15 cm of the nearest vertical stem of *I. frutescens* (hereafter "*Iva*") and directly at the base of an *Iva* plant at 26 of those (17%). Nests near *Iva* typically occurred by single plants growing among salt-meadow grasses, or within 1 m of the edge of salt-meadow habitat in *Iva* "islands" or stands occurring along the marsh edge.

Table 1. Comparisons of nests and random plots (RPs), as expressed by percent cover and percent frequency of occurrence of vegetation types (RPs, *n* = 68; Nests, *n* = 150).

Plant Species	Mean percent cover			Mean percent occurrence		
	Nests	RPs	P^1	Nests	RPs	P^2
S. alterniflora	5.8	11.1	0.09	20.6	30.9	0.10
S. patens	33.3	16.4	<0.001	50.0	41.2	0.23
D. spicata	35.5	35.7	0.97	84.0	82.4	0.76
J. gerardii	16.0	12.0	0.29	41.3	25.0	0.02
I. frutescens	8.2	11.5	0.34	24.2	27.9	0.55
P. australis	0.5	0.3	0.62	3.3	7.4	0.19

[1]Independent-samples t-test; [2]Chi-square test.

Reproductive success

We found 153 active Saltmarsh Sparrow nests during our four years of field work; and assessed nest outcome for all but one. Of 152 nests, 44 (29%) fledged at least one young (a "successful nest"); females averaged 0.51 successful nests, 0.86 fledglings/nest, and 1.26 fledglings/female/ season (fecundity). The smallest complete clutch size documented was 2 (n = 1); mean clutch size (± SD) for 152 clutches was 3.75 ± 0.81 (range = 2–5; mode = 4). Tidal flooding destroyed 57 (38%) of 152 nests, and destroyed partial nest contents at an additional 11 nests (7%) that fledged young. Predation events destroyed 42 (28%) nests, and destroyed partial nest contents in an additional 8 nests (5%) that fledged young. We have no direct observations to identify the predators responsible, although we believe that birds are mainly responsible since there is little damage to the nests. Of depredated nests, 39% were in the nestling stage when destroyed, and 54% in the incubation stage; of flooded nests, 38% were in the nestling stage when destroyed, and 57% in the incubation stage.

Significant relationships between nest success and vegetation cover type were found only for *J. gerardii* and *I. frutescens* (Fig. 5). Presence of *J. gerardii* was associated with nest failures: percent cover was 19% at unsuccessful nests and 8% at successful nests (t = 2.36, P = 0.02); 19% of

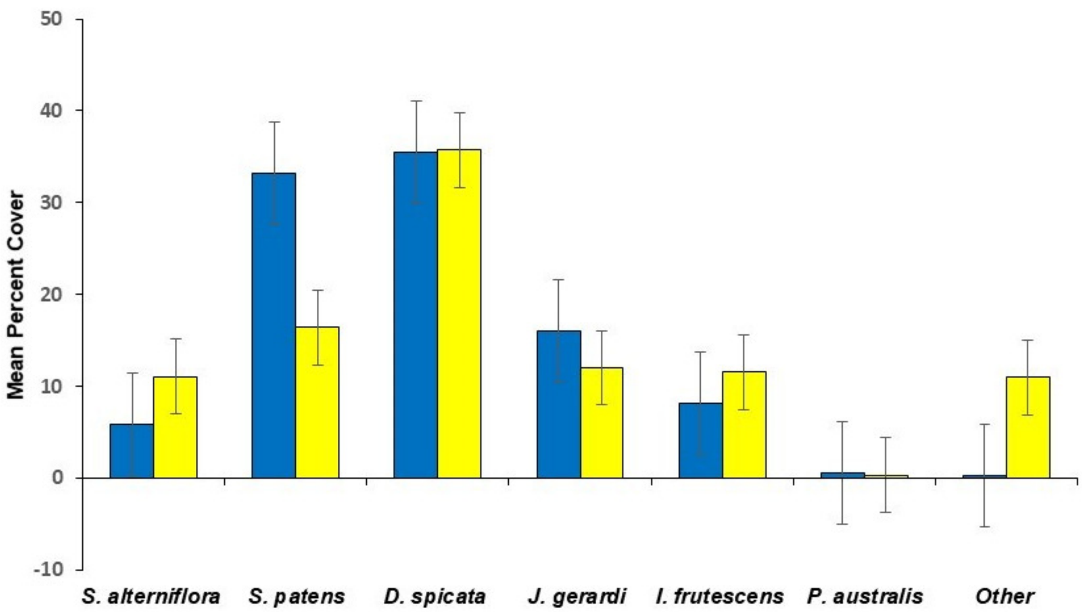

Figure 4. Mean percent cover (and standard error) of salt marsh habitat types within 0.125-m2 plots centered over 150 nests (blue bars), and within 0.125-m2 plots placed at 68 random points (yellow bars).

62 nests with *J. gerardii* present in the plot were successful, vs. 34% of 89 nests with no *J. gerardii* present ($X^2 = 3.7$, $P = 0.05$).

Iva frutescens was associated with positive nest outcomes. Successful nests were placed a mean of 4.4 m (± 8.9) from nearest *Iva*; unsuccessful nests were placed 7.2 m (± 8.9) from nearest *Iva* ($t = 1.75$; $P = 0.08$). Of 60 nests placed within 1 m of the nearest *Iva* plant, 38% were successful, vs. 22% success for 93 nests placed beyond 1 m of the nearest *Iva* plant ($X^2 = 4.9$; $P = 0.03$). Similarly, 38% of 37 nests with *Iva* occurring within the plot (i.e., lying within 15 cm of the edge of the nest) were successful, vs. 25% of 115 nests where *Iva* was absent from the plot ($X^2 = 3.20$; $P = 0.07$). The mean percent cover of *Iva* within the plots of successful nests was 9.8%, vs. 7.6% within the plots of unsuccessful nests ($t = -0.63$; $P = 0.74$).

A breakdown of nest outcomes by successful/depredated/flooded (excluding 9 nests with fates of failed-unknown, abandonment, and lost to a rain-flood) reveals a possible flooding/predation trade-off for females selecting *Iva* at their nests. Nests with *Iva* occurring within the 0.125-m^2 plot demonstrated outcomes of 43% successful, 34% predation, and 23% flooded; nests with *Iva* absent in the plots were 27% successful, 28% depredated,and 45% flooded. Thus, nests near *Iva* may benefit from fewer flooding events due to higher substrate elevations, but be rendered more vulnerable to predation. Consistent with this notion, we analyzed the percent visibility of nests and determined that of 7 nests where *Iva* was the tallest vegetation over the nest, visibility was 51%, vs. 33% visibility at 47 nests with no *Iva* at the nest site ($t = 1.50$; $P = 0.14$).

Discussion

Nest habitat selection and nest success

Our results demonstrate that mixtures of the salt-meadow grasses *S. patens, D. spicata,* and *J. gerardii* formed the dominant cover at 59% of nests, and these plant species occurred with *S. alterniflora* at an additional 18% of nests. This habitat-use pattern is typical for Saltmarsh Sparrows range-wide (e.g., Hartley and Weldon 2020, Greenlaw et al. 2020), and has also been exhibited in Narragansett Bay marshes (DeRagon 1988). Our finding that *S. patens* was selected for nest cover by female sparrows is consistent with findings reported by Greenlaw et al. (2020): "Marsh floristics are important for nest patch selection, with birds generally found in areas dominated by *S. patens*. . ."

Other plant species at our site were generally used for nest cover in proportion to their relative abundance. This included, atypically, the shrubby plant *Iva frutescens,* which was present within 24% of nest-plots, and which formed the dominant cover type within 23% of nest-plots. A review of the literature reveals few reports of Saltmarsh Sparrows nesting in *Iva* habitats. Elliott (1962) recorded a single nest in high-tide bush at his Long Island, New York, study area, and DeRagon (1988) found 3 nests (1.5% of 199 nests) in *Iva* among his 4 Narragansett Bay study sites (all 3 at Rumstick Point, just 900 m from our Jacob's Point study marsh).

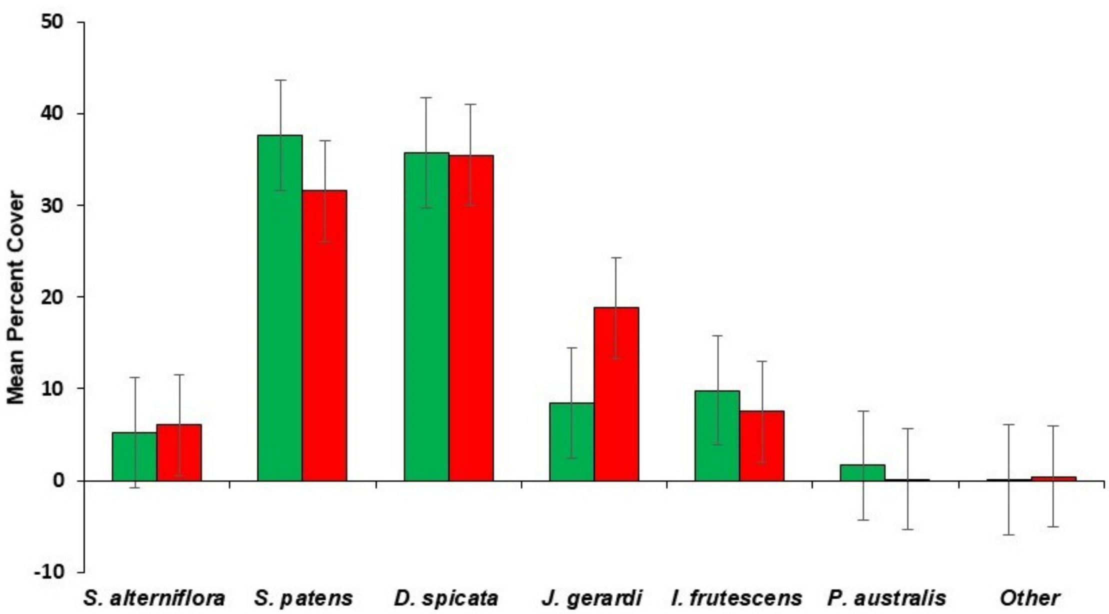

Figure 5. Mean percent cover (with standard errors) of salt marsh habitat types within plots at 41 successful nests (green bars), and 108 unsuccessful nests (red bars).

The percent cover of *J. gerardii* at unsuccessful Saltmarsh Sparrow nests was more than twice that at successful nests. This finding is counter to the conclusion of Hartley and Weldon (2020) that the presence of *J. gerardii* is an indicator of low nest-flooding rates. This rush has a widespread distribution across our study site, and it is likely present at varying substrate elevations. Although we do not report here on nest-site elevations (which we have collected since 2018), we can report that where *J. gerardii* was present in a nest-plot with *I. frutescens*—a plant known to occur at relatively high elevations on the high marsh (e.g., DeRagon 1988)—43% of nests were successful, vs. 25% at nests where *I. frutescens* did not occur in the plot.

In this report we reveal the relatively high use of *Iva* at our study site, and present substantial evidence demonstrating that sparrows nesting at the base of, or in close proximity to, that shrubby plant yield a relatively high proportion of successful nests. We believe that this effect is related to the relatively high substrate elevation of *Iva* stands. Indeed, DeRagon (1988) measured relative substrate elevations of nests in 3 habitat types at his Narragansett Bay study sites: salt meadow (n = 155) 5.3 cm; salt meadow/*S. alterniflora* (n = 17) 2.4 cm; *Iva* (n = 3) 7.0 cm.

Management implications

Ruskin et al. (2017) and Roberts et al. (2019) recommend that salt-marsh conservation/management efforts designed to enhance Saltmarsh Sparrow populations should target site-specific causes of nest failure. At Jacob's Point, tidal flooding and predation destroyed 38% and 28% of nests, respectively, resulting in the production of only 1.26 chicks fledged per female per year—a fecundity value that is likely insufficient to maintain the population. A management plan targeting both factors would optimize probabilities of population survival at this site.

Predation-control strategies for marsh sparrows have been discussed in detail by Roberts et al. (2019). They suggest that the responsible predators at the Forsythe National Wildlife Refuge in southern New Jersey include a variety of mammals and birds—raccoon (*Procyon lotor*), river otter (*Lontra canadensis*), red fox (*Vulpes vulpes*), American mink (*Neovison vison*), meadow vole (*Microtus pennsylvanicus*), great blue heron (*Ardea herodias*), laughing gull (*Leucophaeus atricilla*), herring gull (*Larus argentatus*), great black-backed gull (*L. marinus*), fish crow (*Corvus ossifragus*), American crow (*C. brachyrhynchos*), marsh wren (*Cistothorus palustris*), and red-winged blackbird (*Agelaius phoeniceus*). Our list of "suspects" at Jacobs Point also includes common grackles (*Quiscalus quiscula*) and rails. Post and Greenlaw (1989) reduced predation at Seaside Sparrow (*Ammospiza maritima*) nests with metal barriers placed around nests. Pilot experimentation at Jacob's Point may become a goal for our project beginning with the 2022 breeding season. Managers, however, must always act carefully and deliberately while accounting for potential interactions and unintended consequences to insure than any management intervention results in a net benefit to the population (Ruskin et al. 2017, Roberts et al. 2019).

In the decade prior to the initiation of our study, tidal-flow restoration and impounded surface-water drainage projects—via "runnel" (shallow-channel) excavations—were conducted at Jacob's Point (Adamowicz et al. 2020), and such excavations are expected to continue after our field investigations are completed by fall 2021 (W. Ferguson, Save The Bay, pers. comm.). If so, we suggest implementation of habitat-enhancement techniques proposed by Adamowicz et al. (2020, p. 193)—that the spoils resulting from channel excavation "be repurposed to create Saltmarsh Sparrow nesting microhabitat by placing the sediments over live plants over 4 by 8 foot [1.2 m by 2.4 m] 'islands' (32 square feet [3 m^2]). This step provides safer nesting habitat [for breeding female sparrows]." Based on our findings of relatively high success rates for nests placed within shrubby *Iva* habitats, we suggest that, in a pilot-project approach, (1) marsh islands be created with excavation spoils placed within expanses of high-marsh grasses, and engineered such as to promote growth of *Iva,* and (2) that the size, location, and configuration of the spoil-islands be decided in consultation with biologists who are well versed in local Saltmarsh Sparrow habitat preferences. (W. Ferguson, Save The Bay, relates that her restoration team successfully created such *Iva* islands at Jacob's Point during restoration work conducted in 2015.)

Although Saltmarsh Sparrows nested commonly in or near *Iva* plants or stands, they did so less often than predicted by its abundance on the marsh (Fig. 2). Thus, there is no assurance that sparrows will nest in stands created. Nevertheless, because of the greater success we documented for nests placed in *Iva*, we suggest that it is worth an experimental effort to see if artificially constructed stands would be used by nesting sparrows. The strategies for individual nest protection described by Hartley and Weldon (2020, p. 65) include "placing a structure next to the nests to facilitate young birds climbing up to avoid flooding…". Indeed, the robust life-form of *Iva* plants may provide such a function, which in combination with the relatively high elevation of the substrate may explain the relatively high nest success in *Iva* stands.

Consistent with the monitoring efforts called for in the Atlantic Coast Joint Venture's (ACJV) conservation plan (Hartley and Weldon 2020), our Jacob's Point study marsh will be used as a Narragansett Bay benchmark site for the monitoring of marsh-restoration actions and Saltmarsh Sparrow demographics as rising sea levels encroach on the Northeast coast in the years ahead. Justifications for this include:

- At the conclusion of our Phase-1 field-work at the close of the 2021 nesting season, we will have amassed a 5-year mark-recapture dataset incorporating the breadth of nest-survival data as described in this report, and additionally, 4 years of nest, random-point, and local tide-gauge elevation data.
- ACJV recommends prioritizing conservation attention on the top 20% of ranked patches, since they are most likely to provide maximal benefit to Saltmarsh Sparrow populations over the long term. Using their "Saltmarsh Sparrow Habitat Prioritization Tool" (Reynolds 2019), ACJV has ranked Jacob's Point 10th in priority of 268 marshes state-wide in Rhode Island, and 882nd of 8,680 range-wide, which is above the 90th percentile.
- Two recent, separately executed, habitat assessments of the Jacob's Point marsh have been conducted and are available for reference (Eckberg et al. 2017, Kutcher 2019).
- In the decade prior to the initiation of our study, tidal-flow restoration and surface-water drainage projects were conducted at Jacob's Point (Adamowicz et al. 2020), and the site was included in an evaluation of tidal marsh (hydrological) restoration success across five National Estuarine Research Reserves (Raposa et al. 2018).
- Our SSRI team is already engaged in a data-sharing collaboration with a team of restoration biologists and salt-marsh ecologists (Adamowicz et al. 2020) who are using Jacob's Point as a reference marsh for (1) investigations of high-marsh habitat enhancement by tidal-creek maintenance and runnel excavation (Adamowicz et al. 2020), and (2) impacts of historically constructed embankments—from farming practices—on high-marsh habitats (Adamowicz et al. 2020).

The Saltmarsh Sparrow Research Initiative (www.SALSri.org for contact information) welcomes suggestions from investigators in the ACJV/SHARP community as to how our data and study site can be used towards the development and enhancement of conservation efforts for this imperiled species.

Acknowledgments

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Literature Cited

Adamowicz, S.C., G. Wilson, D.M. Burdick, W. Ferguson, and R. Hopping. 2020. Farmers in the marsh: Lessons from history and case studies for the future. *Wetland Science & Practice* 183:182–195.

Bayard, T.S. and C.S. Elphick. 2011. Planning for sea-level rise: Quantifying patterns of Saltmarsh Sparrow (*Ammodramus caudacutus*) nest flooding under current sea-level conditions. *Auk* 128:393–403.

DeRagon, W.R. 1988. Breeding ecology of Seaside and Sharp-tailed Sparrows in Rhode Island salt marshes. MS thesis. University of Rhode Island, Kingston, RI.

DiQuinzio, D.A., P.W. Paton, and W.R. Eddleman. 2002. Nesting ecology of Saltmarsh Sharp-tailed Sparrows in a tidally restricted salt marsh. *Wetlands* 22:179–185.

Donnelly, J.P., and M.D. Bertness. 2001. Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. *Proceedings of the National Academy of Sciences* 98:14218–14223.

Eckberg, M.L.C., K.B. Raposa, W.S. Ferguson, K. Ruddock, and E.B. Watson. 2017. Development and application of a method to identify salt marsh vulnerability to sea level rise. *Estuaries and Coasts* 40:694–710.

Elliott, J.J. 1962. Sharp-tailed and Seaside Sparrows on Long Island, New York. *Kingbird* 12:115-123.

Field, C.R., T.S. Bayard, C. Gjerdrum, J.M. Hill, S. Meiman, and C.S. Elphick. 2017. High-resolution tide projections reveal extinction threshold in response to sea-level rise. *Global Change Biology* 23:2058–2070.

Greenlaw, J. S., C.S. Elphick, W. Post, and J.D. Rising. 2020. Saltmarsh Sparrow *(Ammospiza caudacuta), version 1.0. In: P.G. Rodewald (ed). Birds of the World. Cornell Lab of Ornithology, Ithaca, NY.* https://doi.org/10.2173/bow.sstspa.01. Accessed 9 December 2020.

Hartley, M.J. and A.J. Weldon, eds. 2020. Saltmarsh Sparrow Conservation Plan. Atlantic Coast Joint Venture. https://www.acjv.org/documents/SALS_plan_final.pdf. Accessed 9 December 2020.

Kocek, A., K. Ruskin, E. Patterson, and B. Olsen. 2019. Nest Vegetation Measurements Standard Operating Procedure. Saltmarsh Habitat and Avian Research Program (SHARP). https://www.tidalmarshbirds.org/?page_id=1595. Accessed 9 December 2020.

Kutcher, T.E. 2019. Salt marsh rapid assessment method, MarshRAM: analysis and application. Technical report to the Rhode Island Department of Environmental Management. Rhode Island Natural History Survey, Kingston, RI.

Post, W., and J.S. Greenlaw. 1989. Metal barriers protect near-ground nests from predators. *Journal of Field Ornithology* 60:102–103.

Raposa, K.B., R.L. Weber, M.L. Cole Ekberg, and W. Ferguson. 2017. Vegetation dynamics in Rhode Island salt marshes during a period of accelerating sea level rise and extreme sea level events. *Estuaries and Coasts* 40:640–650.

Raposa, K.B., S. Lerberg, C. Cornu, J. Fear, N. Garfield, C. Peter, R.L.J. Weber, G. Moore, D. Burdick, and M. Dionne. 2018. Evaluating tidal wetland restoration performance using National Estuarine Research Reserve System reference sites and the restoration performance index (RPI). *Estuaries and Coasts* 41:36-51.

Reynolds, D. 2019. Saltmarsh Sparrow Habitat Tool, Habitat Restoration Initiatives, Atlantic Coast Joint Venture. https://fws.maps.arcgis.com/apps/MapSeries/index.html?appid=1bc5b29be4ac43d8949b2941d2ce5174. Accessed 31 December 2020.

Roberts, S.G., R.A. Kern, M.A. Etterson, C.S. Elphick, B.J. Olsen, and W.G. Shriver. 2019. Preventing local extinctions to tidal marsh endemic sparrows in Eastern North America. *Condor 121:1–14.*

Ruskin, K.J., M.A. Etterson, T.P. Hodgman, A.C. Borowske, J.B. Cohen, C.S. Elphick, C.R. Field, R.A. Longenecker, E. King, A.R. Kocek, A.I. Kovach, K.M. O'Brien, N. Pau, W.G. Shriver, J. Walsh, and B.J. Olsen. 2017. Demographic analysis demonstrates systematic but independent spatial variation in abiotic and biotic stressors across 59 percent of a global species range. *Auk* 134:903–916.

Watson, E.B., C. Wigand, E.W. Davey, H.M. Andrews, J. Bishop, and K. B. Raposa. 2017. Wetland loss patterns and inundation-productivity relationships prognosticate widespread salt marsh loss for southern New England. *Estuaries and Coasts* 40:662–681.

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