BREEDING ECOLOGY OF
SEASIDE AND SHARP-TAILED SPARROWS
IN RHODE ISLAND SALT MARSHES

BY

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THESIS ABSTRACT

The breeding ecology of Seaside (Ammodramus maritimus) and Sharp-tailed Sparrows (A. caudacutus) was investigated at four Rhode Island salt marshes which differed in ditching regime, plant community composition, and abundance of open water. Seaside Sparrows exhibited a strong preference for Spartina alterniflora communities at the two marshes where they bred. High-marsh S. alterniflora stands were used most extensively at the largely unditched Hundred Acre Cove site, while low-marsh S. alterniflora was the most often used type at the ditched, Palmer River marsh. Palmer River territories were, on average, twice as large as those at Hundred Acre Cove (9010 m^2 vs. 4545 m^2), yet contained equivalent areas of S. alterniflora, the preferred foraging habitat. High-marsh S. alterniflora was also the most frequently used nesting cover at Hundred Acre Cove. At Palmer River one nest was built in S. alterniflora within an irregularly flooded, clogged ditch, and one nest was located in Iva frutescens.

In both 1981 and 1982, population density was much lower at the ditched, Palmer River site (0.11 and 0.22 males ha^{-1}, respectively) than at Hundred Acre Cove (0.55 and 0.62 ha^{-1}). The difference in relative abundance of high-marsh S. alterniflora was believed to be chiefly responsible for the differences in population density between the two sites.

Sharp-tailed Sparrow nest-site ecology and nest success was investigated at four marshes during 1981 and 1982. Nearly 80% of 199 nests were built in high-marsh graminoids (Spartina patens, Distichlis spicata, and Juncus gerardii). Nest sites in high-marsh graminoids were located only in the upper 60% of that community's elevational range which reduced the risk of nest flooding during full-moon spring tides.

Sixty-three percent of all nest failures were caused by spring tides, primarily those occurring at the new moon. Most females renested immediately after flooding, and the probability of success was found to be greatest for these nests due to the similarity in the length of the nesting cycle and lunar periodicity. At the time of the next new-moon tides, some 28-30 days after the nest was started, young sparrows either had left the nest or were old enough to climb atop the nest or vegetation and avoid drowning.

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And to my wife, Gemma..."like my heart and me, dedicated to you."

PREFACE TO THE THESIS

Approximately 90% of the area of tidal wetlands between Maine and Virginia were ditched for mosquito control between 1912 and 1938 (Bourn and Cottam 1950). Currently, 65% of Rhode Island's salt marsh area is ditched (Stoll and Golet 1983). While most researchers agree that ditching alters physical features and vegetation of salt marshes to some degree (Britton et al. 1915; Cottam et al. 1938; Stearns et al. 1940; Bourn and Cottam 1950; Miller and Egler 1950; Ferrigno 1979), the extent of impact on salt marsh biota has been widely debated (see reviews by Daiber 1982, 1986).

In 1980, Dr. Frank Golet of the U.R.I. Department of Natural Resources Science (NRS) began a 3-year study of the influence of habitat composition on salt-marsh avifauna in southeastern New England. Six marshes varying in ditching intensity and area of surface water, and located in the northern and eastern portions of the Narragansett Bay estuary, were selected for study. The specific objectives of the project were to:

1) Identify the principal physical and biological features of salt marshes that determine avian richness and abundance;
2) Isolate the specific features of salt marshes that govern their suitability as breeding habitat, wintering habitat, or migration stops for individual species of birds;
3) Demonstrate how various patterns and intensities of mosquito ditching affect those features that determine the value of salt marshes as avian habitat; and

4) Suggest ways in which mosquito ditching practices might be modified to minimize adverse impacts on birds, and possibly even enhance the quality of salt marshes as avian habitat.

Such knowledge would greatly facilitate decision-making by regulatory agencies, including the R.I. Mosquito Abatement Board, the R.I. Coastal Resources Management Council, and the U.S. Army Corps of Engineers, as they review applications to alter coastal wetlands for mosquito control or other purposes. The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service, all of whom also review coastal wetland permit applications, would likewise benefit from such research. Preliminary results from the project have been reported in Reinert et al. (1981), Stoll and Golet (1983), and DeRagon (1984).

Field data were collected through year-round avian censuses and breeding ecology studies. Steven Reinert, NRS Research Assistant, conducted weekly or biweekly censuses for two full years in order to ascertain avian richness and abundance, and to quantify habitat use by all species throughout the year. Some of Reinert's data are used in this thesis to characterize Seaside Sparrow (_Ammodramus maritimus_) habitat use.

It was my responsibility to describe the breeding biology, nest-site ecology, and territory composition of breeding species. During the summer of 1981, breeding ecology studies of all avian species were conducted at all six marshes. In 1982, I concentrated on Sharp-tailed Sparrows (_Ammodramus caudacutus_), the most numerous breeding species in 1981, and Seaside Sparrows at four of the marshes.

Two marshes (one ditched and one unditched) which had low numbers of both species in 1981 were not studied in 1982; the small amount of data (from 5 nest sites) gathered at those marshes in 1981 is not included in this thesis.

This thesis reports on specific aspects of Seaside and Sharp-tailed Sparrow breeding ecology, and is divided into three sections. Chapter 1 describes the ditching regimes and principal habitats of the four areas studied, and serves as background for the following two sections. Chapter 2 compares habitat use by Seaside Sparrows at the two study areas where this species bred, Hundred Acre Cove and Palmer River. Chapter 3 documents Sharp-tailed Sparrow nesting ecology, chronology, and nest success. Appendices to the thesis include detailed descriptions of individual nest sites and territories. Additional findings on Sharp-tailed Sparrow nest-site selection, including among-site comparisons, will be reported elsewhere.

Manuscripts follow the style recommended by the editors of the Wilson Bulletin.

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CHAPTER 1: DESCRIPTION OF STUDY AREAS

Four salt marshes adjacent to Narragansett Bay, Rhode Island, were chosen for study (Fig. 1). Sites differed in ditching intensity, abundance of ponds, and plant community composition (Table 1). Three sites (Hundred Acre Cove, Palmer River, and Rumstick Point) are within 6 km of each other in the town of Barrington. The remaining site, Seapowet, is 22 km from the others, in Tiverton.

At all sites except Seapowet, study area boundaries conformed to the natural configuration of the marshes, terminating at the upland edge on one side and low-energy tidal water on the other. At the 61-ha Seapowet marsh, a 21.3-ha section was delineated as the study area. The surrounding upland at all marshes consisted of deciduous forest and either agricultural or low-density residential land.

During the summer of 1980 a grid system was installed at all sites with the aid of a transit. Oak stakes, 2.5 cm square, were driven into the substrate at 30-m intervals. Stakes were left exposed only 30 cm above the substrate to minimize their use as either songposts by resident passerines or perches by raptors.

Plant communities and water bodies were mapped stereoscopically from 1:2400-scale false-color infrared aerial photographs taken in October 1980. Cover maps including the positions of all grid stakes were prepared at the same scale and used to plot the locations of birds and nests in the field.

Salt-marsh habitats have been broadly categorized as low marsh or high marsh according to tidal regime (Miller and Egler 1950, Redfield 1972). Low marsh is regularly flooded, the soil being alternately

Fig. 1. Location of study areas. Abbreviations for sites are as follows: HAC = Hundred Acre Cove; PRB = Palmer River; RPT = Rumstick Point; and SEA = Seapowet.

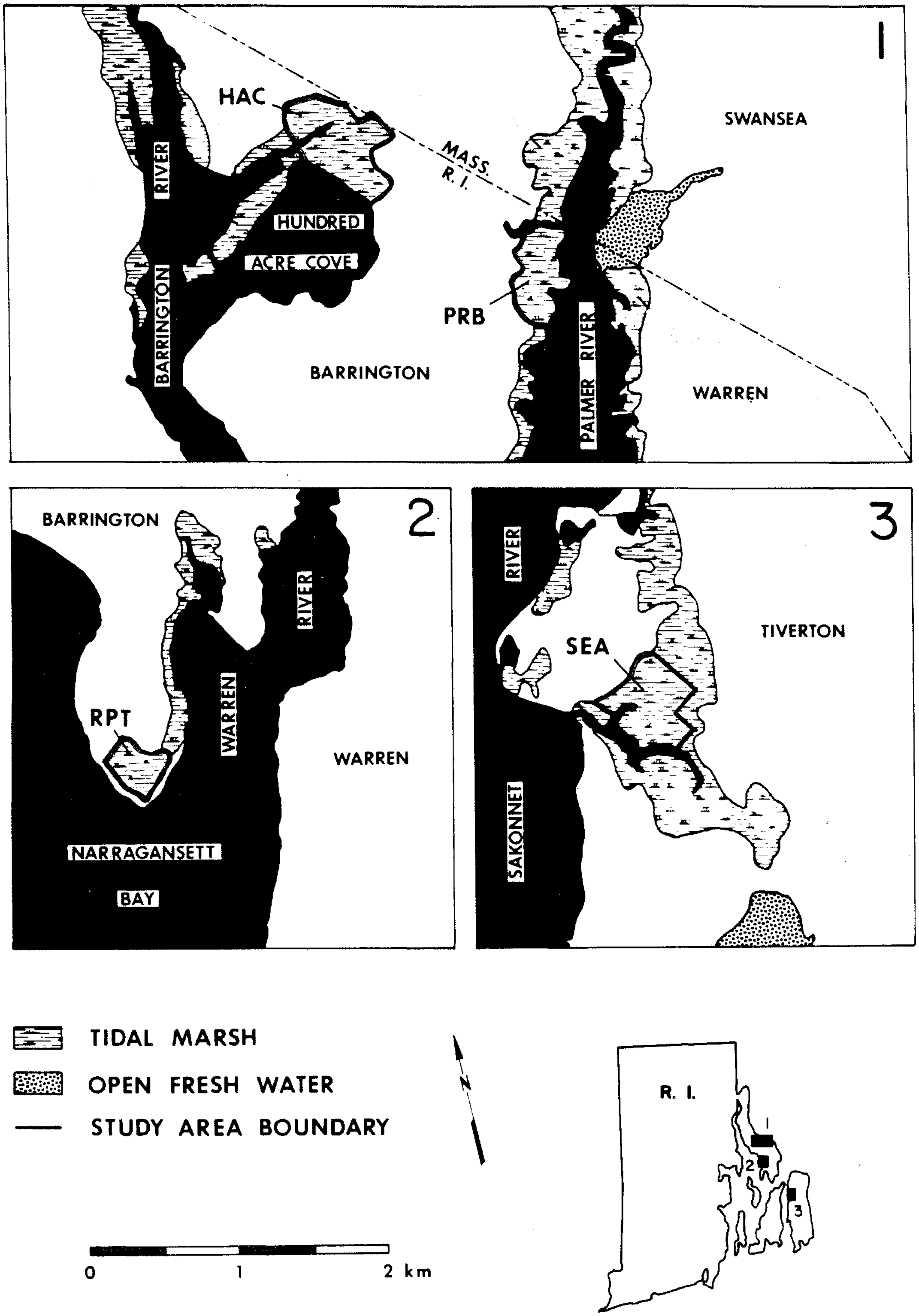
1
HAC
RIVER
BARRINGTON
HUNDRED
ACRE COVE
MASS.
R. I.
SWANSEA
PRB
PALMER RIVER
BARRINGTON
WARREN
2
BARRINGTON
RIVER
WARREN
RPT
WARREN
NARRAGANSETT
BAY
3
RIVER
SAKONNET
SEA
TIVERTON
TIDAL MARSH
OPEN FRESH WATER
STUDY AREA BOUNDARY
N
0
1
2 km
R. I.
1
2
3

Table 1
Area, ditching regime, and habitat composition of study areas.

	Seapowet	Hundred Acre Cove	Palmer River	Rumstick Point
Area (ha)	21.3	30.7	18.6	11.5
Ditching regime	unditched	partially ditched	parallel-ditched	grid-ditched
Length of creeks (m)	1507	1637	0	443
Length of ditches (m)	0	2594	2796	3256
Total channel density (m ha^{-1})	71	138	150	322
Percent of area covered by...				
High-marsh graminoids	33.8	58.7	81.6	60.0
High-marsh *S. alterniflora*	27.8[a]	20.3	4.4	0.3
Low-marsh *S. alterniflora*	18.2	7.7	8.1	22.7
Ponds	10.1	10.1	0.3	0.1
Tidal flat/open water	9.5	3.0	0.2	8.8
Iva frutescens	0.6	0.2	2.9	8.1
Salicornia	0.0	0.0	2.6	0.0

[a] At Seapowet this community includes medium-height (0.3-1.0 m) and dwarf (<0.3 m) *Spartina alterniflora*. The dwarf form was absent from other sites or did not occur in stands large enough to map.

inundated and exposed at least once daily; high marsh is irregularly flooded, i.e., inundated less often than daily (Cowardin et al. 1979). Surface water floods the high marsh on only a few days each month, during spring (new- and full-moon) tides.

Plant communities were classified according to physiognomy (life form) and tidal regime, and were named for the dominant species. Botanical nomenclature follows S.C.S. (1982). Because relatively few plant species inhabit salt marshes, plant communities frequently are monospecific. The principal habitats within the four study areas were:

1. Channels--natural creeks and man-made ditches.
2. Tidal flat/open water--unvegetated substrate which lies exposed in channels and embayments during low tide, or, alternately, open water present in those areas during high tide.
3. Ponds--water bodies located above mean high tide. Most ponds were less than 80 cm deep with a relatively firm organic bottom. Surface water was present through most of the year; however, during the summer, water levels dropped slowly between spring tides due to evaporation and infiltration, exposing the substrate for a week or more at a time. Sparse beds of the submergent *Ruppia maritima* were present in larger ponds. Dense mats of algae, primarily *Cladophora*, frequently formed on the surface during summer.
4. Low-marsh *Spartina alterniflora*--the tall form of *S. alterniflora* growing in the regularly flooded zone along the margins of channels and embayments. In the upper reaches of the Narragansett Bay estuary, low-marsh *S. alterniflora* attains a height of 1-2 m at maturity.

5. *High-marsh S. alterniflora*--irregularly flooded *S. alterniflora* stands which occupied shallow depressions within the high marsh, either as isolated patches or as bands along the margins of ponds. Medium-height (0.3-1.0 m tall) *S. alterniflora* was the most common form at the study sites; large areas of dwarf *S. alterniflora* (<0.3 m tall) were present only at Seapowet.
6. *High-marsh graminoids*--pure or mixed stands of *Spartina patens*, *Distichlis spicata*, and *Juncus gerardii*. Plants in this community were shorter and denser than *S. alterniflora*. High-marsh graminoids dominated the irregularly flooded zone of all study areas.
7. *Iva frutescens*--shrub community which occurred at the highest elevations in some marshes, both along ditches where mounds of spoil persist and along the upland edge. Stands of *I. frutescens* averaged 1.0-1.3 m tall and included *J. gerardii* and, occasionally, *D. spicata* ground cover.
8. *Salicornia*--succulent (primarily *S. europaea*) which formed nearly pure stands in shallow, high-marsh depressions at some sites, notably Palmer River. *Salicornia* also occurred in mixtures with grasses.
9. *Forbs*--non-graminoid herbaceous plants (e.g., *Limonium carolinianum*, *Solidago sempervirens*).

Seapowet, the largest salt marsh in Rhode Island, occupies a broad lowland separated from Narragansett Bay by upland promontories and is connected to the Bay via a large tidal creek. Numerous ponds of various sizes are scattered throughout this unditched marsh. Several creeks meander through the study area, resulting in a high degree of interspersion of high- and low-marsh habitats. Stands of dwarf *S.*

alterniflora, rarely found at the other study areas, occupy broad areas of the marsh. Only a few small stands of I. frutescens and J. gerardii occurred at Seapowet.

The study area at Hundred Acre Cove lies along the north and east sides of a large embayment of the Barrington River. The largely unditched central portion of this 30.7-ha marsh is dominated by a 2.7-ha pond surrounded by a 30- to 60-m band of medium-height S. alterniflora. High-marsh graminoids dominate the remainder of the marsh, particularly in the northern and southern quarters where ditches are present. Between 1976 and 1980, the Barrington Department of Public Works practiced Open Marsh Water Management (OMWM) at this site, filling small depressions, digging three radial ditches adjacent to the central pond, and cleaning and lengthening 1600 m of tidal ditches along the perimeter of the marsh (Boyes and Capotosto 1980). Except for disturbed areas immediately adjacent to newly-dug ditches, the vegetation of the marsh had not changed noticeably through 1982. Iva frutescens and J. gerardii were scarce at Hundred Acre Cove.

Along the west side of the Palmer River in Barrington lies an 18.6-ha marsh which was ditched in the early 1930s in an irregular, but generally parallel, pattern. Ditches run perpendicular to the river at intervals of 24 to 135 meters. Only one small (600-m^2) pond is present. High-marsh graminoids occupy broad areas between ditches, and are broken only by scattered stands of medium-height S. alterniflora or Salicornia. Iva frutescens borders the upland edge, and also surrounds five small (40- to 160-m^2) upland islands within the marsh. The islands support grasses, deciduous shrubs (Myrica pennsylvanica, Rhus toxicodendron), red cedar (Juniperus virginiana), and small white oak (Quercus alba) trees.

The marsh at Rumstick Point in Barrington lies behind a narrow barrier beach at the tip of a peninsula extending southward into Narragansett Bay. This 11.5-ha marsh was grid-ditched in the early 1930s. Two sets of ditches spaced at 30-m intervals crosshatch the area, resulting in a high degree of interspersion of high- and low-marsh vegetation. The inter-ditch polygons are dominated by high-marsh graminoids, primarily *S. patens* and *J. gerardii*, while the ditches support low-marsh *S. alterniflora*. *Iva frutescens* and *J. gerardii*, which border the upland edge, are most abundant at this site. Only one small (80-m^2) pond is present.

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CHAPTER 2: HABITAT USE BY SEASIDE SPARROWS (_Ammodramus maritimus_) IN RHODE ISLAND

ABSTRACT

Seaside Sparrows (_Ammodramus maritimus_) breed exclusively in salt marshes along the Atlantic and Gulf coasts and have been adversely affected by human-induced changes in these relatively scarce habitats. Breeding ecology information is lacking in New England, where widespread, intensive ditching for mosquito control has altered the cover/water patterns of marshes. The breeding ecology of Seaside Sparrows was investigated at two Rhode Island marshes which differed in ditching regime, plant community composition, and abundance of open water. General habitat use data collected during transect censuses in 1981 and 1982 revealed a strong preference for _Spartina alterniflora_ communities at both sites. High-marsh _S. alterniflora_ stands were used most extensively at the largely unditched Hundred Acre Cove site, while low-marsh _S. alterniflora_ was the type most used at the ditched, Palmer River marsh, where high-marsh _S. alterniflora_ was scarce. High-marsh graminoids, while abundant, were used little at either study area.

Territories at Hundred Acre Cove contained a higher percentage of high-marsh _S. alterniflora_ and a lower percentage of high-marsh graminoids than expected from the relative abundance of those communities. Palmer River territories were, on average, twice as large as those at Hundred Acre Cove (9010 m^2 vs. 4545 m^2), yet contained equivalent areas of _S. alterniflora_, the preferred foraging habitat.

The abundance and distribution of *S. alterniflora* was important in determining territory size and configuration.

At Hundred Acre Cove, 26 of 32 Seaside Sparrow nests were built in high-marsh *S. alterniflora*, and 6 nests were built in *Spartina patens*. Distance to nearest plant community edge was the only nest-site characteristic that differed between nest communities; *S. patens* nests were 0.2 ± 0.04 m from an edge, while *S. alterniflora* nests were 4.40 ± 0.7 m distant. The two nests found at Palmer River were in communities unlike those used at Hundred Acre Cove: *S. alterniflora* within an irregularly flooded, clogged ditch; and *Iva frutescens*.

In both 1981 and 1982, population density was much lower at the ditched, Palmer River site (0.11 and 0.22 males ha^{-1}, respectively) than at Hundred Acre Cove (0.55 and 0.62 ha^{-1}). A difference in the relative abundance of high-marsh *S. alterniflora* was believed to be chiefly responsible for the differences in population density between the two sites.

INTRODUCTION

Over one-half of the original acreage of salt marsh in the conterminous United States has been lost (Tiner 1984). The annual loss rate of coastal wetlands has increased from 0.2%, between 1922 and 1954, to 0.5% during the period from 1954 to 1974 (Gosselink and Baumann 1980). Between 1954 and 1974, 23% of the losses were due to human activities such as agriculture and urban development (Frayer et al. 1983). Outside of Louisiana, where coastal subsidence was the major cause of coastal wetland loss, losses were directly related to population density (Gosselink and Baumann 1980).

Except for one subspecies, Seaside Sparrows (*Ammodramus maritimus*) are found exclusively in salt marshes along the Atlantic and Gulf coasts (A.O.U. 1983). As a result, they have been adversely affected by both natural and human-induced changes in these relatively scarce habitats. Most notable is the extirpation of the subspecies *A. m. nigrescens* (Dusky Seaside Sparrow) from Florida's Atlantic coast. Breeding habitat was destroyed by the creation of impoundments for mosquito control (Baker 1973, Sykes 1980) and draining and burning for livestock use (Kale 1983). *A. m. pelonota*, which also inhabited Florida's Atlantic coast, was extirpated primarily as a result of the northward range expansion of mangroves (*Avicennia germinans* and *Rhizophora mangle*; Nicholson 1950, Kale 1983). The lack of Seaside Sparrow population estimates prior to 1950 makes an evaluation of their present status difficult, but there are documented instances where local populations were eliminated by filling of tidal wetlands (Howe and Sturtevant 1903, Stone 1937, Elliott 1962).

In the Northeast, ditching for mosquito control has been a major form of salt-marsh alteration. Approximately 90% of the acreage of tidal wetlands between Maine and Virginia were ditched between 1912 and 1938 (Bourn and Cottam 1950). Currently, 65% of Rhode Island's salt marsh area is ditched (Stoll and Golet 1983). Intensive ditching has drained permanent ponds and high-marsh _Spartina alterniflora_ pannes, and produced broad expanses of high-marsh graminoids (_Spartina patens_, _Distichlis spicata_, and _Juncus gerardii_) or salt-marsh shrubs (_Iva frutescens_ and _Baccharis halimifolia_; Bourn and Cottam 1950, Miller and Egler 1950).

Differences in density, food habits, nest-site selection, and territory size and composition have been demonstrated between Seaside Sparrow populations breeding in altered and marshes in New York and New Jersey (Post 1974, Burger et al. 1982, Greenlaw 1983, Merriam 1983), but, except for recent work in North Dartmouth, MA (Marshall 1986, Marshall and Reinert 1987), studies of New England populations are lacking. During the early 1980's, populations were known to occur at only 6 marshes in Connecticut (Noble Proctor, Southern Conn. State Univ., pers. comm., 1981), 5 marshes in Massachusetts (Mass. Breeding Bird Atlas data, Richard Forster, Mass. Audubon Soc., pers. comm., 1982), and 9 general areas in Rhode Island (Stoll and Golet 1983). The Merrimack River, which forms the boundary between Massachusetts and New Hampshire, is the northern range limit of the Northern Seaside Sparrow (_A_. _m_. _maritimus_).

The present investigation was initiated to gain insight into the possible influence of marsh ditching on the breeding ecology of Seaside Sparrows in southeastern New England. Such information is needed in order to assess the potential impacts of future marsh management on this species (Burger et al. 1978, Burger et al. 1982, Daiber 1982). Specific objectives were to document population size, nest-site selection, territory composition, and general habitat use at two marshes which differed in ditching regime, plant community composition, and abundance of open water.

METHODS

Bird observations began in May when Seaside Sparrows arrived in Rhode Island. Observations were made on two to three days per week between 05:00 and 13:00. Population estimates and observations on general habitat use were made in 1981 and 1982; nest-site and territory data were collected in 1982.

To facilitate the recognition of individuals, birds were captured in mist nets and marked with an aluminum U.S. Fish and Wildlife Service band on one leg and a unique combination of three colored, celluloid bands on the other leg. A total of 37 Seaside Sparrows (26 males, 10 females, 1 unknown) was marked. Sex was determined by the presence of a brood patch or cloacal protuberance (Salt 1954).

Male Seaside Sparrows were censused in 1981 and 1982 using the spot-mapping method (Williams 1936, Robbins 1970). Males were considered resident if they displayed on a territory for 21 or more days.

General habitat use was quantified using data collected by Reinert in biweekly censuses during 1981 and 1982. The plant community in which each bird was observed was recorded as the observer walked the center line of a 60-m wide belt transect. One-half of a study area (every other belt) was traversed during each census; the intervening belts were traversed on the succeeding census.

Habitat preferences were determined by chi-square goodness-of-fit analysis; the number of observations in particular plant communities was compared to the number to be expected if use was proportional to the relative abundance of those communities. Expected values were based on proportions of each site's vegetated area, (i.e., unvegetated habitats were excluded). When chi-square results were significant, preference or avoidance of particular communities was determined using Bonferroni intervals (Neu et al. 1974).

Territories of male Seaside Sparrows during May-June 1982 were delineated by plotting songpost locations on cover maps and connecting the outermost points to form the largest possible polygon (Odum and Kuenzler 1955). The areas of plant communities and open water within each territory were measured on cover maps using a compensating polar planimeter. Habitat composition of combined territories at each site was compared to the site's composition using chi-square goodness-of-fit analysis.

During 1982, nests were located by flushing attendant adults or by observing parents engaged in foraging trips to feed nestlings. Twice during the breeding season, systematic nest searches were conducted over entire study areas. Two to four persons, spaced at 10-m intervals, slowly walked parallel to grid lines to flush adults from nests.

Nest-site vegetation was quantified within a 4-m^2 circular plot centered on each nest after it was abandoned. The boundaries of plant communities and open water were sketched on a gridded diagram of the plot, and the mapped area of each polygon was later measured with a planimeter. Within each plant community, a visual estimate of the relative cover of each plant species was made to the nearest 5% of subtended area.

In addition to vegetative composition, the following parameters also were measured at nest sites:

1) Height (to nearest cm) of the nest rim above the substrate;
2) Mean and maximum vegetative cover heights, measured in late August;
3) Distance from the nest center to the nearest open water (pond and tidal flat/open water) or unvegetated patch at least 4 m^2 in size;
4) Distance from the nest center to the nearest plant community edge; and
5) Relative elevation of the substrate, determined to the nearest 0.3 cm with an electronic, infrared-beam level (Realist/David White Instruments, Menomonee Falls, WI). Absolute elevation above mean sea level (1929 datum) was calculated after surveying to nearby U.S. Coast and Geodetic Survey benchmarks.

Data were collected only at completed nests; three partly constructed nests also were found, but were not included in analyses. Missing values for some nest-site parameters resulted when nests were destroyed by flooding or could not be relocated before all measurements were made.

Data analysis was performed using SAS software (SAS Institute Inc. 1982). Yate's correction for continuity was used in chi-square analyses with one degree of freedom. When expected values were small, the validity of chi-square analyses was tested using recommendations in Roscoe and Byars (1971) and Lawal and Upton (1980). Means are reported ± one standard error (SE).

RESULTS AND DISCUSSION

Spring arrival.--When Seaside Sparrows arrived at Rhode Island salt marshes in May, channel banks were covered by new-growth low-marsh *Spartina alterniflora* less than 25 cm tall. During winter, the previous year's growth had been removed by ice-scouring and wave action, except along clogged ditches and the upper reaches of tidal channels. High-marsh *S. alterniflora* was not sheared off during winter because of its irregularly flooded tidal regime. In May, clumps of erect residual high-marsh *S. alterniflora* were scattered throughout stands of bent, but not prostrate, stems.

Dead high-marsh graminoids remained rooted in place over the winter, forming a dense, reclining thatch layer. *Juncus gerardii* was the first graminoid to exhibit significant new growth, reaching 50 cm in height by 1 June. At this time, shoots of *Spartina patens* and *Distichlis spicata* were only a few centimeters tall and had not yet overtopped the thatch layer.

Male Seaside Sparrows were first observed on 8 May 1981 (Hundred Acre Cove) and 30 April 1982 (Palmer River), and the remainder of the resident males arrived during the succeeding two weeks in each year. Upon arrival, males immediately began defending territories, using the tallest songposts available: residual S. alterniflora, driftwood, grid stakes, and, at Palmer River, Iva frutescens. Females were first observed during the third week of May in both years.

Transient male Seaside Sparrows were encountered during June of each year; three were observed at Palmer River in 1981, and one was noted at each study site in 1982. After engaging in song and territorial defense for 8 to 18 days, these males left the study areas, and therefore were not included in breeding population estimates.

Population density.--At Hundred Acre Cove, 17 and 19 males maintained territories in 1981 and 1982, respectively. Four unmated males were present each year; however, male:female ratios of 1:0.76 and 1:0.79 were not significantly different from 1:1 ($X^2 = 0.74$ and 0.66, respectively; $P>0.05$). Male density during the respective years was 0.55 and 0.62 ha^{-1}. At Palmer River, 2 males were resident in 1981, and 4 (including one unmated male) were present in 1982. Therefore, yearly male densities were 0.11 and 0.22 ha^{-1}.

In a 1982 statewide survey of singing male Seaside Sparrows, Stoll and Golet (unpubl. data; Dep. Natural Resources Science, U.R.I., Kingston) found mean densities of 0.55 ha^{-1} (range 0.02-1.14) at 14 unditched marshes and 0.14 ha^{-1} (range 0.06-0.19) at 5 ditched marshes in Rhode Island. Studies conducted in New York and New Jersey have shown that Seaside Sparrows had markedly lower densities at altered, versus unaltered, sites (Post 1974, Burger et al. 1982, Greenlaw 1983). These authors felt that the relative lack of high-marsh S. alterniflora at ditched sites was largely responsible for the observed differences in sparrow abundance.

In the present study, breeding densities were lower than reported for Seaside Sparrows outside of New England; this is not surprising since population levels of any species can be expected to decline as it nears the limits of its range. The only additional population estimate available from New England was reported by Marshall (1986), who found a male density of 0.28 ha^{-1} at a ditched marsh in southeastern Massachusetts. The majority of studies conducted south of New England have found male densities greater than 1.00 ha^{-1} at both altered (Woolfenden 1956; Post 1970b, 1974) and unaltered sites (Quay 1953; Post 1970a, 1974, 1981; McDonald 1982, 1983; Delaney and Mosher 1983).

General habitat use during the breeding season.--During both breeding seasons, Seaside Sparrows showed a strong preference for *S. alterniflora* stands; 95% of the birds observed at Hundred Acre Cove and 62% at Palmer River were in either high- or low-marsh *S. alterniflora*. The extent of use of respective *S. alterniflora* communities differed between sites. At Hundred Acre Cove, 86.4% of the observations were made in high-marsh *S. alterniflora*, while at Palmer River, where this community was scarce, low-marsh *S. alterniflora* was used most extensively, accounting for 51.4% of the observations (Table 1). High-marsh graminoids were used less than expected at both study areas, but this community was utilized much more at the ditched, Palmer River site (27.0% of observations) than at Hundred Acre Cove (3.2%).

In several studies of Northern Seaside Sparrow populations at sites where high-marsh *S. alterniflora* was relatively abundant, it was the

Table 1
Use of salt-marsh plant communities by Seaside Sparrows during the breeding season (1 May-15 August), 1981-1982

	Proportion of vegetated marsh area	Proportion of birds observed in each community	95% Family confidence interval on proportion observed
Hundred Acre Cove (N = 125 observations):			
High-marsh graminoids	0.676	0.032 -[a]	0 ≤ p ≤ 0.070
High-marsh *S. alterniflora*	0.234	0.864 +	0.791 ≤ p ≤ 0.937
Low-marsh *S. alterniflora*	0.089	0.088	0.027 ≤ p ≤ 0.149
Iva frutescens	0.002	0.016	0 ≤ p ≤ 0.043
Palmer River (N = 37 observations):			
High-marsh graminoids	0.820	0.270 -	0.082 ≤ p ≤ 0.458
High-marsh *S. alterniflora*	0.044	0.108	0 ≤ p ≤ 0.240
Low-marsh *S. alterniflora*	0.081	0.514 +	0.302 ≤ p ≤ 0.725
Iva frutescens	0.029	0.081	0 ≤ p ≤ 0.197
Salicornia	0.026	0.027	0 ≤ p ≤ 0.096

[a] Signs indicate communities which were used more (+) or less (-) than expected based upon their relative abundance at each site.

preferred foraging habitat (Post 1974, Merriam 1979, Delaney and Mosher 1983, Post et al. 1983). In those altered marshes where high-marsh *S. alterniflora* was scarce, the choice of foraging habitat varied. On a ditched salt-marsh island in New Jersey, Seaside Sparrows foraged primarily along the unvegetated shoreline (Woolfenden 1956). At Tobay, NY, Post (1974) noted that birds foraged in *I. frutescens* and associated wrack during high tide (39% of observations), and along ditch banks during low tide (29%); stands of *S. alterniflora* were used 20% of the time.

The abundance and diversity of invertebrates which are the prey of Seaside Sparrows varies between habitat types. In North Carolina, Davis and Gray (1966) found the greatest abundance of salt-marsh insects in low-marsh *S. alterniflora* stands and *D. spicata*; insects were far less numerous in *S. patens* and *Juncus roemerianus*. These authors suggested that the overall insect productivity of a marsh might be correlated with the amount of *S. alterniflora* present. Post et al. (1983) found that aquatic arthropods fed to nestling Seaside Sparrows were most abundant in *S. alterniflora*.

Size and habitat composition of territories.--In May-June 1982, 18 males established territories around the central 2.7-ha pond and its peripheral high-marsh *S. alterniflora* stand at Hundred Acre Cove (Fig. 1). During the last week of June an additional, though unmated, male usurped space from established males. Because of its late settlement date, this territory was not included in statistical analyses. No territories were located in the northern or southern quarters of the marsh where cover distribution was similar to the Palmer River site

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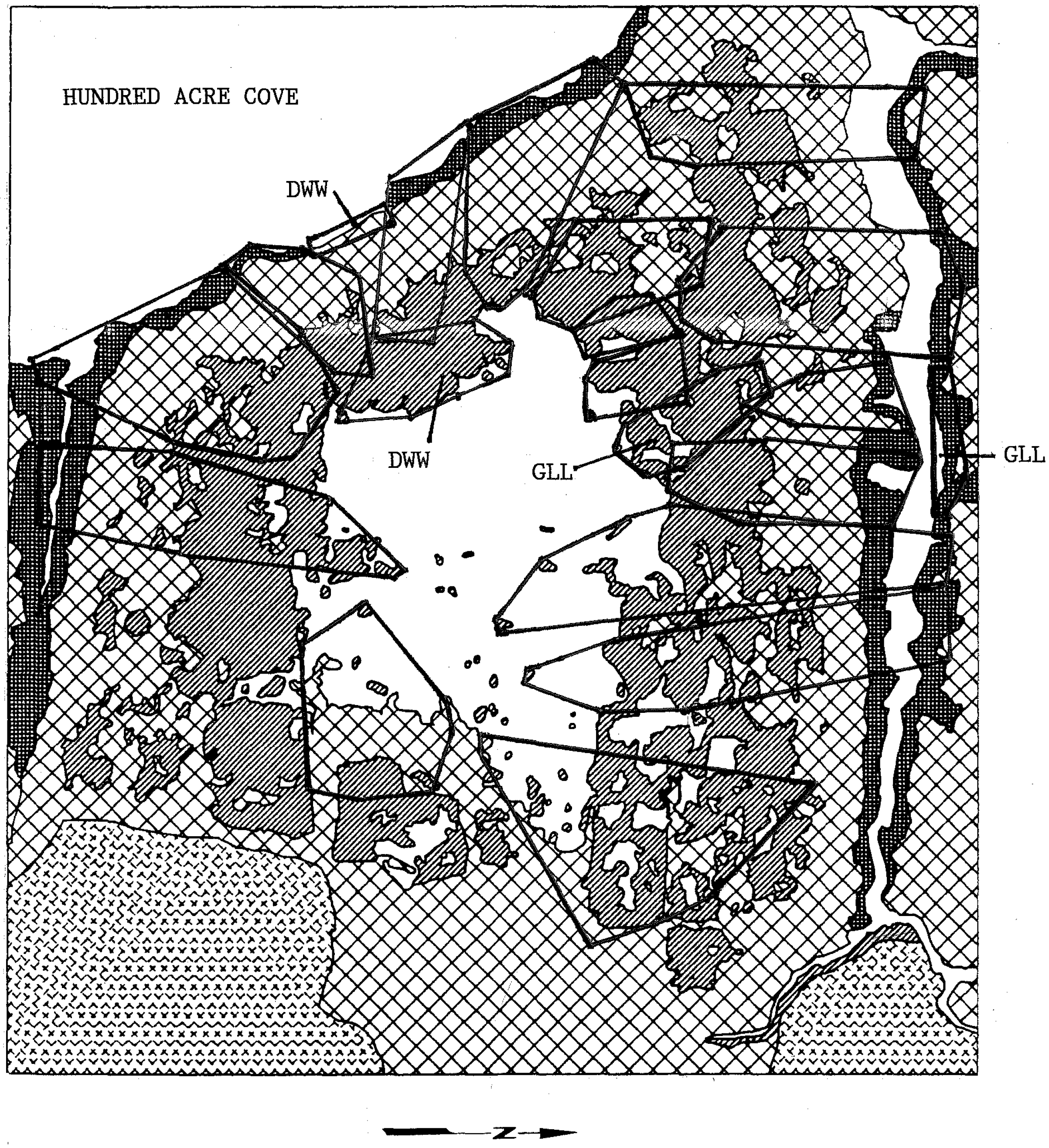
Fig. 1. Location of Seaside Sparrow territories within the central portion of Hundred Acre Cove, 1982.

- ▒ Upland
- ■ Low-marsh *S. alterniflora*
- ▨ High-marsh *S. alterniflora*
- ☒ High-marsh graminoids
- □ Open water


HUNDRED ACRE COVE
DWW
DWW
GLL
GLL
N

(i.e., high-marsh graminoids dissected by ditches, and scattered high-marsh *S. alterniflora* stands).

Habitat composition of pooled Hundred Acre Cove territories differed from that of the study area ($X^2 = 24.87$, $P<0.01$; Fig. 2). A higher percentage of high-marsh *S. alterniflora* and lower percentage of high-marsh graminoids were present in territories than would have been expected from the relative abundance of those communities in the study area as a whole. Size and habitat composition data for individual territories are contained in Appendix A-1.

At Palmer River, four males established territories in 1982 (Fig. 3). Territory boundaries were located primarily along ditches, and, unlike Hundred Acre Cove territories, included *Salicornia* and extensive areas of high-marsh graminoids. Mean territory size at Palmer River (9010 ± 2099 m^2) was nearly twice as large as at Hundred Acre Cove (4545 ± 621 m^2; $t = 2.76$; $P<0.05$).

Habitat composition of pooled Palmer River territories also differed from that of the study area ($X^2 = 29.20$, $P<0.01$; Fig. 2); territories included a higher percentage of *Salicornia* than would have been expected from its relative abundance. Since only one Seaside Sparrow observation was made in *Salicornia* during two breeding seasons (Table 1), the inclusion of this community in territories may have been due simply to its location between highly utilized *S. alterniflora* stands. Alternatively, *Salicornia* may have been underrepresented in transect observations; because of its sparse cover, birds may not have remained in *Salicornia* stands, but sought denser cover, at the approach of the observer.

Table 2 compares the habitat composition of territories between

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Fig. 2. Percent cover of salt-marsh habitats at study areas and within Seaside Sparrow territories, 1982. Abbreviations for habitats are as follows: HMG = high-marsh graminoids; HMSA = high-marsh *S. alterniflora*; WATER = ponds and tidal open water/flats; LMSA = low-marsh *S. alterniflora*; SALIC = *Salicornia*.

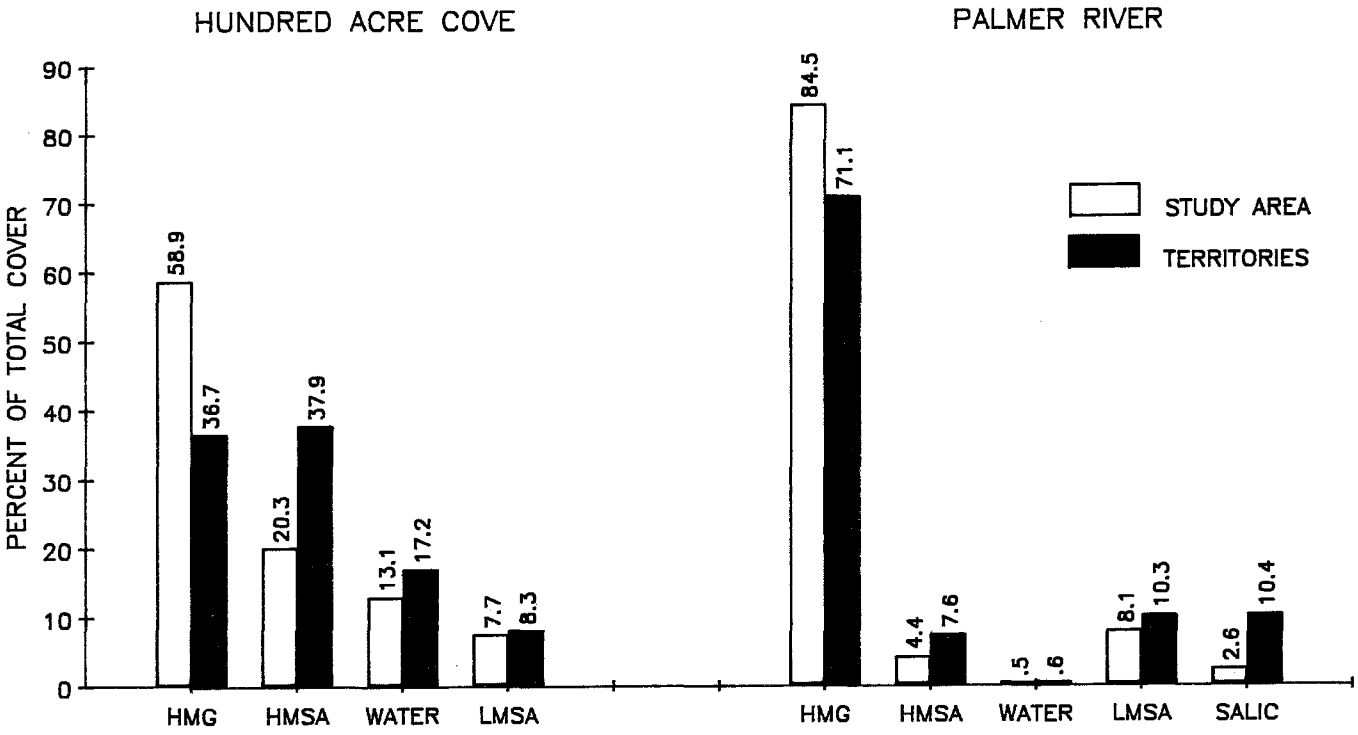
HUNDRED ACRE COVE
PALMER RIVER
PERCENT OF TOTAL COVER
0
10
20
30
40
50
60
70
80
90
58.9
36.7
20.3
37.9
13.1
17.2
7.7
8.3
84.5
71.1
4.4
7.6
.5
.6
8.1
10.3
2.6
10.4
HMG
HMSA
WATER
LMSA
HMG
HMSA
WATER
LMSA
SALIC
STUDY AREA
TERRITORIES

Fig. 3. Location of Seaside Sparrow territories at Palmer River, 1982.

□	High-marsh graminoid	▒	*Salicornia*
▨	High-marsh *S. alterniflora*	▦	Pond
░	Low-marsh *S. alterniflora*	U	Upland island
■	*Iva frutescens*	+	Grid stake

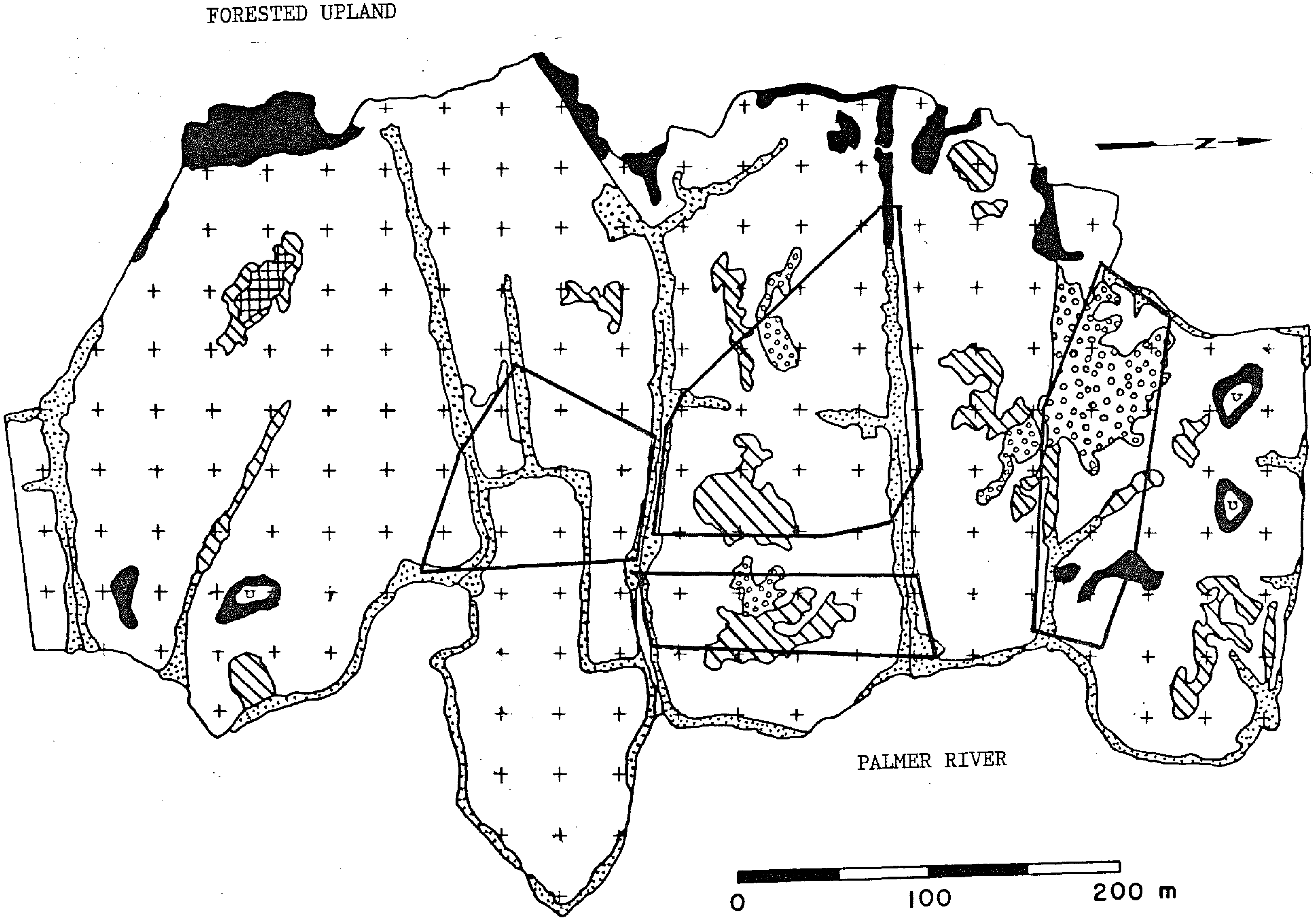
FORESTED UPLAND
N
PALMER RIVER
0
100
200 m

Table 2
Percent cover of habitat types within Seaside Sparrow territories at two Rhode Island salt marshes, 1982

	Hundred Acre Cove (N = 18)	Palmer River (N = 4)
High-marsh *S. alterniflora**	42.4[a] (3.0-87.5)[b]	8.2 (0 -17.6)
High-marsh graminoids*	35.3 (0 -73.9)	69.7 (50.4-84.9)
Pond and tidal flat/open water**	14.1 (0 -50.0)	0.6 (0 - 1.4)
Low-marsh *S. alterniflora*	8.2 (0 -23.0)	9.5 (5.6-13.4)
Salicornia		11.3 (0 -35.3)
Iva frutescens		0.7 (0 - 2.9)

[a] Mean percent cover.
[b] Minimum - maximum percent cover.
* Site means differ at $P<0.05$, t-test.
** Site means differ at $P<0.01$, t-test.

study areas. Palmer River territories contained a significantly higher percentage of high-marsh graminoids and lower percentage of high-marsh *S. alterniflora* and open water than territories at Hundred Acre Cove.

Although the combined percentage of the two *S. alterniflora* communities within territories differed between Hundred Acre Cove (mean = 50.6 ± 4.8%) and Palmer River (17.6 ± 3.0%; t = 3.16, P<0.005) the mean area of *S. alterniflora* within territories was similar between sites (2096 ± 277 m^2 and 1613 ± 5608 m^2, respectively; t = 0.94, P>0.05). Palmer River territories were, on average, twice as large as those at Hundred Acre Cove, yet contained equivalent areas of *S. alterniflora*, the preferred foraging habitat.

Twelve territories at Hundred Acre Cove and three at Palmer River contained both low- and high-marsh *S. alterniflora* stands. One advantage of including both communities within territories stems from their different tidal regimes. Standing water is absent from high-marsh *S. alterniflora* stands except for a few days during spring tides when floodwater collects in surface depressions. At these times, the community is unsuitable for ground foraging. The substrate in low-marsh *S. alterniflora* stands, and along regularly flooded, unvegetated shores, is exposed for at least half of the daily tidal cycle; therefore, it offers accessible foraging habitat every day, even during spring tide periods.

A second advantage of including both *S. alterniflora* communities within a territory may be greater prey diversity. Invertebrate populations vary between high- and low-marsh *S. alterniflora* communities due to differences in hydroperiod, food, and shelter (Davis and Gray 1966). Tabanid larvae, which Merriam (1983) found to constitute 27 to

47% of Seaside Sparrow nestling diets by volume, have been shown to be more numerous in low-marsh S. alterniflora than in irregularly flooded stands (Dukes et al. 1974, Meany et al. 1976).

Spatial patterns of territories.--Males at Palmer River established large, all-purpose territories (Type A of Nice 1937), within which all nesting and foraging activities were accomplished. Most males at Hundred Acre Cove maintained all-purpose territories, but two (GLL and DWW, see Fig. 1) established nesting/foraging territories in high-marsh S. alterniflora adjacent to the pond, and also maintained exclusive, disjunct foraging areas in low-marsh S. alterniflora (GLL) or along the cove's sparsely vegetated shore (DWW). Most of the space between the nesting and disjunct foraging areas was occupied by neighboring males.

Only one study of Seaside Sparrows has reported a spatial pattern other than all-purpose territories. At an unaltered Long Island marsh with an unusually high breeding density (≥20 males ha^{-1}), Post (1974) found that each pair maintained a small (393 ± 90 m^2) exclusive nesting area and foraged throughout a larger (1039 ± 238 m^2), nonexclusive area. Neighboring birds occupied the area between the nest sites and foraging areas of these "grouped" territories. Post (1974) concluded that limited nesting habitat (persistent S. alterniflora) was the major factor contributing to the development of grouped territories.

The spatial patterns of the two Hundred Acre Cove territories described above are intermediate between the extremes of all-purpose and grouped territories; disjunct activity spaces were exclusive, not communal, at Hundred Acre Cove. Since semi-erect, persistent S. alterniflora was present throughout the entire central stand at the start of the breeding season, factors other than that suggested by Post (1974) may have been responsible for the maintenance of disjunct territories at Hundred Acre Cove. The most likely factor was the advantage of access to both regularly and irregularly flooded foraging areas.

Nest sites.--At least one nest of each breeding female was found at Hundred Acre Cove. Nest sites were categorized according to the plant community in which the nest was actually built; that is, the "nest community". The percent cover of plant species and open water within 4-m^2 plots at all nest sites is presented in Appendix A-2, and Hundred Acre Cove data are summarized by nest community in Appendix A-3.

Twenty-six (81.3%) of 32 Seaside Sparrow nests were built in the high-marsh *S. alterniflora* community, which accounted for only 23.4% of the marsh's vegetated area. Nests were wedged between vertical stems, the rims averaging 18.4 ± 0.9 cm above the substrate. Nineteen of these nests were initiated during late May and early June when only residual *S. alterniflora* was present; the mean cover height at nests was 25.0 ± 1.6 cm at that time (N = 10; range 17-36 cm). End-of-season cover height at nests averaged 49.3 ± 1.7 cm (N = 26; range 27-67 cm). Appendix A-4 contains individual nest-site data.

The six remaining nests at Hundred Acre Cove were built by four females in high-marsh graminoids, specifically *Spartina patens*. All of these nests were known to be second or third nesting attempts; earlier nests built in *S. alterniflora* were flooded during incubation.

Table 3 summarizes nest-site characteristics at Hundred Acre Cove. Although the mean elevations of the substrate and nest rim were slightly

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Table 3
Characteristics of Seaside Sparrow nest sites in two plant communities at Hundred Acre Cove, 1982

Nest-site characteristic	High-marsh *Spartina alterniflora* (N = 26)	High-marsh graminoid (*S. patens*) (N = 6)
Elevation of substrate above mean sea level (cm)	83.2 ± 0.8[a] (24)[b]	86.1 ± 0.8
Height of nest rim above substrate (cm)	18.4 ± 0.9 (20)	18.3 ± 1.0
Elevation of nest rim above mean sea level (cm)	101.3 ± 0.9 (18)	104.4 ± 1.2
Mean cover height (cm)	49.3 ± 1.8	43.8 ± 4.7
Maximum cover height (cm)	77.2 ± 2.3	77.7 ± 9.3
Distance to plant community edge (cm)**	4.4 ± 0.7	0.2 ± 0.04
Distance to open water (m)	12.9 ± 2.9	7.5 ± 5.2

[a] Mean ± SE.
[b] Sample size when different from column headings.
** Means differ between nest communities at $P<0.01$, t-test.

higher for S. patens nests, and mean cover height was slightly less, the differences were not statistically different. Distance to the nearest plant community edge was the only parameter that differed between S. alterniflora and S. patens nest sites. Nests in S. patens were placed extremely close to the high-marsh S. alterniflora edge. The mean distance from that edge was 0.2 ± 0.04 m (range 0.1-0.4 m), which was significantly less than the mean distance from S. alterniflora nests to the nearest high-marsh graminoid edge (4.40 ± 0.7 m; range 0.1-12.3 m; $t = 2.84$, $P<0.01$). All Seaside Sparrow nests built in S. patens were located in small high-marsh graminoid patches within high-marsh S. alterniflora stands.

Only two Seaside Sparrow nests were found at Palmer River in 1982, and both were in communities unlike those used at Hundred Acre Cove. One was built in S. alterniflora within an irregularly flooded, clogged ditch. This nest was flooded during incubation, but the pair fledged young from a later nest believed to have been built within a high-marsh S. alterniflora panne; the exact location of the nest was not determined.

The second nest found at Palmer River was located within an 84-m^2 I. frutescens stand. The nest was built 19 cm above the substrate in a crotch of small branches and was partially concealed by J. gerardii. Since the clutch initiation date was 1 June, this may have been the female's first nesting attempt of the year. Woolfenden (1968) and Greenlaw (1983) have noted that I. frutescens was the most frequently used nesting habitat in marshes where S. alterniflora was scarce.

Post-breeding-season habitat use.--Habitat use changed slightly after the breeding season. At Hundred Acre Cove, low-marsh S. alterniflora was preferred and high-marsh S. alterniflora was used in proportion to its abundance (Table 4). Low-marsh S. alterniflora also was the primary habitat used at Palmer River, but data were too few to test its use relative to its abundance.

Increased use of low-marsh S. alterniflora coincided with the relaxation of territorial defense at the end of the breeding season and the movement of parents and young away from nest sites. Juveniles, frequently accompanied by adults, were most often seen in low-marsh S. alterniflora after 15 August. In late August, sparrows were seen feeding on the seeds of low-marsh S. alterniflora, which flowered profusely in contrast to the high-marsh ecophene. Low-marsh S. alterniflora apparently provided both preferred food and cover at the end of the breeding season.

Conclusions.--The strong preference of Northern Seaside Sparrows for Spartina alterniflora is clear from the results of this and other studies. Irregularly flooded stands, particularly those with residual cover in spring, are primary nest sites (Post 1970a, 1974; Woolfenden 1968; Greenlaw 1983; Marshall and Reinert 1987; this study). Analysis of general habitat use in the present study revealed a strong preference for S. alterniflora. This was not surprising, since S. alterniflora has been shown to be the primary foraging habitat of several populations (Post 1974, Merriam 1979, Delaney and Mosher 1983, Post et al. 1983). Additionally, the abundance and distribution of this community have been shown to be important in determining territory size and configuration (Post 1974, this study).

Table 4
Use of salt-marsh plant communities by Seaside Sparrows during the post-breeding period (16 August-12 October), 1981-1982

	Proportion of vegetated marsh area	Proportion of birds observed in each community	95% Family confidence interval on proportion observed
Hundred Acre Cove (N = 78 observations):			
High-marsh graminoids	0.676	0.051 -[a]	$0 \le p \le 0.107$
High-marsh _S. alterniflora_	0.234	0.282	$0.168 \le p \le 0.396$
Low-marsh _S. alterniflora_	0.089	0.667 +	$0.547 \le p \le 0.786$
Iva frutescens	0.002	0	
Palmer River (N = 6 observations[b]):			
High-marsh graminoids	0.820	0	
High-marsh _S. alterniflora_	0.044	0.167	
Low-marsh _S. alterniflora_	0.081	0.833	
Iva frutescens	0.029	0	
Salicornia	0.026	0	

[a] Signs indicate communities which were used more (+) or less (-) than expected based upon their relative abundance at each site.

[b] The number of observations at Palmer River were too few for statistical analysis.

Populations inhabiting ditched marshes, where high-marsh S. alterniflora is usually scarce, have exhibited differences in breeding ecology from those in unaltered marshes. At ditched sites, primary foraging areas may include low-marsh S. alterniflora, Iva frutescens, wrack, and unvegetated shores (Woolfenden 1956, Post 1974, Greenlaw 1983, Merriam 1983); high-marsh graminoids may be used for foraging to a higher degree as well (this study). At Long Island ditched marshes, nest sites were located primarily in I. frutescens within 100 m of suitable foraging areas (Post 1970b, Greenlaw 1983). Parents in altered sites have been found to travel significantly greater distances to gather food for nestlings (Post 1974) and delivered smaller food items and lower total volume of food to older nestlings (Merriam 1983). Territories at ditched sites were much larger and included broad expanses of little-used high-marsh graminoids (Post 1974, this study).

Although these aspects of breeding ecology varied between Seaside Sparrow populations at altered, as opposed to unaltered, marshes, Post (1974) found no difference in reproductive success, and concluded that populations exhibited different, but equally successful, resource utilization strategies. Productivity per hectare, however, would be greater at unditched sites because of the greater density of birds. Population density was the major difference observed in comparative studies of Seaside Sparrows at ditched and unditched marshes; all found much lower densities at ditched sites (Post 1974, Burger et al. 1982, Greenlaw 1983, this study). The relative lack of high-marsh S. alterniflora at ditched sites was believed to be largely responsible for the observed differences in sparrow density.

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CHAPTER 3: NESTING ECOLOGY OF SHARP-TAILED SPARROWS (*Ammodramus caudacutus*) IN RHODE ISLAND

ABSTRACT

As a result of tidal inundation and simple vegetation structure, relatively few passerine species breed in North American salt marshes. Sharp-tailed Sparrows (*Ammodramus caudacutus*) are one of the most abundant breeding species in southeastern New England salt marshes and, therefore, are an excellent subject for the study of nest-site selection in tidal wetlands. Nesting ecology and nest-site characteristics affecting nest success are described for Sharp-tailed Sparrows breeding in four Rhode Island salt marshes during 1981 and 1982.

Nearly 80% of 199 Sharp-tailed Sparrow nests were built in high-marsh graminoids (*Spartina patens*, *Distichlis spicata*, and *Juncus gerardii*). Mean substrate elevation at high-marsh graminoid nest sites (5.3 ± 0.3 cm) was significantly greater than the mean at 550 grid located points within that community (0.0 ± 0.3 cm). New-moon spring tides during the breeding season were high enough to inundate 87-100% of the nests in high-marsh graminoids; however, full-moon tides had the potential to flood only 6-47% of the nests. Maximizing nest-site elevation thus reduced the risk of flooding for half of the spring tides occurring during the breeding season.

Sixty-three percent of all nest failures were caused by spring tides, primarily those occurring at the new moon. Each year, females began laying in late May, and the first new-moon tide of the season, in

June, destroyed the majority of early nests. Most females renested immediately after flooding, and the probability of success was found to be greatest for those nests. Crucial factors affecting breeding success were the differential heights of new- vs. full-moon spring tides and the similarity between the length of the nesting cycle and lunar periodicity. Nests initiated during new-moon spring tides were less likely to be flooded by the following, lower, full-moon tide. When the next new-moon tide occurred, some 28-30 days after the nest was started, young sparrows either had left the nest or were old enough to climb atop the nest or vegetation and avoid drowning. Rapid renesting in response to new-moon flooding enhanced the likelihood of breeding success. The similarity in the lengths of the nesting cycle and lunar periodicity is coincidental, rather than an adaptive strategy exhibited by Sharp-tailed Sparrows.

INTRODUCTION

As a result of tidal inundation and simple vegetation structure, relatively few passerine species breed in North American salt marshes (Daiber 1982, Burger et al. 1982). Periodic tidal inundation has shaped nest-site selection for nearly all avian species breeding in this habitat (Daiber 1982, Burger et al. 1978, Burger 1985), and has been cited as the principal cause of nest failure in many studies (Oney 1954, Bongiorno 1970, Post 1974, Burger and Shisler 1978). In summarizing the mechanisms of nest-site selection which minimize flooding, Burger (1985) noted that birds either choose elevated locations within the marsh or build their nests high above the substrate. The upper limit of nest placement is determined by the maximum height of vegetation suitable for nest attachment and the density of cover required to provide protection from predators, rain, and wind (Post 1974, Burger 1985).

Sharp-tailed Sparrows (Ammodramus caudacutus) are one of the most abundant breeding species in southeastern New England salt marshes (Reinert et al. 1981, Clarke et al. 1984), and, therefore, are an excellent subject for the study of nest-site selection in tidal wetlands. In eastern North America, Sharp-tailed Sparrows breed exclusively in tidal marshes from North Carolina to Quebec and along the shores of James Bay, Ontario (A.O.U. 1983). South of Maine they reside in Spartina-dominated salt marshes, but to the north they also inhabit brackish tidal marshes.

Sharp-tailed Sparrows are promiscuous and non-territorial (Woolfenden 1956). After copulation, females select the nest site and care for young alone. Several authors (Forbush 1929, Montagna 1942, Hill 1968, Enders and Post 1971) have commented on the semi-colonial nature of this species, noting that small groups nest in particular sections of a marsh but are absent from surrounding, apparently similar, habitat. Salt-marsh populations have been described as nesting primarily in the *Spartina patens*-*Distichlis spicata* community, either in the highest portions of the marsh or near tidal channels (Lewis 1920; Forbush 1929; Montagna 1940, 1942; Woolfenden 1956; Hill 1968; Post 1970b). Occasionally, nests have been found in irregularly flooded *Spartina alterniflora* stands (Post 1970a) or *Iva frutescens* (Elliott 1962). No quantitative studies of Sharp-tailed Sparrow nest-site characteristics and selection have been conducted.

Sharp-tailed Sparrow populations were studied at four Rhode Island salt marshes which varied in vegetative composition, ditching intensity, and abundance of ponds (see Chapter 1). Specific objectives of this paper are to describe the nesting ecology of this species in southeastern New England, and to identify key nest-site characteristics affecting nest success.

METHODS

In 1981 and 1982, bird observations began in May when Sharp-tailed Sparrows arrived in Rhode Island and continued until nesting activity ceased in late August. Observations were made on four to six days per week between 05:00 and 13:00.

To facilitate the recognition of individuals, birds were captured in mist nets and marked with an aluminum U.S. Fish and Wildlife Service band on one leg, and a unique combination of three colored, celluloid bands on the other leg. Special efforts were made to capture female sparrows at their nest sites. A total of 97 Sharp-tailed Sparrows (59 males, 36 females, 1 unknown) was marked. Sex was determined by the presence of a brood patch or cloacal protuberance (Salt 1954).

Because Sharp-tailed Sparrows are non-territorial, breeding population estimates were based on the maximum number of females nesting simultaneously at each site.

Nests were located by flushing attendant adults or by observing females engaged in foraging trips to feed nestlings. Twice during each breeding season, systematic nest searches were conducted over entire study areas. Two to four persons, spaced at 10-m intervals, slowly walked parallel to grid lines to flush females from nests.

Nests were visited every 2 to 5 days in order to determine the timing of the various stages of the nesting cycle and nest success. Clutch initiation date (the date on which the first egg of a clutch was laid) was determined by back-dating and is accurate to ±1 day.

Nest-site vegetation was quantified within a circular 4-m^2 plot centered on each nest after it was abandoned. The boundaries of plant communities and open water were sketched on a gridded diagram of the plot, and the mapped area of each polygon was later measured with a planimeter. Within each plant community, a visual estimate of the relative cover of each plant species was made to the nearest 5% of subtended area. High-marsh graminoids tend to persist through the winter as a dead, rooted, prostrate mat through which spring growth protrudes (Blum 1968). The area covered by this thatch layer within each 4-m^2 plot also was measured.

In 1982, circular 4-m^2 plots also were sampled at points 10 m northwest of randomly selected grid stakes. At each study area, plots were added until 0.1% of the site's vegetated area, as determined from cover maps, was sampled. As a result, 67 random plots were established at Hundred Acre Cove, 46 at Palmer River, 43 at Seapowet, and 26 at Rumstick Point. When a random point fell on an area with less than 30% cover, the plot was not sampled, and another point was chosen to replace it.

In addition to plant community composition, the following parameters also were measured at nest sites and at random points:

1) Thickness of the thatch layer (at random points and 1982 nests only);
2) Height (to nearest cm) of the nest rim above the substrate;
3) Mean and maximum vegetative cover heights, measured in late August;
4) Distance from the nest center or random point to the nearest open water (pond and tidal flat/open water) or unvegetated patch at least 4 m^2 in size;
5) Distance from the nest center or random point to the nearest plant community edge; and
6) Relative elevation of the substrate, determined to the nearest 0.3 cm with an electronic, infrared-beam level (Realist/David White Instruments, Menomonee Falls, WI).

Because of slight differences in absolute elevation among study areas (see Appendix B-3), elevations were expressed relative to a site-specific datum, the mean elevation of the high-marsh graminoid community. The mean of spot elevations measured at all grid stakes occurring in high-marsh graminoids was set equal to zero at each site; this standardization allowed the pooling of data from separate study areas. The number of grid-stake elevations used to calculate means was 206 at Hundred Acre Cove, 168 at Palmer River, 96 at Seapowet, and 81 at Rumstick Point.

Tide gauges were installed at all sites to monitor the peak levels of spring tides during the 1982 breeding season. A 3-m length of 2.5-cm diameter PVC pipe was driven 1.5 m into a channel bank below mean high water. Before high tide, the shaft was heavily chalked and a sleeve of larger diameter PVC was secured over the shaft. A series of holes drilled in the sleeve allowed tidewater to enter while protecting the chalked surface from wave action and rain. The maximum tide level was recorded as the height of dissolved chalk above a reference point on the shaft. Using the electronic level, the elevation of the reference point was later related to marsh datum.

Data analysis was performed using SAS software (SAS Institute Inc. 1982). Yate's correction for continuity was used in chi-square analyses with one degree of freedom. Tukey's mean separation test was used in all analyses of variance. Means are reported ± one standard error (SE). Missing values for some nest-site parameters resulted when nests were destroyed by flooding or could not be relocated before all measurements were made.

RESULTS

Spring arrival--Sharp-tailed Sparrows began arriving at study sites during the second week of May; the majority arrived during the third week of that month. For the first two weeks after they returned, foraging and courtship activities were concentrated along channels in low-marsh *Spartina alterniflora* and, at Hundred Acre Cove, in the large, central high-marsh *S. alterniflora* stand. Sparrows were not commonly encountered in the high-marsh graminoid community until after 1 June when females began nesting and males began roaming widely over the marsh. Unlike Seaside Sparrows (*A. maritimus*) which also bred at two study areas, male Sharp-tailed Sparrows sang as frequently from high-marsh graminoids as from taller *S. alterniflora* and driftwood.

Population density--Breeding (female) population estimates and densities at all four study areas are given in Table 1. Although estimates were slightly higher at each site in 1982, between-year differences in the number of breeding Sharp-tailed Sparrows were not significant (X^2 contingency test = 0.50, $P>0.05$).

Nest-site ecology--A total of 199 Sharp-tailed Sparrow nests were found, 68 in 1981 and 131 in 1982. More nests were constructed in 1982 because more destructive flooding occurred in that year than in 1981. Data for individual nest sites are contained in Appendices B-1 and B-2.

Significant differences between years were found for only one nest-site parameter at one site; mean cover height at Seapowet nests was greater in 1981 (32.7 ± 1.8 cm; N = 29) than in 1982 (29.3 ± 0.8 cm; N =

Table 1
Breeding abundance and density of female Sharp-tailed Sparrows in four Rhode Island salt marshes, 1981-1982

	1981		1982	
	No. females[a]	Density (ha^{-1})	No. females[a]	Density (ha^{-1})
Seapowet	19	0.89	21	0.99
Rumstick Point	6	0.52	9	0.78
Palmer River	9	0.48	13	0.70
Hundred Acre Cove	13	0.42	14	0.46

[a] Maximum number of simultaneously-nesting females.

60; t = 2.84, P<0.05). Since between-year variation was negligible for all nest-site parameters, data from the two years were pooled for each site.

Nest sites were classified into four categories, termed "nest communities," based upon the vegetation in which the nest was actually placed: high-marsh graminoids, high-marsh S. alterniflora, mixed graminoids, and Iva frutescens. Frequency of use of nest communities varied among sites as a function of relative community abundance. The high-marsh graminoid community dominated all study areas (see Table 1 in Chapter 1) and also was the most frequently used nest community at each site (Table 2). Nearly 80% of all nests were built within high-marsh graminoids.

Nests in high-marsh S. alterniflora were found only at Seapowet (14.6%) and Hundred Acre Cove (13.6%), where that community accounted for 27.8% and 20.3%, respectively, of the marsh area. All but two of 19 S. alterniflora nests were built in medium-height stands (50-100 cm tall). At Seapowet, two nests were located in dwarf S. alterniflora stands where the cover height was only 20-27 cm.

Eighteen nests (9.0%) were built in mixed graminoids. This category represents mixtures of S. alterniflora and high-marsh graminoids where neither type comprised 70% or more of the cover at the nest. Medium-height S. alterniflora was the ecophene present at all but two mixed graminoid nest sites. One nest at Seapowet was built in a mixture of dwarf S. alterniflora and Distichlis spicata, and one at Palmer River was located on the upper edge of a ditchbank where low-marsh S. alterniflora intergraded with Spartina patens.

Nests in I. frutescens (N = 3) were found only at Rumstick Point,

Table 2

Frequency of occurrence (%) of Sharp-tailed Sparrow nests in four plant communities of Rhode Island salt marshes, 1981-1982

	Seapowet	Hundred Acre Cove	Palmer River	Rumstick Point	All sites (N)
High-marsh graminoids	75.3	70.5	97.7	81.8	79.9 (159)
High-marsh *S. alterniflora*	14.6	13.6	0	0	9.5 (19)
Mixed graminoids	10.1	15.9	2.3	4.5	9.0 (18)
Iva frutescens	0	0	0	13.6	1.5 (3)
Number of nests	89	44	44	22	199

where the relative abundance of this shrub community was greatest (8.1%).

Sharp-tailed Sparrows built their nests near the ground, on or within the thatch layer when present. All nests were concealed from above by vegetation. The mean clearance between the nest bottom and the substrate at 65 nests found in 1981 was 8.4 ± 0.4 cm; the minimum clearance was 2 cm.

Of 159 nests built within the high-marsh graminoid community, the thatch layer served as primary support for 154 (96.9%). Thatch was present less frequently (89.2%) at 120 random points located in high-marsh graminoids ($X^2 = 5.59$, $P<0.05$); however, the mean thickness of the thatch layer, when present, was equal at random points (7.1 ± 0.2 cm) and nest sites (7.3 ± 0.2 cm; $N = 103$ 1982 nests; $t = 0.53$, $P>0.05$). Apparently, within the high-marsh graminoid community, Sharp-tailed Sparrows selected nest sites with a thatch layer regardless of its thickness.

Because the thatch layer was composed of high-marsh graminoid species, its occurrence and use as nest support was less in other nest communities. Nests built in _S_. _alterniflora_ were loosely wedged between erect stems and could be easily removed by hand. A thatch layer was present at only one of these nests and was used as primary support in that instance. Thatch was present under 14 nests built in mixed graminoids, but served as primary support for only eight. All other nests in mixed graminoids were wedged between _S_. _alterniflora_ stems. The three nests in _I_. _frutescens_ stands were placed in crotches formed by slender branches at the bases of shrubs and were concealed by _J_. _gerardii_ or _D_. _spicata_ ground cover.

Mean and maximum cover heights were greatest in I. frutescens, least in high-marsh graminoids, and intermediate in the high-marsh S. alterniflora and mixed graminoid communities (Table 3). Nests were built higher above the substrate in plant communities with taller vegetation; mean nest height in high-marsh S. alterniflora and mixed graminoids was significantly greater than in high-marsh graminoids (Table 3).

Substrate elevation at nest sites differed among nest communities (Table 3). Nest sites in I. frutescens were significantly more elevated than those in high-marsh S. alterniflora. Since high-marsh S. alterniflora occurred primarily in depressions within the high marsh, the substrate at mixed and high-marsh graminoid nest sites was intermediate in elevation between high-marsh S. alterniflora and I. frutescens.

The risk of flooding for any nest is a function of the elevation of the nest itself, compared to the elevation of spring tides. Although substrate elevations were lower at high-marsh S. alterniflora and mixed graminoid nest sites than at high-marsh graminoid nest sites, taller vegetation in the former two communities allowed nests to be built higher above the ground. Consequently, mean nest rim elevation was not significantly different among plant communities (Table 3).

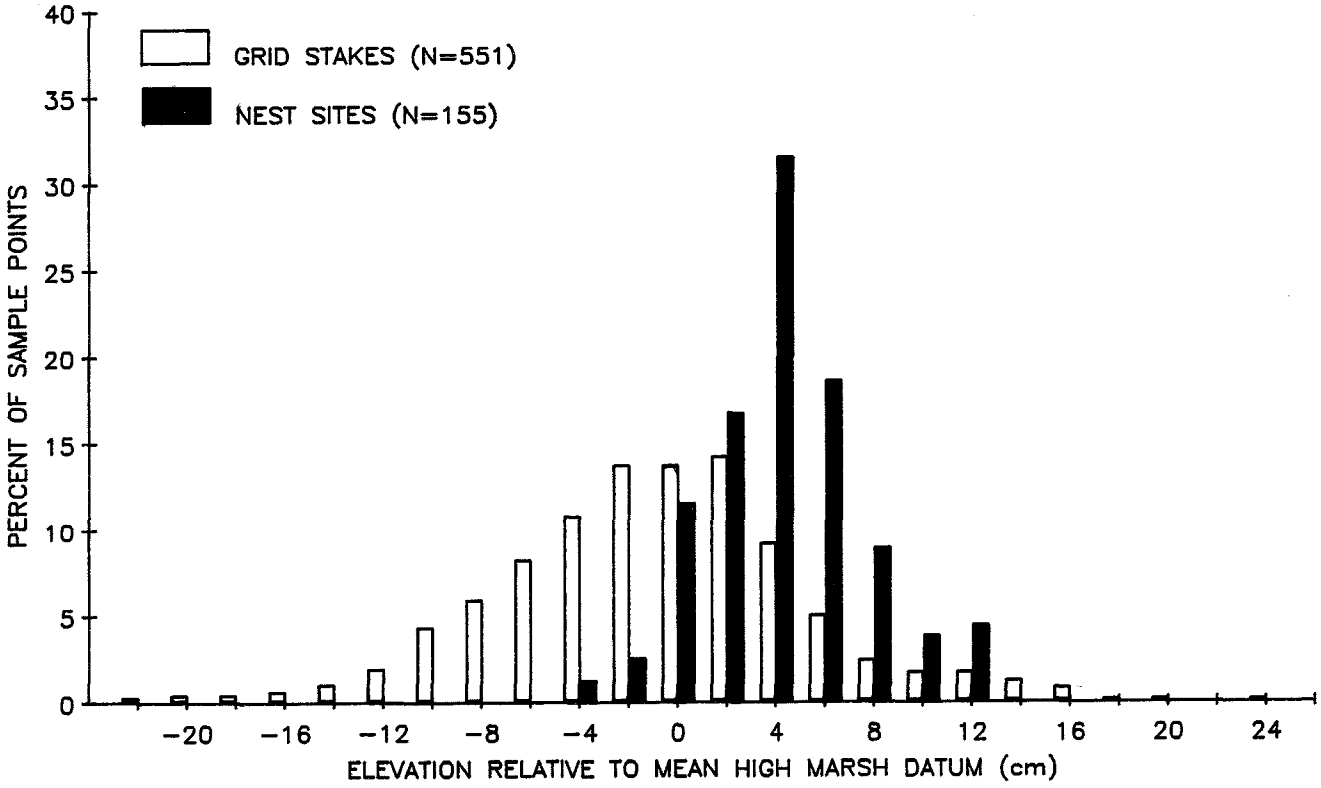
Sharp-tailed Sparrows nested only in more elevated areas of the high-marsh. Figure 1 depicts the distribution of substrate elevations at high-marsh graminoid nest sites and at all grid stakes occurring in high-marsh graminoids. The mean substrate elevation at nest sites (5.3 ± 0.3 cm) was significantly greater than the high-marsh datum determined from grid stakes (0.0 ± 0.3 cm; t = 9.82, $P<0.0001$). This relationship

Table 3

Variation among nest communities in Sharp-tailed Sparrow nest-site characteristics 1981-1982. Mean values with the same letter are not significantly different among communities. Sample sizes are given in parentheses. Brackets enclose data which had small (N<3) sample size and were excluded from analyses of variance.

Characteristic	*Iva frutescens*	High-marsh *S. alterniflora*	Mixed graminoids	High-marsh graminoids
Maximum cover height (cm)	76.7 ± 13.2 a (3)	64.7 ± 2.9 a (19)	67.8 ± 3.4 a (18)	48.0 ± 1.0 b (156)
Mean cover height (cm)	40.7 ± 5.0 a (3)	37.8 ± 2.7 ab (19)	38.0 ± 1.7 ab (18)	29.9 ± 0.5 b (156)
Height of nest rim above substrate (cm)	[16.5] (2)	16.8 ± 1.1 a (18)	15.1 ± 0.7 a (14)	12.6 ± 0.2 b (139)
Thickness of thatch layer beneath nest (1982 nests only; cm)	[13.0] (1)	(0)	9.0 ± 0.9 a (13)	7.3 ± 0.2 b (103)
Relative elevation of nest rim (cm)	[24.2] (2)	17.4 ± 1.2 a (18)	17.0 ± 1.8 a (13)	17.8 ± 0.4 a (137)
Relative elevation of substrate (cm)	7.0 ± 4.4 a (3)	0.7 ± 1.0 b (19)	2.4 ± 1.5 ab (17)	5.3 ± 0.3 ab (155)
Distance to plant community edge (m)	2.2 ± 1.9 a (3)	3.7 ± 1.0 a (19)	1.5 ± 0.3 a (18)	6.0 ± 0.5 a (158)
Distance to open water (m)	6.2 ± 2.8 a (3)	5.9 ± 1.8 a (19)	9.3 ± 2.4 a (18)	13.2 ± 1.0 a (158)

Figure 1. Distribution of substrate elevations at Sharp-tailed Sparrow nest sites and grid stakes in the high-marsh graminoid community only. Values are the percent of nest sites or grid stakes within each elevation range.


40
35
30
25
20
15
10
5
0
PERCENT OF SAMPLE POINTS
GRID STAKES (N=551)
NEST SITES (N=155)
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
ELEVATION RELATIVE TO MEAN HIGH MARSH DATUM (cm)

also was significant at each study area (see Appendix B-3). In addition, the range of substrate elevations at nest sites, -3.4 to +13.8 cm, was much narrower than the range at grid stakes, -21.8 to +24.5 cm. No nests in high-marsh graminoids were located where the substrate elevation was less than -3.4 cm; therefore, females avoided the lower 40% of that community's elevational range when selecting nest sites.

Nesting chronology--Figure 2 depicts the chronology of clutch initiations during both breeding seasons, along with the predicted maximum daily tide height at Newport, RI (N.O.A.A. 1980, 1981). Each year, females began laying in late May. Data for this period in 1981 are sparse because it represented the first weeks of field work, before proficiency at locating nests was developed and most early nests were undoubtedly destroyed by the 2 June new-moon tide before they could be found; therefore, the typical early-season pattern of clutch initiations may be more accurately shown by 1982 data.

During June of each year, new-moon spring tides destroyed the majority of early nests. Most females began new nests immediately after flooding. Because spring tides inundated the marsh over a 2-3 day period, some nests were flooded before the predicted peaks shown in Fig. 2. Since nest-building requires approximately four days, construction of most new nests began about four days prior to the first-egg dates depicted in Fig. 2; that is, within ±2 days of the date of peak spring tide.

Widespread nest destruction by June new-moon tides synchronized re-nesting attempts of females. During the ensuing incubation period, lower, less destructive full-moon tides occurred in both years, and the

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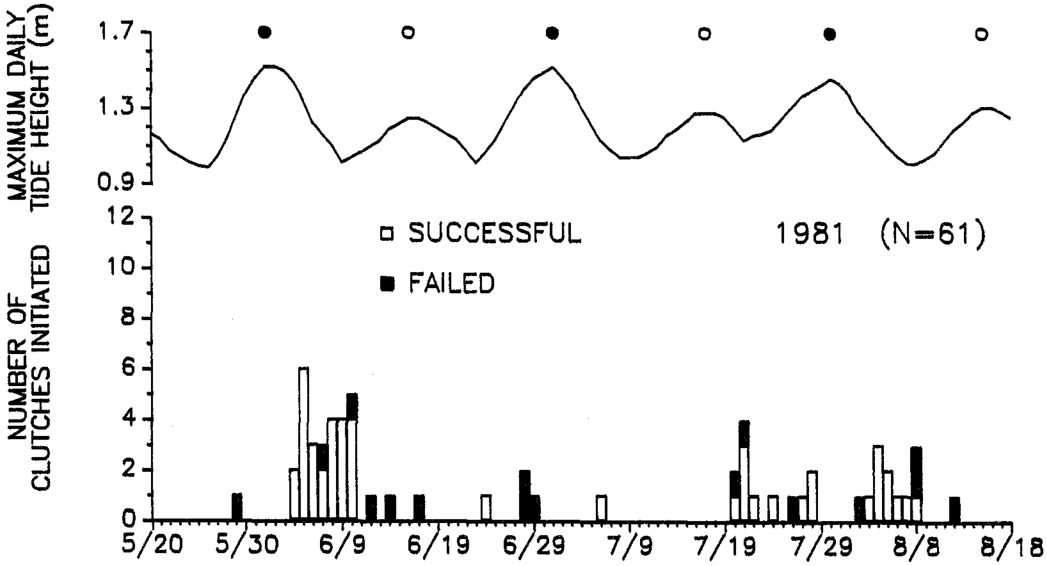
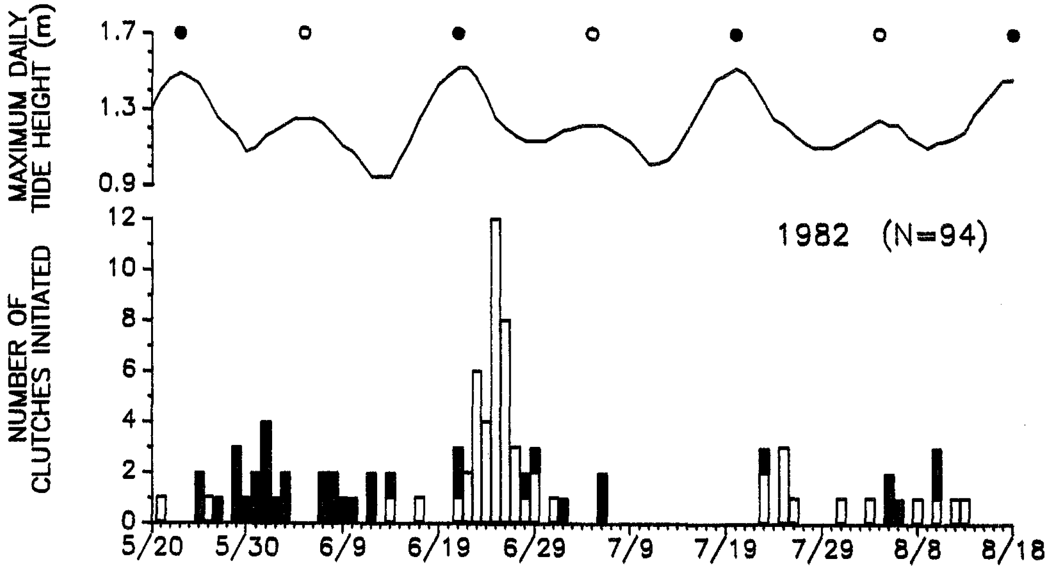
Figure 2. Daily clutch initiations by Sharp-tailed Sparrows during 1981 and 1982. Open bars represent successful clutches (where at least one young left the nest), and shaded bars represent failed clutches. Tidal curves are the predicted maximum daily tide height at Newport, RI (N.O.A.A. 1980, 1981). Open circles indicate full moon; solid circles represent new moon.


MAXIMUM DAILY TIDE HEIGHT (m)
1.7
1.3
0.9
NUMBER OF CLUTCHES INITIATED
12
10
8
6
4
2
0
□ SUCCESSFUL
■ FAILED
1981 (N=61)
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
8/18


MAXIMUM DAILY TIDE HEIGHT (m)
1.7
1.3
0.9
NUMBER OF CLUTCHES INITIATED
12
10
8
6
4
2
0
1982 (N=94)
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
8/18

majority of females were successful in fledging young 23 to 27 days after clutch initiation. Females continued to feed young out of the nest for 15-20 days, which accounts for the lull in clutch initiations during early to mid-July. In 1982, a second new-moon tide on 20 July destroyed several nests containing nearly-fledged young, and caused another, smaller wave of nest initiations immediately thereafter (N = 7).

In 1981, approximately 50% of the females began late-season clutches in mid-July, and the majority of these were believed to be second broods. In 1982, fewer females (approx. 25%) initiated late clutches, beginning around 1 August. Since the first major tidal inundation of the breeding season occurred later in 1982 than in 1981 (21 June vs. 2 June), many females may have been discouraged from attempting second broods in 1982 by the lateness of the season.

Sharp-tailed Sparrows have been reported to raise only one brood per year north of New Jersey (Forbush 1929, Daiber 1982). Cruickshank (1942) and Hill (1968) suggested that many late-season nesting attempts may, in fact, be second broods. This was verified in the present study from observations of banded females. In 1982, three females were known to start second broods after successfully fledging three young each from earlier nests, and two of these females each fledged one young from late nests. The interval between first-egg dates of first and second broods was 44, 47, and 49 days.

Nest success--Nests were considered successful if at least one young left the nest. Partly constructed nests (N = 18) were not included in nest success analyses, nor were nests which held young or eggs but for which the fate of the clutch was unknown (N = 9).

Of 172 nests with known fate, 41.3% were unsuccessful. Eight (11.3%) of the failed nests showed evidence of predation. Mammalian predators were believed responsible for six of these failures. Potential predators included red fox (Vulpes vulpes) and raccoon (Procyon lotor), which were known to occur at all study areas, and mink (Mustela vison), which were observed at Hundred Acre Cove. Two nests containing young at Seapowet were preyed upon by egrets. Both nests were located near ponds used daily by waders. On 12 August 1981, the date predation took place, 132 Snowy Egrets (Egretta thula), 43 Great Egrets (Casmerodius albus), and 15 Little Blue Herons (Egretta caerulea) were present at Seapowet (S. Reinert, pers. comm., 1982).

Five nests failed due to exposure or desertion unrelated to tidal flooding. The reason for failure at 13 nests which were found after abandonment was unknown; none of these nests contained feather sheath fragments in the lining, indicating that nestlings, if present, did not survive beyond 6 to 7 days of age.

Sixty-three percent (N = 45) of all nest failures were caused by spring tides. During the 1981 and 1982 breeding seasons, new-moon tides ran 25-30 cm higher than full-moon tides and were responsible for the majority of nest losses due to flooding (see Fig. 2).

The maximum height reached by 1982 spring tides, measured at tide gauges in each study area, was used to determine their nest-flooding potential within the high-marsh graminoid community. From the array of elevations measured at grid stakes and nest sites, the percentage of points lower than the peak tide level was determined (Table 4). All three of the new-moon spring tides that occurred during the 1982 breeding season were high enough to flood the marsh surface at all grid stakes and to inundate 87-100% of the nests in high-marsh graminoids. Therefore, nest flooding by new-moon tides was nearly inescapable. Full-moon tides, however, showed much lower flooding potentials; while still high enough to inundate the substrate at 93-100% of the grid stakes, these tides reached the rim elevation of only 6-47% of the nests. Since rim elevation was not significantly different among nests built in high- marsh graminoids, mixed graminoids, and S. alterniflora (Table 3), flooding potential also was similar among nest communities.

Renesting females did not modify nest-site selection in response to tidal flooding. Neither nest height nor substrate elevation below the nest differed significantly between nests built before (N = 28) and immediately after (N = 48) the 21 June 1982 new-moon tide.

Of the nests for which fate could be determined, 58.7% (N = 101) were successful. Nest success rate differed significantly between years (80.4% in 1981 vs. 52.6% in 1982; contingency $X^2 = 4.05$; $P<0.05$) as a result of the timing of new-moon tides each season. Two major periods of nest destruction due to new-moon tides occurred in 1982 (21 June and 20 July) as opposed to one in 1981 (2 June). Consequently, more renesting occurred in 1982 (see Fig. 2), but the overall success rate was lower. Also, the first new-moon tide occurred later in the season in 1982, after more nests had been initiated. The number of nests initiated per female per year was 1.5 in 1981 and 2.3 in 1982; however, the number of successful nests per female was the same (1.0) each year.

Nest-site characteristics (those listed in Table 3, as well as plant species coverage) were compared between successful and failed nests (Student's t-tests). Surprisingly, there were no significant

Table 4
Flooding potential of spring tides at grid stakes and Sharp-tailed Sparrow nest sites in high-marsh graminoids during the 1982 breeding season

Date of peak spring tide	Lunar phase	Grid stakes (N=551)[a]	Nest sites	
			Substrate (N=102)	Nest rim (N=87)
5 June	Full	99[b]	99	47
21 June	New	100	100	100
5 July	Full	94	79	6
20 July	New	100	100	100
4 August	Full	93	66	8
18 August	New	100	100	87

[a] Due to vandalism, tide gauge data were missing for August at Rumstick Point; therefore, sample sizes were 470, 90, and 76 for the respective columns during August.

[b] Values represent percentage of points lower than the maximum height of tides measured at tide gauges.

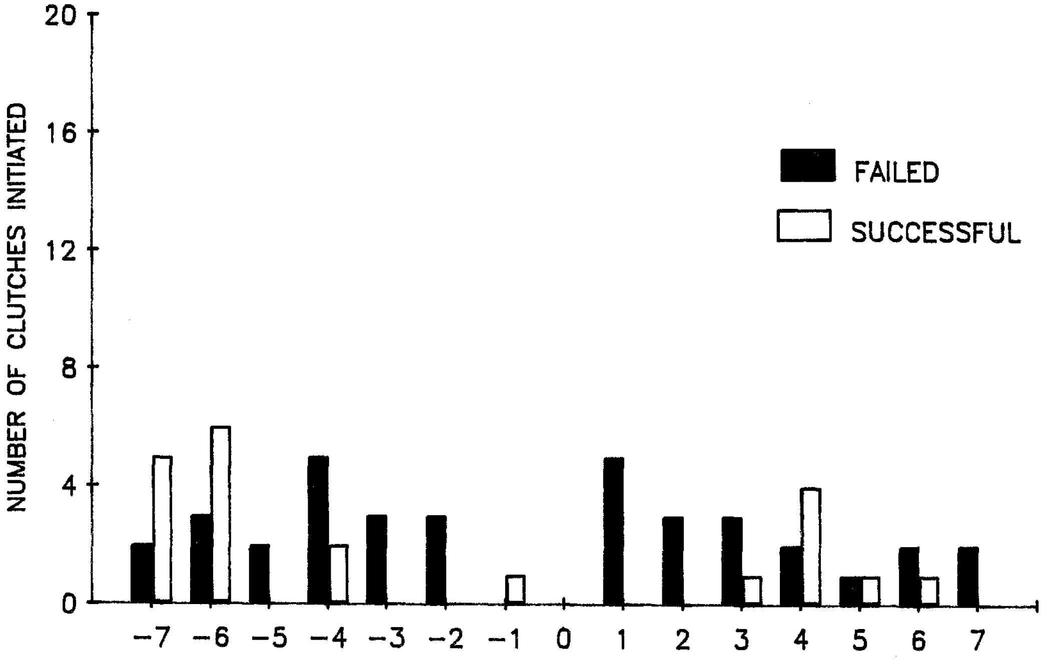
differences. These results suggested that factors other than plant species composition, vegetation structure, nest height, and nest location on the marsh were the major determinants of nest success.

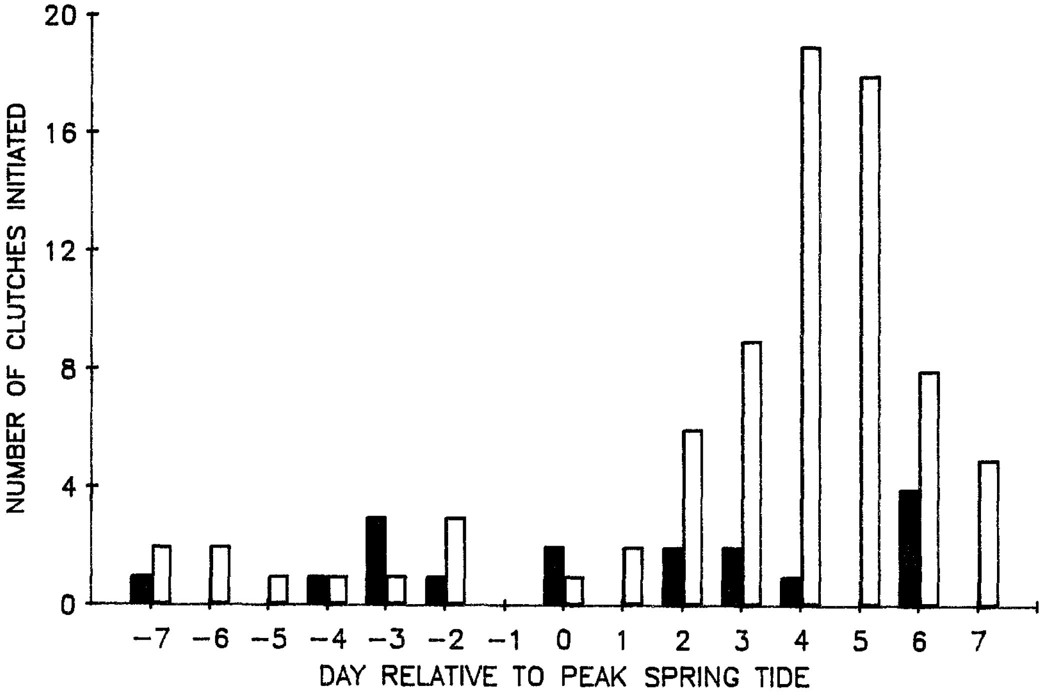
Temporal differences between successful and failed nests were found for those clutches started ±7 days of the peak new-moon tide. When clutch initiation dates were expressed as days relative to peak tide date, the mean for failed nests (day 0) was significantly different from the mean for successful nests (day +3; $t = 2.39$; $P<0.05$; Fig. 3). This relationship was not significant for clutches started close to full-moon tides ($t = 1.51$, $P>0.05$). Figure 3 illustrates that the majority of successful clutches were started 2 to 6 days following a new-moon tide. Therefore, the probability of success was greatest for renesting attempts that started at new-moon spring tides.

DISCUSSION

Sharp-tailed Sparrows breed successfully in salt marshes by nesting at relatively high elevations--thus surviving lower flood tides--and renesting immediately after tidal destruction of nests. Over a two-year period, flooding by spring tides was responsible for over 60% of nest failures. In each instance, a pulse of renesting immediately followed the destructive tide; the synchronized response of the entire population was particularly dramatic following the first new-moon spring tide of the breeding season, in June. Lewis (1920) was perhaps the first to note the relationship between the height of spring tides and the time of nesting by Sharp-tailed Sparrows. Worth (1972) also reported "waves" of

Figure 3. Number and fate of Sharp-tailed Sparrow clutches initiated on days relative to full- and new-moon spring tides.


FULL MOON


NEW MOON

Seaside Sparrow and Sharp-tailed Sparrow nesting activity caused by spring tides.

As suggested by Bleakney (1972) and Teal and Teal (1969), the probability of success was greatest for nests begun during or immediately after spring tides. In the present study, the time of clutch initiation relative to the peak new-moon tide date was, in fact, the only significantly different parameter between successful and failed nests. Crucial factors affecting breeding success were the differential heights of new- vs. full-moon spring tides and the similarity between the length of the nesting cycle and lunar periodicity.

Female Sharp-tailed Sparrows spend 26-31 days at a nest, including 3-4 days for construction, 3-5 days for egg-laying, 11-12 days for incubation, and 9-10 days for the nestling period. Since spring tides occur every 14-15 days, a nest initiated on a random date most likely would be exposed to two spring tides, at least one of which would have the potential for destroying the nest. A nest started within 2-4 days of the peak spring tide date would be at risk during the next spring tide, which would occur during the incubation period. Because the most widespread nest flooding and subsequent renesting is associated with new-moon tides, the spring tide occurring during incubation would most often be a full-moon tide, which has a much lower potential for nest flooding. If the nest survives this period, the probability of success is greatly enhanced because the following spring tide would occur after young have left the nest, or, at the least, when nestlings are old enough to climb onto the nest and surrounding vegetation to avoid drowning. The similarity in the lengths of the nesting and lunar cycles is coincidental, since 27-30 days is the length of the nesting period for nearly all small passerines, regardless of breeding habitat.

Several studies of salt-marsh breeding birds conducted south of New England have found that major nest flooding occurred only during storm tides or extreme spring tides (Stewart 1952, Oney 1954, Bongiorno 1970, Post 1974, Burger and Lesser 1978, Burger 1982, Frederick 1987). Nest destruction observed in the present study was caused by normally high spring tides. The occurrence of spring tides during each breeding season is a certainty; however, the height and date of the first spring tide of the season is variable among years. Sharp-tailed Sparrows begin nesting at the same time each year, approximately 1-2 weeks after arrival (Post and Greenlaw 1982, pers. obs.). The majority of females in the present study fledged at least one brood per year. If the first destructive spring tide occurs early in the nesting season, as in 1981, there is sufficient time for females to attempt to raise a second brood.

Nests in the high-marsh graminoid community (80% of all nests), were constructed only within the upper 60% of that community's elevational range. The substrate below nests built in high-marsh _S. alterniflora_ and mixed graminoid communities was relatively low in elevation, but taller vegetation there allowed nests to be built higher above the substrate, at elevations similar to those of high-marsh graminoid nests. Maximizing nest elevation reduced the risk of flooding by half of the spring tides occurring during the breeding season; that is, the full-moon tides. New-moon tides were nearly certain to flood nests regardless of their elevation. Rapid renesting in response to new-moon tidal flooding enhanced the likelihood of breeding success.

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APPENDICES

APPENDIX A-1

Size and habitat composition of Seaside Sparrow territories, 1982

Terr. no.	Male color code[a]	Terr. size (m^2)	Habitat type[b] (% cover)						
			HMSA	LMSA	HMG	IVA	SAL	POND	CHAN
Hundred Acre Cove:									
1	Unb	4474	24.2	0.0	25.8	0.0	0.0	50.0	0.0
2	YRR	7146	40.7	9.8	37.2	0.0	0.0	11.4	0.9
3	OOD	8623	26.1	16.6	53.7	0.0	0.0	1.7	1.9
4	OWW	2542	28.1	5.0	67.0	0.0	0.0	0.0	0.0
5	WDD	2248	23.4	20.6	56.1	0.0	0.0	0.0	0.0
6	DWW	2719	82.3	0.0	9.6	0.0	0.0	0.0	8.1
7	WWR	5052	11.4	14.7	73.9	0.0	0.0	0.0	0.0
8	LLR	3186	61.1	0.0	38.9	0.0	0.0	0.0	0.0
9	Unb	4539	35.0	4.3	45.1	0.0	0.0	0.0	15.6
10	RDD	944	87.5	0.0	0.0	0.0	0.0	12.5	0.0
11	DYY	7319	34.7	13.3	37.6	0.0	0.0	0.0	14.4
12	YLL	1318	77.6	0.0	0.0	0.0	0.0	22.4	0.0
13	ROO	1967	3.0	23.0	72.0	0.0	0.0	0.0	2.0
14	GLL	2584	67.0	17.0	7.6	0.0	0.0	8.4	0.0
15	OOY	3737	41.0	12.6	40.5	0.0	0.0	0.0	5.8
16	PPD	8837	31.1	5.1	27.8	0.0	0.0	29.1	6.7
17	DRR	5845	38.7	5.4	24.7	0.0	0.0	24.2	7.0
18	BOO	8721	50.5	0.0	17.4	0.0	0.0	32.1	0.0
Palmer River:									
1	RWW	8541	5.0	6.4	50.4	2.9	35.3	0.0	0.0
2	YOO	14782	10.0	12.2	74.6	0.0	2.6	0.0	0.5
3	Unb	4737	17.6	5.6	68.8	0.0	7.4	0.0	0.6
4	Unb	7980	0.0	13.7	84.9	0.0	0.0	0.0	1.4

[a] Unb=unbanded; B=black; D=dark blue; G=green; L=light blue; O=orange; P=pink; R= red; Y= yellow; W=white.

[b] HMSA=high-marsh *S. alterniflora*; LMSA=low-marsh *S. alterniflora*; HMG=high-marsh graminoids; IVA=*I. frutescens*; SAL=*Salicornia*; POND=permanent pond; CHAN=channel (natural creek or man-made ditch).

APPENDIX A-2

Percent cover of plant species and open water within individual 4-m² plots centered on Seaside Sparrow nests, 1982

Nest no.[a]	Spartina alterniflora	Spartina patens	Distichlis spicata	Juncus gerardii	Iva frutescens	Pond	Nest community[b]
Hundred Acre Cove:							
200	100.00	0	0	0	0	0	HMSA
201	68.00	0	7.50	0	0	24.50	HMSA
202	95.00	0	5.00	0	0	0	HMSA
203	90.75	0	0	0	0	9.25	HMSA
204	70.50	11.00	0	0	0	18.50	HMSA
206	100.00	0	0	0	0	0	HMSA
207	75.25	0	0	0	0	24.75	HMSA
208	100.00	0	0	0	0	0	HMSA
209	100.00	0	0	0	0	0	HMSA
210	100.00	0	0	0	0	0	HMSA
211	85.00	5.00	10.00	0	0	0	HMSA
212	100.00	0	0	0	0	0	HMSA
213	100.00	0	0	0	0	0	HMSA
214	100.00	0	0	0	0	0	HMSA
215	100.00	0	0	0	0	0	HMSA
216	97.00	0	0	0	0	3.00	HMSA
217	79.00	14.25	6.75	0	0	0	HMSA
218	61.25	3.25	0	0	0	35.50	HMSA
219	100.00	0	0	0	0	0	HMSA
220	35.00	39.00	7.25	0	0	18.75	HMG
221	91.50	0	8.50	0	0	0	HMSA
222	84.25	15.75	0	0	0	0	HMG
223	100.00	0	0	0	0	0	HMSA
227	87.50	12.50	0	0	0	0	HMSA
228	100.00	0	0	0	0	0	HMSA
229	24.75	63.00	12.25	0	0	0	HMG
230	64.25	35.75	0	0	0	0	HMSA
231	100.00	0	0	0	0	0	HMSA
232	46.00	48.00	6.00	0	0	0	HMG
233	20.00	80.00	0	0	0	0	HMG
234	12.25	81.75	6.00	0	0	0	HMG
235	100.00	0	0	0	0	0	HMSA
Palmer River:							
201	100.00	0	0	0	0	0	DSA
202	0	0	0	10.00	90.00	0	IVA

[a] Nest numbers do not reflect laying chronology. Missing numbers are incomplete nests, which were excluded from analysis.

[b] Denotes the plant community in which the nest was built: HMSA=high-marsh S. alterniflora; HMG=high-marsh graminoids; DSA=irregularly flooded S. alterniflora within a clogged ditch; IVA=Iva frutescens.

APPENDIX A-3

Mean percent cover and frequency of occurrence of plant species and open water within 4-m^2 circular plots centered on Seaside Sparrow nests at Hundred Acre Cove, 1982

	Nest community	
	High-marsh _S. alterniflora_ (N = 26)	High-marsh graminoid (_S. patens_; N = 6)
Spartina patens***	3.1 ± 1.5[a] (23.1)[b]	54.6 ± 10.4 (100.0)
_Distichlis spicata_*	1.5 ± 0.6 (19.2)	5.3 ± 1.9 (66.7)
High-marsh _S. alterniflora_***	91.0 ± 2.5 (100.0)	37.0 ± 10.6 (100.0)
Open water (pond)	4.4 ± 1.9 (19.2)	3.1 (16.7)

[a] Mean percent cover ± SE.
[b] Frequency of occurrence (%).
* Means differ between nest communities at $P<0.05$, t-test.
*** Means differ between nest communities at $P<0.0001$, t-test.

APPENDIX A-4

Additional characteristics of Seaside Sparrow nest sites and clutches at two Rhode Island salt marshes, 1982

Nest no.	Mean veg've cover height (cm)	Max. veg've cover height (cm)	Dist. to open water[a] (m)	Dist. to plant comm. edge (m)	Substrate elevation above MSL[b] (cm)	Nest height above substrate (cm)	Nest rim elevation above MSL[b] (cm)	First egg date[c] (1982)	Nest fate[d]
Hundred Acre Cove:									
200	51	79	2.8	11.6	75.6	17	92.6	24 May	F
201	43	71	0.5	8.4	90.2	18	108.2	1 Jun	S
202	55	83	5.3	1.4	85.6	18	103.6	2 Jun	F
203	62	87	0.7	3.5	82.6	18	100.6	--	F
204	45	66	0.4	0.6	85.3	--	--	--	-
206	54	88	3.7	6.4	84.4	24	108.4	28 May	F
207	52	89	0.4	1.3	74.4	--	--	5 Jun	-
208	47	73	41.5	4.8	83.5	16	99.5	30 May	F
209	49	74	8.9	9.3	84.1	--	--	28 May	F
210	39	61	2.2	1.4	86.0	--	--	--	F
211	53	66	4.7	12.3	82.9	18	100.9	9 Jun	F
212	59	90	40.9	2.5	--	23	--	3 Jun	F
213	30	47	2.9	2.0	86.3	12	98.3	--	F
214	38	57	17.4	2.7	--	19	--	6 Jun	F
215	49	70	7.5	2.6	82.6	17	99.6	9 Jun	F
216	62	92	1.0	11.2	85.0	15	100.0	9 Jun	F
217	60	91	23.5	1.9	85.3	19	104.3	9 Jun	F
218	58	91	0.3	0.9	74.1	31	105.1	--	F
219	45	72	8.4	3.4	82.6	18	100.6	9 Jun	F
220	34	65	0.5	0.1	89.3	16	105.3	25 Jun	S
221	49	74	21.8	4.6	81.7	14	95.7	1 Jul	F
222	44	82	1.2	0.2	85.6	19	104.6	24 Jun	S
223	52	89	6.1	2.9	82.0	20	102.0	24 Jun	S
227	58	82	13.1	7.2	86.0	16	102.0	8 Jul	F
228	53	86	13.0	5.6	86.3	--	--	--	F
229	62	67	2.5	0.4	84.7	22	106.7	25 Jun	S
230	27	72	55.5	0.1	83.5	20	103.5	9 Jul	F
231	47	80	26.1	1.4	83.5	15	98.5	<2 Jul	F
232	39	77	4.6	0.1	85.0	17	102.0	23 Jul	S
233	52	120	33.4	0.1	87.8	20	107.8	26 Jul	S
234	32	55	2.5	0.2	84.1	16	100.1	--	F
235	44	78	27.6	4.4	84.1	--	--	--	-
Palmer River:									
201	67	100	1.7	1.3	78.0	--	--	<4 Jun	F
202	73	103	4.6	1.2	108.2	19	127.2	1 Jun	S

[a] Open water includes pond and tidal flat/open water.

[b] Elevation above mean sea level, 1929 datum.

[c] Date (± 1 day) on which first egg of clutch was laid.

[d] F = failed; S = successful (at least one young left nest).

APPENDIX B-1

Percent cover of plant species, open water, and thatch layer within 4-m^2 circular plots at Sharp-tailed Sparrow nest sites in four Rhode Island salt marshes, 1981-1982.

Nest No.	Spartina alterniflora	Spartina patens	Distichlis spicata	Juncus gerardii	Iva frutescens	Other[a]	Open water[b]	Thatch layer	Nest comm.[c]
Hundred Acre Cove, 1981:									
H101	33.25	64.50	0	0	0	0	2.25	80.50	HM
H102	85.00	0	15.00	0	0	0	0	0	HMSA
H103	89.00	11.00	0	0	0	0	0	0	MIX
H104	0	85.00	0	0	0	0	15.00	85.00	HM
H105	0	90.00	10.00	0	0	0	0	100.00	HM
H106	0	90.00	10.00	0	0	0	0	100.00	HM
H107	0	75.00	25.00	0	0	0	0	100.00	HM
H108	75.00	25.00	0	0	0	0	0	50.00	HMSA
H109	30.00	35.00	35.00	0	0	0	0	100.00	HM
H110	0	75.00	25.00	0	0	0	0	100.00	HM
H111	27.75	53.00	19.25	0	0	0	0	74.50	HM
H112	75.00	20.00	5.00	0	0	0	0	0	HMSA
H113	10.00	30.00	60.00	0	0	0	0	100.00	HM
H114	26.00	36.75	0	0	0	0	37.25	32.50	HMSA
H115	10.00	60.00	30.00	0	0	0	0	100.00	HM
H116	0	0	100.00	0	0	0	0	100.00	HM
Hundred Acre Cove, 1982:									
H201	42.00	49.25	0	0	0	0	8.75	49.25	HM
H202	76.25	23.75	0	0	0	0	0	34.00	HM
H203	50.00	0	50.00	0	0	0	0	60.00	MIX
H204	60.00	40.00	0	0	0	0	0	80.00	MIX
H205	0	90.00	10.00	0	0	0	0	100.00	HM
H206	100.00	0	0	0	0	0	0	0	HMSA
H207	13.75	82.75	3.50	0	0	0	0	100.00	HM
H208	0	20.00	80.00	0	0	0	0	100.00	HM
H209	0	25.00	60.00	5.00	0	10.00 (PV)	0	100.00	HM
H210	0	10.00	70.00	20.00	0	0	0	100.00	HM
H211	0	10.00	70.00	20.00	0	0	0	100.00	HM
H212	0	91.50	0	0	0	0	8.50	91.50	HM
H213	0	70.00	10.00	20.00	0	0	0	100.00	HM
H214	0	90.00	10.00	0	0	0	0	100.00	HM
H215	0	20.00	80.00	0	0	0	0	100.00	HM
H216	30.00	10.00	60.00	0	0	0	0	90.00	HM
H217	40.00	10.00	50.00	0	0	0	0	100.00	MIX
H218	45.00	45.00	10.00	0	0	0	0	100.00	MIX
H219	5.00	95.00	0	0	0	0	0	100.00	HM
H220	73.00	27.00	0	0	0	0	0	21.25	HMSA
H221	76.25	23.75	0	0	0	0	0	26.50	HM
H222	37.25	62.75	0	0	0	0	0	78.50	HM
H223	50.00	45.00	5.00	0	0	0	0	80.00	MIX
H224	39.75	60.25	0	0	0	0	0	63.75	HM
H225	0	10.00	90.00	0	0	0	0	100.00	HM

APPENDIX B-1 continued

Nest No.	Spartina alter-niflora	Spartina patens	Dis-tichlis spicata	Juncus gerardii	Iva fru-tescens	Other[a]	Open water[b]	Thatch layer	Nest comm.[c]
Hundred Acre Cove, 1982, continued:									
H226	10.00	20.00	70.00	0	0	0	0	100.00	HM
H227	40.00	60.00	0	0	0	0	0	100.00	MIX
H228	39.50	60.50	0	0	0	0	0	75.50	HM
Palmer River, 1981:									
P101	0	20.00	80.00	0	0	0	0	0	HM
P102	0	74.75	2.50	22.75	0	0	0	100.00	HM
P103	0	10.00	90.00	0	0	0	0	100.00	HM
P104	0	10.00	70.00	20.00	0	0	0	100.00	HM
P105	0	70.00	30.00	0	0	0	0	100.00	HM
P106	0	50.25	49.75	0	0	0	0	100.00	HM
P107	0	15.00	85.00	0	0	0	0	0	HM
P108	0	80.00	20.00	0	0	0	0	0	HM
P109	47.25	52.75	0	0	0	0	0	0	MIX
P110	28.75	34.25	22.75	0	0	0	14.25	57.00	HM
P111	57.75	33.75	8.50	0	0	0	0	42.25	HM
P112	0	82.00	9.00	0	0	0	9.00	91.00	HM
P113	0	51.50	22.75	25.75	0	0	0	100.00	HM
P114	0	76.50	10.00	13.50	0	0	0	100.00	HM
P115	0	54.00	22.00	24.00	0	0	0	100.00	HM
Palmer River, 1982:									
P201	0	90.00	10.00	0	0	0	0	100.00	HM
P202	0	90.00	10.00	0	0	0	0	100.00	HM
P203	0	0	60.00	40.00	0	0	0	100.00	HM
P205	0	0	40.00	60.00	0	0	0	100.00	HM
P206	0	0	20.00	80.00	0	0	0	100.00	HM
P207	0	10.00	0	90.00	0	0	0	100.00	HM
P208	0	0	0	93.00	7.00	0	0	100.00	HM
P209	0	0	10.00	90.00	0	0	0	100.00	HM
P210	0	100.00	0	0	0	0	0	100.00	HM
P211	0	10.00	90.00	0	0	0	0	100.00	HM
P212	43.50	56.50	0	0	0	0	0	56.50	HM
P213	0	90.00	10.00	0	0	0	0	100.00	HM
P214	0	10.00	10.00	80.00	0	0	0	100.00	HM
P215	0	10.00	20.00	70.00	0	0	0	100.00	HM
P216	27.25	72.75	0	0	0	0	0	0	HM
P217	0	100.00	0	0	0	0	0	100.00	HM
P218	25.50	55.50	19.00	0	0	0	0	100.00	HM
P219	0	0	90.00	10.00	0	0	0	100.00	HM
P220	0	95.00	5.00	0	0	0	0	100.00	HM
P221	0	70.00	20.00	10.00	0	0	0	100.00	HM
P222	0	100.00	0	0	0	0	0	100.00	HM
P223	0	37.50	14.75	47.75	0	0	0	100.00	HM
P224	3.00	40.25	40.25	0	0	0	16.50	80.75	HM
P225	5.00	90.00	5.00	0	0	0	0	100.00	HM

APPENDIX B-1 continued

Nest No.	*Spartina alter-niflora*	*Spartina patens*	*Dis-tichlis spicata*	*Juncus gerardii*	*Iva fru-tescens*	Other[a]	Open water[b]	Thatch layer	Nest comm.[c]
Palmer River, 1982, continued:									
P226	0	95.00	5.00	0	0	0	0	100.00	HM
P227	0	50.00	50.00	0	0	0	0	90.00	HM
P228	10.50	71.25	18.25	0	0	0	0	82.75	HM
P229	48.25	46.50	5.25	0	0	0	0	51.75	HM
P231	0	50.00	50.00	0	0	0	0	100.00	HM
Rumstick Point, 1981:									
R101	0	90.00	10.00	0	0	0	0	100.00	HM
R102	0	35.50	32.25	32.25	0	0	0	100.00	HM
R103	0	0	30.00	70.00	0	0	0	100.00	HM
R104	0	0	8.75	54.00	29.50	0	7.75	80.50	IVA
R105	0	80.00	20.00	0	0	0	0	100.00	HM
R106	0	0	78.25	14.75	0	0	7.00	60.75	HM
R107	0	40.00	30.00	30.00	0	0	0	100.00	HM
R108	12.25	0	72.00	0	15.75	0	0	72.00	IVA
Rumstick Point, 1982:									
R201	0	0	25.00	75.00	0	0	0	100.00	HM
R202	0	0	30.00	70.00	0	0	0	100.00	HM
R203	0	0	50.00	50.00	0	0	0	100.00	HM
R204	0	0	92.25	0	7.75	0	0	100.00	IVA
R205	40.00	10.00	10.00	40.00	0	0	0	80.00	MIX
R206	0	40.00	60.00	0	0	0	0	100.00	HM
R207	0	80.00	10.00	10.00	0	0	0	100.00	HM
R208	0	50.00	25.00	25.00	0	0	0	100.00	HM
R209	0	34.25	20.00	45.75	0	0	0	100.00	HM
R210	0	0	50.00	50.00	0	0	0	100.00	HM
R211	0	0	30.00	70.00	0	0	0	100.00	HM
R212	0	50.00	50.00	0	0	0	0	100.00	HM
R213	0	0	30.00	70.00	0	0	0	100.00	HM
R214	0	100.00	0	0	0	0	0	100.00	HM
Seapowet, 1981:									
S101	82.50	0	0	0	0	0	17.50	0	HMSA
S102	20.00	50.00	30.00	0	0	0	0	100.00	HM
S103	0	75.00	25.00	0	0	0	0	100.00	HM
S104	0	85.00	15.00	0	0	0	0	100.00	HM
S105	0	90.00	10.00	0	0	0	0	100.00	HM
S106	0	60.00	40.00	0	0	0	0	100.00	HM
S107	0	90.00	10.00	0	0	0	0	100.00	HM
S108	0	85.00	15.00	0	0	0	0	100.00	HM
S109	0	85.00	15.00	0	0	0	0	100.00	HM
S110	0	40.00	60.00	0	0	0	0	100.00	HM
S112	83.25	0	0	0	0	0	16.75	0	HMSA
S113	0	90.00	10.00	0	0	0	0	100.00	HM
S114	0	90.00	10.00	0	0	0	0	100.00	HM
S115	4.50	47.75	47.75	0	0	0	0	95.00	HM

APPENDIX B-1 continued

Nest No.	Spartina alterniflora	Spartina patens	Distichlis spicata	Juncus gerardii	Iva frutescens	Other[a]	Open water[b]	Thatch layer	Nest comm.[c]
Seapowet, 1981, continued:									
S116	25.75	63.50	0	0	0	0	10.75	63.50	HM
S117	0	100.00	0	0	0	0	0	100.00	HM
S118	6.25	30.00	63.75	0	0	0	0	100.00	HM
S119	23.75	24.00	0	0	0	0	52.25	24.00	HM
S120	5.00	75.00	20.00	0	0	0	0	100.00	HM
S121	43.50	4.25	52.25	0	0	0	0	13.25	MIX
S122	0	50.00	50.00	0	0	0	0	100.00	HM
S123	10.75	86.25	3.00	0	0	0	0	100.00	HM
S124	36.50	16.25	32.50	0	0	0	14.75	81.50	MIX
S125	100.00	0	0	0	0	0	0	0	HMSA
S126	0	70.00	30.00	0	0	0	0	100.00	HM
S127	0	50.00	50.00	0	0	0	0	100.00	HM
S128	0	50.00	50.00	0	0	0	0	100.00	HM
S129	22.00	78.00	0	0	0	0	0	97.25	HM
S130	58.75	32.25	0	0	0	0	9.00	32.25	HM
Seapowet, 1982:									
S201	0	60.00	40.00	0	0	0	0	100.00	HM
S202	0	80.00	20.00	0	0	0	0	100.00	HM
S203	44.50	55.50	0	0	0	0	0	55.50	HM
S204	50.00	0	50.00	0	0	0	0	100.00	MIX
S205	28.25	67.75	0	0	0	0	4.00	67.75	HM
S206	0	0	20.00	80.00	0	0	0	100.00	HM
S207	9.75	54.25	36.00	0	0	0	0	90.25	HM
S208	50.00	30.00	20.00	0	0	0	0	100.00	MIX
S209	30.25	61.00	8.75	0	0	0	0	87.25	HM
S210	0	70.00	25.00	0	0	5.0 (LC)	0	100.00	HM
S211	0	20.00	80.00	0	0	0	0	100.00	HM
S212	3.50	87.25	0	0	0	0	9.25	87.25	HM
S213	12.25	79.75	8.00	0	0	0	0	79.75	HM
S214	5.00	75.00	20.00	0	0	0	0	100.00	HM
S215	0	10.00	90.00	0	0	0	0	100.00	HM
S216	60.00	6.50	0	0	0	0	33.50	0	HMSA
S217	0	0	0	100.00	0	0	0	100.00	HM
S218	35.00	65.00	0	0	0	0	0	100.00	MIX
S219	46.50	53.50	0	0	0	0	0	100.00	MIX
S220	25.00	0	75.00	0	0	0	0	100.00	HM
S221	77.75	0	0	0	0	0	22.25	0	HMSA
S222	0	60.00	40.00	0	0	0	0	100.00	HM
S223	100.00	0	0	0	0	0	0	0	HMSA
S224	0	80.00	20.00	0	0	0	0	100.00	HM
S225	0	0	100.00	0	0	0	0	100.00	HM
S226	20.00	10.00	70.00	0	0	0	0	100.00	MIX
S227	0	80.00	20.00	0	0	0	0	100.00	HM
S228	0	20.00	80.00	0	0	0	0	100.00	HM

APPENDIX B-1 continued

Nest No.	*Spartina alterniflora*	*Spartina patens*	*Distichlis spicata*	*Juncus gerardii*	*Iva frutescens*	Other[a]	Open water[b]	Thatch layer	Nest comm.[c]
Seapowet, 1982, continued:									
S229	0	50.00	50.00	0	0	0	0	100.00	HM
S230	100.00	0	0	0	0	0	0	0	HMSA
S231	6.00	94.00	0	0	0	0	0	94.00	HM
S232	0	0	100.00	0	0	0	0	100.00	HM
S233	0	95.00	5.00	0	0	0	0	100.00	HM
S234	27.75	72.25	0	0	0	0	0	65.25	HMSA
S235	64.25	0	0	0	0	0	35.75	0	HMSA
S236	0	85.00	10.00	0	0	5.00 (LC)	0	100.00	HM
S237	100.00	0	0	0	0	0	0	0	HMSA
S238	0	0	40.00	60.00	0	0	0	100.00	HM
S239	34.00	35.25	30.75	0	0	0	0	88.00	HM
S240	3.75	54.25	42.00	0	0	0	0	61.25	HM
S241	0	0	40.00	60.00	0	0	0	100.00	HM
S242	0	0	40.00	60.00	0	0	0	100.00	HM
S243	34.75	56.50	0	0	0	8.75 (SE)	0	56.50	HM
S244	5.00	25.00	70.00	0	0	0	0	100.00	HM
S245	0	90.00	10.00	0	0	0	0	100.00	HM
S246	25.50	63.25	7.00	0	0	0	4.25	70.25	HM
S247	0	100.00	0	0	0	0	0	100.00	HM
S248	28.75	64.00	7.25	0	0	0	0	71.25	HM
S249	0	90.00	0	0	0	0	10.00	90.00	HM
S250	43.75	33.75	22.50	0	0	0	0	56.25	HM
S251	20.75	79.25	0	0	0	0	0	79.25	HM
S252	67.50	2.50	0.25	0	0	0	29.75	3.00	HMSA
S253	68.75	22.25	9.00	0	0	0	0	89.25	MIX
S254	69.25	5.00	25.75	0	0	0	0	51.25	MIX
S255	0	60.00	40.00	0	0	0	0	100.00	HM
S256	71.00	25.25	0	0	0	0	3.75	17.25	HM
S257	52.50	40.25	4.50	0	0	2.75 (LC)	0	44.75	HMSA
S258	35.00	63.25	0	0	0	1.75 (LC)	0	63.25	HM
S259	79.75	0	0	0	0	0	20.25	0	HMSA
S260	0	57.50	0	42.50	0	0	0	100.00	HM

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[a] PV=*Panicum virgatum*; SE=*Salicornia europaea*; LC=*Limonium carolinianum*.

[b] Includes pond and tidal flat/open water.

[c] Nest community is the plant community in which the nest was built: HMG=high-marsh graminoids; MIX=mixed graminoids; HMSA=high-marsh *Spartina alterniflora*; IVA=*Iva frutescens*.

APPENDIX B-2

Additional characteristics of Sharp-tailed Sparrow nest sites and clutches at four Rhode Island salt marshes, 1981-1982.

Nest No.	Thatch layer thickness (cm)	Mean veg've cover height (cm)	Max. veg've cover height (cm)	Nearest open water Dist. (m)	Nearest open water Tidal regime[a]	Dist. to veg've edge (m)	Relative substrate elevation (cm)	Nest height above substrate (cm)	Relative nest rim elevation (cm)	First egg date	Nest fate[b]
Hundred Acre Cove, 1981:											
H101	--	33	43	0.8	IRR	0.5	5.0	15	20.0	05 Jun	S
H102	--	35	71	1.8	IRR	4.1	3.5	--	--	08 Jun	S
H103	--	48	74	1.1	IRR	0.3	12.3	16	28.3	08 Jun	S
H104	--	32	60	0.5	IRR	1.0	--	15	--	05 Jun	S
H105	--	33	48	7.8	REG	15.9	12.9	16	28.9	09 Jun	S
H106	--	37	58	1.2	IRR	3.4	5.9	17	22.9	08 Jun	S
H107	--	33	51	10.6	REG	13.4	5.6	18	23.6	09 Jun	S
H108	--	48	64	8.5	REG	2.0	5.6	15	20.6	10 Jun	F
H109	--	45	86	3.4	REG	1.8	-1.1	18	16.9	24 Jun	S
H110	--	37	51	2.6	REG	19.2	5.9	17	22.9	29 Jun	F
H111	--	33	55	1.6	IRR	0.1	4.7	12	16.7	07 Jun	S
H112	--	29	70	12.8	REG	5.8	2.2	7	9.2	--	I
H113	--	36	72	18.8	REG	2.6	--	16	--	21 Jul	S
H114	--	43	62	0.4	REG	0.2	-0.5	22	21.5	05 Aug	S
H115	--	33	42	10.9	IRR	4.9	1.9	14	15.9	28 Jul	S
H116	--	36	47	30.2	REG	16.4	4.7	21	25.7	12 Aug	F
Hundred Acre Cove, 1982:											
H201	9	45	93	0.6	IRR	0.4	8.9	--	--	--	I
H202	8	36	52	3.5	IRR	0.1	4.7	13	17.7	--	I
H203	0	37	54	3.7	IRR	1.7	2.8	--	--	--	F
H204	10	47	83	35.6	REG	1.4	3.5	20	23.5	01 Jun	F
H205	7	--	--	1.5	IRR	3.5	--	--	--	31 May	F
H206	0	30	54	21.3	IRR	5.6	1.0	17	18.0	31 May	F
H207	6	30	42	3.3	IRR	0.4	2.8	10	12.8	03 Jun	F
H208	8	37	57	28.1	REG	2.9	3.8	--	--	08 Jun	F
H209	4	35	54	22.7	REG	15.1	7.4	12	19.4	08 Jun	F
H210	5	28	42	18.1	REG	2.5	13.8	11	24.8	24 Jun	S
H211	5	--	--	--	--	--	--	--	--	--	F
H212	10	33	54	0.7	REG	15.1	8.9	13	21.9	25 Jun	S
H213	8	21	45	9.7	IRR	8.0	6.5	13	19.5	25 Jun	S
H214	9	30	36	15.6	IRR	4.0	3.2	8	11.2	25 Jun	U
H215	9	34	37	22.2	REG	3.4	9.9	14	23.9	25 Jun	S
H216	11	53	93	11.7	REG	1.7	0.4	15	15.4	24 Jun	S
H217	8	47	82	22.9	REG	2.8	-0.5	18	17.5	21 Jun	F
H218	15	42	77	15.3	REG	4.2	-1.1	15	13.9	23 Jun	S
H219	7	28	51	5.5	REG	13.7	12.6	9	21.6	25 Jun	S
H220	0	29	56	2.9	IRR	0.9	5.6	13	18.6	25 Jun	U
H221	8	41	75	3.8	IRR	0.5	3.5	15	18.5	26 Jun	U
H222	13	45	69	1.9	IRR	0.7	1.9	14	15.9	26 Jun	S
H223	12	33	64	3.3	IRR	1.6	5.6	13	18.6	25 Jun	S
H224	4	35	80	1.3	IRR	0.3	1.6	13	14.6	24 Jun	S
H225	8	23	41	20.2	IRR	14.6	5.0	16	21.0	25 Jul	U

APPENDIX B-2 continued

Nest No.	Thatch layer thick-ness (cm)	Mean veg've cover height (cm)	Max. veg've cover height (cm)	Nearest open water		Dist. to veg've edge (m)	Relative substrate elevation (cm)	Nest height above substrate (cm)	Relative nest rim elevation (cm)	First egg date	Nest fate[b]
				Dist. (m)	Tidal regime[a]						
Hundred Acre Cove, 1982, continued:											
H226	10	26	70	28.3	REG	2.4	-2.3	14	11.7	10 Aug	F
H227	8	40	84	2.3	IRR	1.0	4.7	19	23.7	03 Aug	S
H228	8	35	63	2.5	IRR	0.7	1.9	--	--	--	I
Palmer River, 1981:											
P101	--	24	39	8.2	REG	5.7	2.1	10	12.1	29 May	F
P102	--	24	48	20.3	REG	18.4	6.1	18	24.1	10 Jun	S
P103	--	34	48	5.9	REG	1.8	2.7	16	18.7	28 Jun	F
P104	--	--	--	23.9	REG	22.7	4.6	--	--	06 Jun	S
P105	--	27	43	36.0	REG	36.0	8.2	12	20.2	04 Jun	S
P106	--	26	40	22.7	IRR	5.5	6.1	12	18.1	06 Jun	S
P107	--	35	47	9.2	IRR	2.2	6.1	--	--	09 Jun	S
P108	--	36	50	4.3	IRR	5.4	4.6	8	12.6	10 Jun	S
P109	--	47	90	2.0	REG	0.3	-10.7	14	3.3	28 Jun	F
P110	--	27	42	0.4	IRR	0.3	5.2	10	15.2	--	F
P111	--	24	32	1.0	IRR	0.4	5.5	15	20.5	08 Aug	S
P112	--	18	21	0.9	IRR	1.2	7.0	10	17.0	28 Jul	S
P113	--	32	46	25.5	REG	13.7	6.1	16	22.1	21 Jul	S
P114	--	22	29	18.0	REG	15.8	3.6	14	17.6	08 Aug	F
P115	--	25	40	21.7	REG	10.1	5.5	11	16.5	--	F
Palmer River, 1982:											
P201	6	22	53	13.3	IRR	7.4	5.8	13	18.8	--	F
P202	9	34	47	9.1	REG	6.9	5.2	9	14.2	21 May	S
P203	3	34	51	10.8	REG	9.5	0.6	--	--	30 May	F
P205	9	35	50	32.2	IRR	30.7	0.3	10	10.3	--	I
P206	8	45	63	13.3	REG	11.1	7.3	--	--	--	I
P207	10	37	51	15.7	REG	14.3	4.9	15	19.9	--	I
P208	7	27	71	20.0	REG	0.8	12.5	--	--	01 Jun	F
P209	5	38	56	7.4	REG	4.0	2.4	--	--	02 Jun	F
P210	6	18	38	22.8	REG	2.4	0.3	10	10.3	14 Jun	F
P211	5	26	43	25.8	IRR	9.4	0.3	11	11.3	--	I
P212	5	28	42	8.9	REG	0.3	-1.5	11	9.5	23 Jun	S
P213	7	28	44	15.2	IRR	15.1	0.9	12	12.9	22 Jun	S
P214	8	32	57	11.2	REG	8.7	-1.2	14	12.8	25 Jun	S
P215	7	32	48	16.9	REG	13.5	0.6	13	13.6	25 Jun	S
P216	0	23	55	52.6	REG	0.8	1.5	12	13.5	21 Jun	S
P217	6	26	36	17.5	REG	15.8	7.0	11	18.0	26 Jun	S
P218	9	35	75	4.7	IRR	0.8	11.6	7	18.6	--	F
P219	4	33	54	30.5	REG	11.1	2.4	9	11.4	22 Jun	S
P220	9	32	45	22.1	IRR	12.3	5.2	12	17.2	24 Jun	S
P221	4	35	44	49.6	REG	22.2	8.2	10	18.2	26 Jun	S
P222	6	23	37	25.7	REG	22.1	3.3	9	12.3	29 Jun	F
P223	7	30	48	5.8	REG	7.7	4.6	15	19.6	29 Jun	S
P224	12	28	42	0.4	IRR	1.0	5.2	14	19.2	01 Jul	S
P225	6	30	61	2.7	IRR	1.3	4.6	17	21.6	--	I

APPENDIX B-2 continued

Nest No.	Thatch layer thickness (cm)	Mean veg've cover height (cm)	Max. veg've cover height (cm)	Nearest open water		Dist. to veg've edge (m)	Relative substrate elevation (cm)	Nest height above substrate (cm)	Relative nest rim elevation (cm)	First egg date	Nest fate[b]
				Dist. (m)	Tidal regime[a]						
Palmer River, 1982, continued:											
P226	8	34	49	16.6	REG	13.9	5.5	18	23.5	12 Aug	S
P227	9	27	40	34.3	REG	10.4	3.6	15	18.6	26 Jul	S
P228	4	28	61	10.4	IRR	0.4	5.5	--	--	--	I
P229	8	38	71	2.8	IRR	0.2	5.2	--	--	13 Aug	S
P231	6	22	39	23.4	REG	3.4	0.6	9	9.6	--	F
Rumstick Point, 1981:											
R101	--	28	42	6.7	REG	4.6	-1.4	13	11.6	14 Jun	F
R102	--	26	53	11.9	REG	5.9	7.2	--	--	12 Jun	F
R103	--	27	52	14.2	REG	4.7	6.3	17	23.3	04 Jun	S
R104	--	33	103	11.0	REG	0.1	15.1	17	32.1	06 Jun	S
R105	--	30	42	17.6	REG	8.6	4.1	15	19.1	05 Jun	S
R106	--	30	44	5.3	REG	3.9	8.4	15	23.4	26 Jul	F
R107	--	29	39	10.0	REG	8.9	4.4	11	15.4	03 Aug	S
R108	--	50	62	1.1	REG	0.6	5.6	--	--	02 Aug	F
Rumstick Point, 1982:											
R201	6	43	55	12.1	REG	6.3	9.9	10	19.9	25 May	F
R202	8	35	56	5.6	REG	2.0	3.8	16	19.8	25 May	F
R203	10	30	45	7.8	REG	2.4	13.6	11	24.6	01 Jun	F
R204	13	39	65	6.6	REG	5.9	0.2	16	16.2	10 Jun	F
R205	6	32	65	12.8	REG	2.5	5.3	--	--	29 May	F
R206	9	30	57	10.1	REG	2.8	5.3	10	15.3	25 Jun	S
R207	6	24	39	10.2	REG	8.6	13.0	13	26.0	23 Jun	S
R208	8	24	35	9.4	REG	8.3	2.6	11	13.6	21 Jun	F
R209	10	30	52	12.3	REG	12.5	5.3	16	21.3	29 Jun	S
R210	10	25	47	9.6	REG	5.5	5.3	10	15.3	23 Jun	S
R211	5	34	54	10.5	REG	8.2	8.1	12	20.1	26 Jun	S
R212	8	30	56	8.9	REG	8.0	7.2	14	21.2	23 Jun	S
R213	9	29	41	12.7	REG	1.4	11.7	12	23.7	26 Jun	S
R214	8	29	52	14.1	REG	11.4	6.9	--	--	--	I
Seapowet, 1981:											
S101	--	64	80	0.6	IRR	12.0	4.5	16	20.5	05 Jun	S
S102	--	38	61	8.9	IRR	1.5	11.2	13	24.2	07 Jun	F
S103	--	32	50	18.0	REG	7.3	6.7	16	22.7	08 Jun	S
S104	--	30	45	25.1	IRR	5.3	6.7	9	15.7	07 Jun	S
S105	--	30	47	15.3	REG	4.3	4.5	12	16.5	05 Jun	S
S106	--	32	42	26.3	IRR	2.6	1.8	9	10.8	10 Jun	S
S107	--	28	44	6.4	IRR	15.2	7.0	10	17.0	09 Jun	S
S108	--	30	46	20.4	REG	8.2	5.8	10	15.8	17 Jun	F
S109	--	32	43	26.3	IRR	5.7	8.5	13	21.5	--	F
S110	--	29	43	3.3	IRR	4.8	3.6	11	14.6	10 Jun	S
S112	--	53	80	0.6	IRR	1.2	-7.0	21	14.0	05 Jun	S
S113	--	31	60	2.2	IRR	1.3	4.8	14	18.8	08 Jun	U
S114	--	32	47	13.9	REG	10.2	9.1	11	20.1	10 Jun	U
S115	--	33	45	1.8	IRR	1.0	6.4	10	16.4	--	F

APPENDIX B-2 continued

Nest No.	Thatch layer thickness (cm)	Mean veg've cover height (cm)	Max. veg've cover height (cm)	Nearest open water		Dist. to veg've edge (m)	Relative substrate elevation (cm)	Nest height above substrate (cm)	Relative nest rim elevation (cm)	First egg date	Nest fate[b]
				Dist. (m)	Tidal regime[a]						
Seapowet, 1981, continued:											
S116	--	33	46	0.6	IRR	0.3	4.5	14	18.5	06 Jul	S
S117	--	38	62	10.1	IRR	8.4	1.8	11	12.8	22 Jul	S
S118	--	32	71	9.6	IRR	4.6	7.9	13	20.9	21 Jul	S
S119	--	18	46	0.5	IRR	0.3	4.8	13	17.8	20 Jul	F
S120	--	38	55	21.3	REG	1.3	4.8	16	20.8	08 Aug	F
S121	--	38	60	2.2	IRR	0.6	3.6	15	18.6	21 Jul	F
S122	--	32	46	7.6	IRR	7.9	5.5	13	18.5	24 Jul	S
S123	--	23	34	3.3	IRR	0.1	5.2	13	18.2	04 Aug	S
S124	--	26	52	0.6	IRR	2.1	-4.0	15	11.0	20 Jul	S
S125	--	51	66	1.3	IRR	1.6	1.2	25	26.2	04 Aug	S
S126	--	25	35	2.5	IRR	1.8	7.9	13	20.9	05 Aug	S
S127	--	23	30	9.9	IRR	5.5	5.8	14	19.8	04 Aug	S
S128	--	27	37	9.9	IRR	7.6	3.3	10	13.3	06 Aug	S
S129	--	20	23	18.4	IRR	1.0	0.0	8	8.0	27 Jul	S
S130	--	31	55	0.8	IRR	0.5	6.7	14	20.7	07 Aug	S
Seapowet, 1982:											
S201	6	23	38	16.8	IRR	8.4	6.4	9	15.4	26 May	S
S202	5	23	35	6.5	IRR	2.9	5.2	8	13.2	29 May	F
S203	10	23	54	1.0	IRR	0.2	7.9	--	--	--	F
S204	6	27	48	26.3	IRR	0.8	-4.0	--	--	27 May	F
S205	11	28	46	0.7	IRR	0.1	6.7	--	--	--	F
S206	6	26	46	29.5	REG	7.8	5.5	9	14.5	29 May	F
S207	7	24	57	12.8	IRR	0.6	7.0	9	16.0	07 Jun	F
S208	5	30	60	1.5	IRR	0.8	9.4	9	18.4	--	I
S209	8	28	36	9.6	IRR	0.6	2.4	10	12.4	--	I
S210	8	32	43	4.1	IRR	1.2	2.4	11	13.4	03 Jun	F
S211	5	29	39	3.3	IRR	2.7	3.0	10	13.0	07 Jun	F
S212	9	32	49	0.8	IRR	0.7	7.0	19	26.0	12 Jun	F
S213	6	27	46	5.8	IRR	0.2	7.9	9	16.9	12 Jun	F
S214	5	27	48	18.7	IRR	2.1	6.1	10	16.1	01 Jun	F
S215	6	25	33	24.5	IRR	6.3	5.5	15	20.5	17 Jun	S
S216	0	40	71	0.4	IRR	0.8	-6.7	23	16.3	14 Jun	S
S217	2	34	49	12.4	IRR	2.0	13.4	16	29.4	09 Jun	F
S218	5	31	49	11.0	IRR	3.4	11.6	--	--	--	U
S219	10	42	81	6.9	REG	1.2	-4.0	15	11.0	--	I
S220	9	39	71	6.5	IRR	3.8	7.9	15	22.9	25 Jun	S
S221	0	36	64	0.4	IRR	2.2	2.7	18	20.7	27 Jun	S
S222	7	24	39	5.0	IRR	7.5	4.2	11	15.2	28 Jun	F
S223	0	46	73	15.5	IRR	10.7	0.0	17	17.0	25 Jun	S
S224	10	32	42	28.7	REG	2.8	3.3	12	15.3	--	F
S225	7	28	38	7.7	IRR	7.3	6.1	14	20.1	27 Jun	S
S226	8	42	85	1.5	IRR	2.0	5.8	12	17.8	26 Jun	S
S227	5	24	35	17.5	IRR	4.6	3.6	9	12.6	25 Jun	S
S228	8	25	37	9.3	IRR	7.1	0.9	13	13.9	23 Jun	S

APPENDIX B-2 continued

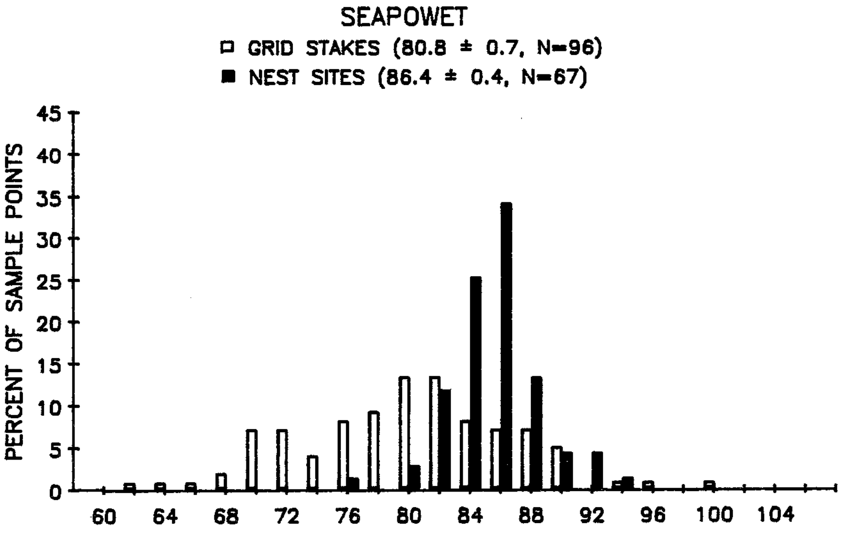
	Thatch layer thick-	Mean veg've cover	Max. veg've cover	Nearest open water		Dist. to veg've	Relative substrate	Nest height above	Relative nest rim	First	
Nest No.	ness (cm)	height (cm)	height (cm)	Dist. (m)	Tidal regime[a]	edge (m)	elevation (cm)	substrate (cm)	elevation (cm)	egg date	Nest fate[b]
Seapowet, 1982, continued:											
S229	6	29	51	10.0	IRR	2.8	3.6	10	13.6	25 Jun	S
S230	0	37	68	1.0	IRR	12.1	3.0	15	18.0	28 Jun	S
S231	9	29	43	1.5	IRR	0.9	8.8	14	22.8	27 Jun	S
S232	7	28	36	4.2	IRR	9.0	3.3	9	12.3	--	F
S233	6	31	44	7.9	IRR	9.0	10.9	--	--	06 Jul	F
S234	0	21	61	19.3	REG	0.4	-6.7	12	5.3	06 Jul	F
S235	0	27	55	0.2	IRR	2.4	1.2	12	13.2	26 Jun	S
S236	6	22	35	29.6	REG	5.4	4.8	9	13.8	02 Jul	F
S237	0	27	47	2.7	IRR	2.6	4.5	14	18.5	11 Jul	U
S238	7	30	46	54.0	REG	15.7	5.8	13	18.8	26 Jun	S
S239	7	20	51	5.1	IRR	0.7	-3.4	10	6.6	--	I
S240	8	27	48	22.1	IRR	1.0	4.8	11	15.8	23 Jul	S
S241	6	31	41	81.0	REG	11.3	11.2	10	21.2	--	U
S242	7	28	50	84.0	REG	9.5	11.2	15	26.2	23 Jul	F
S243	4	28	49	1.6	IRR	0.4	9.7	14	23.7	--	I
S244	11	39	51	5.4	IRR	4.0	9.7	14	23.7	--	F
S245	7	23	33	3.7	IRR	2.9	5.2	11	16.2	25 Jul	S
S246	10	28	40	3.1	IRR	0.4	4.8	17	21.8	--	F
S247	8	28	41	5.9	IRR	5.9	5.8	12	17.8	06 Aug	F
S248	3	23	38	26.1	IRR	0.4	3.6	12	15.6	25 Jul	S
S249	6	25	34	0.8	IRR	1.1	1.8	15	16.8	31 Jul	S
S250	8	27	40	2.9	IRR	0.2	2.1	11	13.1	25 Jul	S
S251	6	23	40	25.6	IRR	0.5	2.7	14	16.7	--	F
S252	0	45	77	0.4	IRR	0.9	-5.8	22	16.2	23 Jul	S
S253	11	35	47	6.4	IRR	0.4	0.9	15	15.9	10 Aug	F
S254	13	40	66	11.7	REG	0.2	--	16	--	05 Aug	F
S255	9	23	39	2.6	IRR	2.3	5.2	13	18.2	--	I
S256	8	25	43	0.8	IRR	0.1	9.1	14	23.1	08 Aug	S
S257	0	20	29	21.5	IRR	0.2	2.7	12	14.7	05 Aug	F
S258	8	23	32	8.0	IRR	0.2	3.9	--	--	--	I
S259	0	37	81	0.3	IRR	3.8	2.7	22	24.7	10 Aug	S
S260	3	33	48	12.2	IRR	12.1	5.8	--	--	--	F

[a] REG=regularly flooded; IRR=irregularly flooded.

[b] S=successful; F=failed; U=unknown fate; I=incomplete nest.

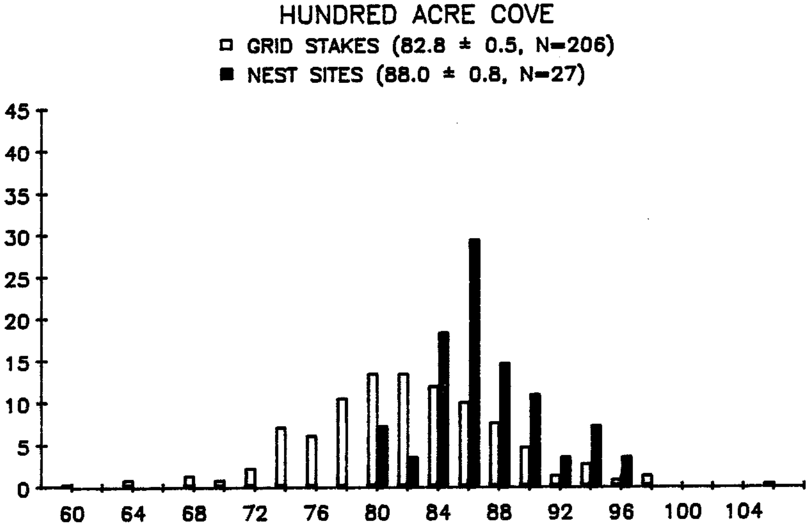
APPENDIX B-3

Distribution of substrate elevations at Sharp-tailed Sparrow nest sites and grid stakes in the high-marsh graminoid community only, at four Rhode Island salt marshes. Values are the percent of nest sites or grid stakes within each elevation range. Mean elevation, SE, and sample size are given in parentheses. At each study area, mean substrate elevation at nest sites was significantly greater than at grid stakes ($P<0.0004$).


SEAPOWET

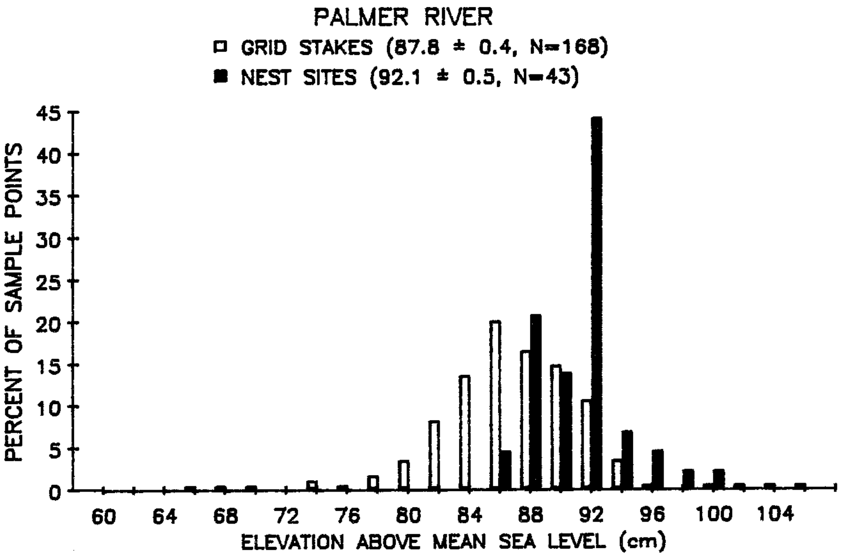
□ GRID STAKES (80.8 ± 0.7, N=96)

■ NEST SITES (86.4 ± 0.4, N=67)


HUNDRED ACRE COVE

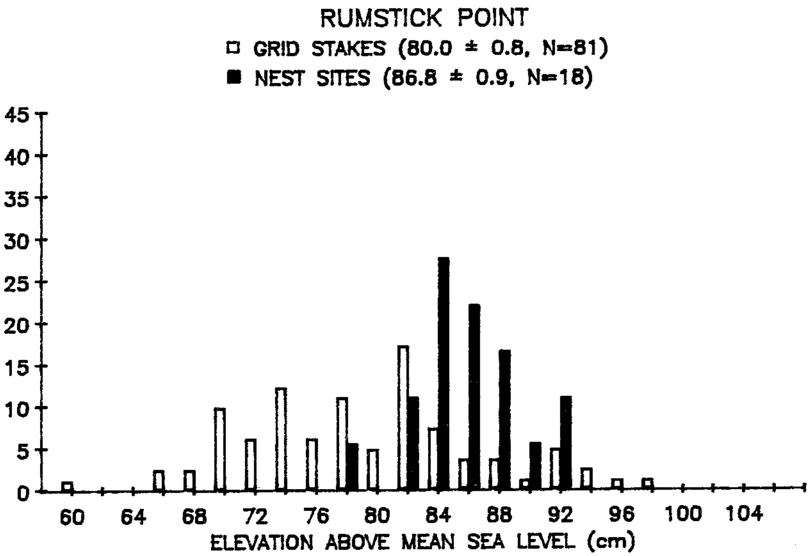
□ GRID STAKES (82.8 ± 0.5, N=206)

■ NEST SITES (88.0 ± 0.8, N=27)


PALMER RIVER

□ GRID STAKES (87.8 ± 0.4, N=168)

■ NEST SITES (92.1 ± 0.5, N=43)


RUMSTICK POINT

□ GRID STAKES (80.0 ± 0.8, N=81)

■ NEST SITES (86.8 ± 0.9, N=18)

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