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Population Estimation and Spatial Distribution of the Wintering Marsh Sparrow Guild in Virginia

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Population Estimation and Spatial Distribution of the Wintering Tidal Marsh Sparrow Guild in Virginia

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Executive Summary

Knowing how many individuals there are of a species and where are they distributed are the most fundamental requirements for conservation and management. We estimated the winter population sizes of the Seaside Sparrow (*Ammodrammus maritimus*), Nelson's Sparrow (*Ammodrammus nelsoni*), and Saltmarsh Sparrow (*Ammodrammus caudacutus*) within the Virginia tidal areas of the Chesapeake Bay and the Seaside of the lower Delmarva Peninsula to determine their winter population distribution. These three species are of special concern because their populations are restricted to marsh habitats that are regionally and globally in decline. Estimating their numbers creates a historical benchmark for monitoring and makes connections for population movements between breeding and winter areas. Connecting the breeding and wintering grounds of migratory bird species is essential for full life cycle conservation.

We calculated the winter population sizes for these species by multiplying the density of birds detected from surveys by the amount of available marsh habitat. The density of birds was obtained by averaging the standardized number of birds detected during rope-drag transects per area across 95 marsh patches. We also estimated the subspecies composition of the Nelson's and Saltmarsh Sparrows from additional capture surveys. We used GIS coverage of Virginia tidal marshes to sum for the total area of plant communities that are used by these sparrows.

The Virginia portion of the Chesapeake Bay and the Seaside of the Delmarva Peninsula support approximately 27,000 Seaside Sparrows, 65,000 Nelson's Sparrows, and 50,000 Saltmarsh Sparrows during the winter. Seaside Sparrows were found in significantly greater density in the marshes of the Chesapeake Bay than on the Seaside of the lower Delmarva Peninsula. The overall population numbers of the Seaside Sparrow in Virginia are lower in winter compared to the breeding season. This suggests that a large portion of Virginia's breeding population migrate southward in fall/winter. The number of Seaside Sparrows that move into Virginia from northerly breeding areas in winter remains unknown. Subspecies composition during winter also offers clues to the geographic origin of some populations. Further breakdown of the population estimates by subspecies indicate that the region supports 53,000 of the interior Nelson's Sparrow and 11,000 of the coastal breeding form. This may be considered a relatively large percentage of the overall known population for the coastal Nelson's Sparrow (*A.n. subvirgatus*) and highlights the region's importance to their survival. The Saltmarsh Sparrow was divided into approximately 42,000 of the northern-Atlantic breeding form (*A.c. caudacutus*) and over 8,000 of the Mid-Atlantic breeding form (*A.c. diversus*). The Virginia coastal marshes receive a large influx of migrants from Saltmarsh Sparrow populations that emanate from the breeding areas of the northern Atlantic.

These estimates provide an opportunity for relative comparison to other geographic regions so conservation actions can be spatially prioritized. This study provided a technique by which density values are obtained from a high frequency sampling technique while also using a unique double-pass rope drag technique refine estimates based on detection probability. This project could serve as a standardized protocol in which to collect data on bird density for these species in other regions during winter.

Background

The Chesapeake Bay and the Seaside of the Delmarva Peninsula support the largest estuary in the world. Based on its geographic position and its wealth of emergent wetlands this region serves as critical breeding, migratory, and wintering habitat for a collection of bird species that depend exclusively on marsh habitats. Among these include the suite of marsh sparrows utilizing tidal saltmarsh habitat in the Chesapeake Bay region in winter. The Saltmarsh Sparrow (*Ammodrammus caudacutus*), Nelson's Sparrow (*Ammodrammus nelsoni*), and Seaside Sparrow (*Ammodrammus maritimus*) are included within several high priority bird conservation lists, including Virginia Wildlife Action Plan (VDGIF 2005), the Atlantic Coast Joint Venture Bird Conservation Region 30 Implementation Plan (ACJV 2008), and the Mid-Atlantic Partners in Flight Coastal Plain Bird Conservation Plan (Watts 1999).

Research on the status and distribution of these marsh sparrows has primarily been focused on the breeding season (Gjerdrum et al. 2005, Shriver et al. 2007, Bayard and Elphick 2011). However, very few studies have examined the migratory and wintering portions of their life cycle. Marsh sparrows may spend up to 6 months on winter areas which may be the most critical time for adult survival (Sandercock 2002, Winder et al. 2012). Marsh habitats in the Chesapeake Bay Region that serve as wintering areas for these species have been declining or been degraded for over a century. The Chesapeake Bay is experiencing rates of sea-level rise that is 2-3 times greater than other regions of the world so rates of wetland loss may increase in the future (Church et al. 2004). Over the next 100 years it has been estimated that 75-80% of the marsh cover in the Bay could be lost to rising waters (Glick et al. 2008) Moreover, the Bay is expected to undergo a state change for remaining wetland cover as areas dominated by high marsh are converted to low marsh. These changes have the potential to drastically alter the amount of available habitat for these marsh sparrows.

The winter populations of Seaside Sparrow, Nelson's Sparrow, and Saltmarsh Sparrow within the Chesapeake Bay and the Seaside marshes of the Delmarva Peninsula are composed of mixture of subspecies forms that emanate from different breeding locations. Because of this, wetland changes that limit habitat or reduce survival in the Chesapeake Bay have the potential to influence all breeding populations but perhaps influence some more than others based on the relative proportion of individuals from each population that winter here. The subspecies form of the Seaside Sparrow found in Virginia (*A m. maritimus)* breeds throughout the Mid-Atlantic and northern Atlantic regions and is the only form present in the Chesapeake Bay Region and Seaside marshes of the Delmarva Peninsula during winter. However, Nelson's Sparrows that winter here winter may be comprised of subspecies from interior locations (*A.n. alterus* or *A.n. nelsoni*) or coastal breeding areas (*A.n. subvirgatus*) (Figure 1). Finally Saltmarsh Sparrows are separated into Mid-Atlantic (*A.c. diversus*) and northern Atlantic (*A. c. caudacutus*) breeding forms that are both supported by the Chesapeake Bay in winter (Figure 2). Determining the relative connectivity between breeding grounds of these forms and their wintering areas is important for full life cycle conservation. For instance, this linkage allows winter areas to be ranked for their relative importance in supporting breeding populations by size and provides the opportunity to examine if winter habitat is a limiting factor on overall population size.

The objectives of this project are to estimate the population sizes for these marsh sparrows across tidal saltmarsh habitats in Virginia. The results of this study provide the first ever population estimates for these species over such a large area. This project serves as an historical benchmark for future comparisons of sparrow populations and a conceptual benchmark for conservation as the model protocol to estimate populations of these species in other regions. Specifically, the objective of this project were to 1) determine the density of these sparrows across Chesapeake Bay and Seaside of the Delmarva Peninsula marshes, 2) determine the distribution and proportion of subspecies forms, and 3) provide population estimates and winter distributions the three marsh *Ammodrammus* species in tidal salt marshes in Virginia.

Figure 1. Breeding range of the three Nelson's Sparrow subspecies (from Ridgely et al. 2003).

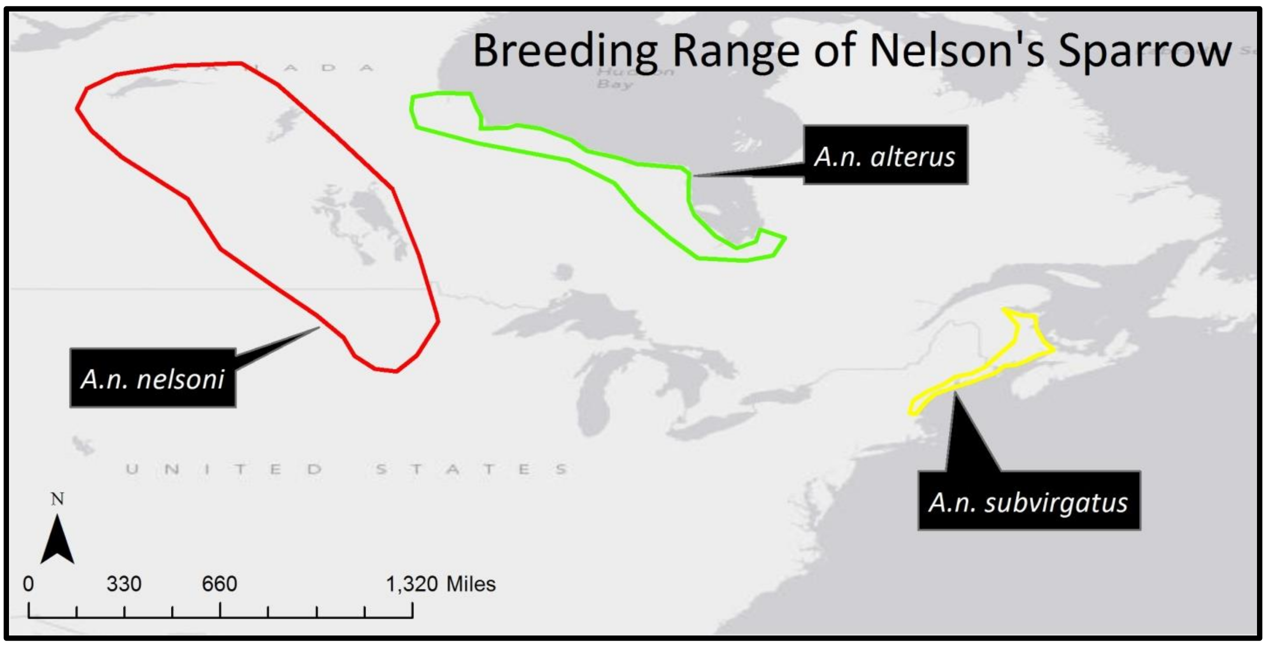
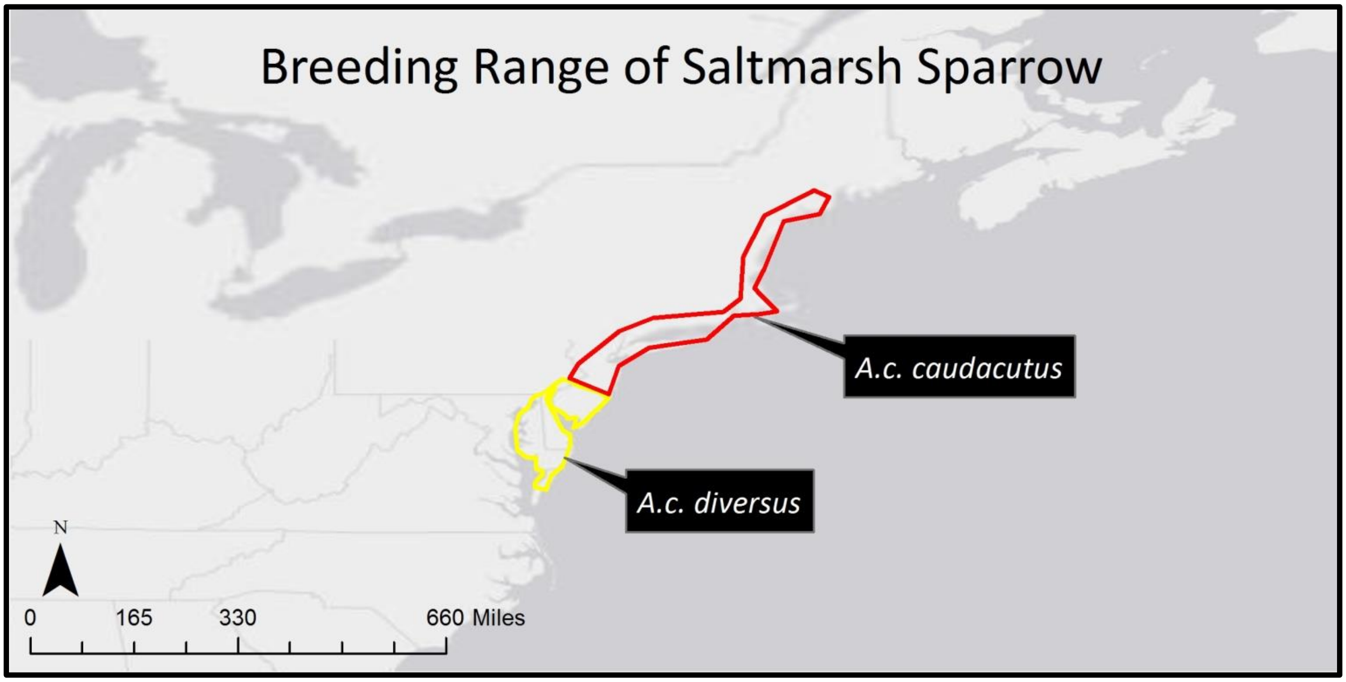


Figure 2. Breeding range of the two recognized Saltmarsh Sparrow subspecies (from Ridgely et al. 2003).



Methods

Sampling Design – We developed population estimates for the three tidal marsh sparrow species by multiplying the density of birds detected per hectare by available marsh area. This required data on marsh sparrow distribution and density to be collected in the field. Marsh bird distribution and density are known to be strongly influenced by marsh geography and habitat area during the breeding season (Watts 1992). To examine this possibility in winter, we balanced the sampling effort across three geographic zones and four patch size categories as follows: The Bay region was geographically split into 1) the Western Shore of the Chesapeake Bay, 2) Bayside of the Delmarva Peninsula, and 3) Seaside of the Delmarva Peninsula (Figure 3). Patch size categories were grouped as 1-5ha, 6-20ha, 21-50ha, and > 50ha. We attempted to have an equal number of replicates in each study cell but eventually had to vary those numbers because of constraints of marsh patch availability (Table 1).

Bird Surveys – We used a standardized rope drag transect (Peterson and Best 1985) to sample marsh sparrow density. Transects were 60m wide (rope distance) and their length varied from 200-250m so they could fit into marshes of different sizes and dimensions. We increased the number of transects surveyed in larger marshes in order to sample more area. Each transect was surveyed 3 times during the winter between mid-falling and mid-rising tide to avoid any biases produced by high tide inundation that moves birds out of lower marshes and into high marsh roosting habitats (Paxton 2007). We chose marshes with mixtures of high and low marsh so that each habitat type and the ecotone between each could be sampled. The vegetation within individual transects were typically dominated by *Spartina alterniflora* and *Juncus roemerianus* but often contained 20-30% cover of *Spartina patens* and *Distichlis* *spicata*. Transect were oriented to intersect different vegetation types from start to finish so rope drags would flush birds from different cover types.

Rope drags are designed to increase the detection probability by flushing birds hidden within dense vegetation. We implemented a double-pass technique that would help determine detection probability by comparing the detection decay rate between the first and second pass. A transect was walked by three people with two stationed on either end of the rope with one walking down the middle. On the initial pass all detected birds were registered and tracked to determine if they flushed off the transect. A reverse pass was made immediately after to detect any additional birds missed by the first pass. Detections of Nelson's and Saltmarsh Sparrows were combined as "Sharp-tailed Sparrow" because of difficulty in discerning these two species visually on flush surveys.

Species and Subspecies Composition– The composition of the Sharp-tailed Sparrow complex was examined further by capturing birds for identification in the hand. We selected a subset of the marshes used for transect surveys and attempted to capture as many marsh sparrows in each by flushing them into mist nets. All birds captured were identified to species form by plumage characteristics (Pyle 1997). These birds were also identified to subspecies based on published identification keys (Greenlaw and Woolfenden 2007, Smith 2011).

Figure 3. Starting locations for rope drag transects in Virginia used to survey 95 marshes the winter of 2013-2014. Marshes selected for this study were divided into three geographic zones: the Western Shore of the Chesapeake Bay, the Bayside of the Delmarva Peninsula, and the Seaside of the Delmarva Peninsula.

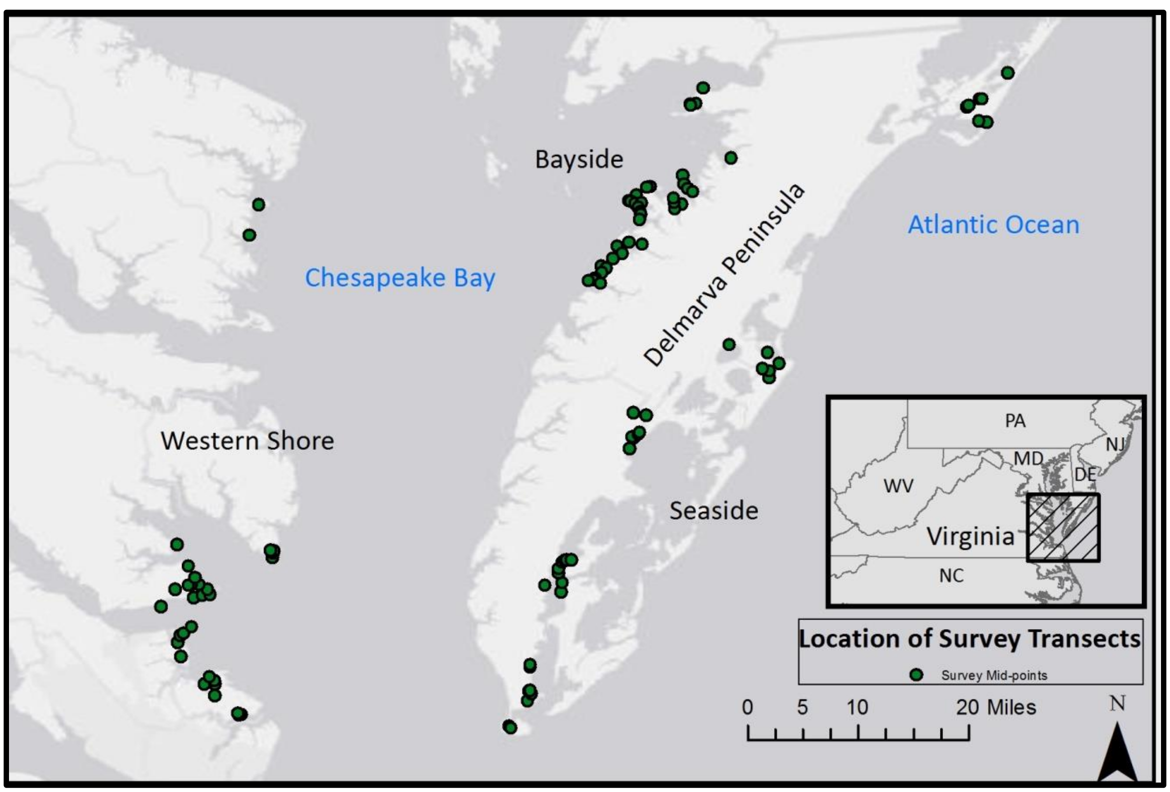


Table 1. Summary of geographic locations and patch size of marshes that were surveyed during winter 2014.

Survey Transects	1 to 5ha	5 to 20ha	20 to 50ha	>50HA	Totals
Western Shore	6	6	8	10	30
Delmarva Peninsula - Bayside	7	5	7	10	28
Delmarva Peninsula - Seaside	9	8	10	9	37
All areas	22	19	25	29	95

Figure 4. Example of survey transect (green line) on the Bayside shoreline of the Delmarva Peninsula. Most survey transects, like this one, cut across several vegetation zones of low and high marsh (and through tidal creeks). The mosaic of colors in this marsh photo represent different vegetation types such as *S. alterniflora* and *J. roemerianus*.

Species Composition

Bird Density - Bird density values were calculated for patch size and geographical combinations using individual patches as the sampling unit. For each patch, we calculated a single value based on the average number of detections across the three rounds of surveys. A single value was calculated for any patch that contained multiple transects by first summing the data for all embedded transects. Results of the double-pass technique indicated that 82% of Seaside Sparrows and 88% of all Sharp-tailed Sparrows were detected during the first pass. We used these values as the detection rate to correct for birds missed during the first pass. Therefore, the estimated number of birds per survey (C) was calculated as C = N/P, where N = the number of birds detected on the first pass and P = the detection rate. It should be noted that number of times a bird was detected on a second pass was low. Second pass detections of Seaside Sparrows only occurred during 24 out of 285 (8%) surveys conducted and second pass detections of Sharp-tailed Sparrows only occurred during 39 (13%) surveys. Birds per survey were converted to birds per hectare based on the area of each transect. Bird density values were compared using two-way ANOVA using patch size and geographic zones.

Population Projections – Bird population estimates for the Virginia portion of the Chesapeake Bay and the Seaside of the Delmarva Peninsula were calculated by multiplying average bird density values by the area of available marsh habitat. Patch size did not have a significant influence on bird density (see Results). Because of this, there was no reason to calculate density values for each patch size class so all were combined within a geographic zone. We created a population estimate and range for each geographic zone by multiplying the mean bid density of individual patches by the area of available habitat. A high and low range of each population estimate was calculated based on ± 95% confidence intervals of the mean bird density.

Habitat area was calculated from GIS coverage of marsh vegetation produced by the Center for Coastal Resource Management (1992). This GIS coverage classifies marsh vegetation cover into distinct communities according to results of aerial surveys. We selected a portion of their marsh community types that represent habitats used by Seaside Sparrows, Nelson's Sparrows, and Saltmarsh Sparrows. In general, these include marsh communities that occur under brackish and salty conditions (i.e. salinity values of 5.0-18.0 and 18.0-30 ppt, respectively). Specifically, within this GIS classification system, we selected 1) brackish water mixed, 2) saltmarsh cordgrass, 3) saltbush, 4) saltmeadow hay, and 5) black needlerush communities. The amount of marsh area within these categories was summed within and across the geographic zones. Separate population estimates are made for the different forms/subspecies of Nelson's and Saltmarsh Sparrows according to their relative capture rates.

Results

Survey Effort

We conducted a total of 303 survey transects across 141.7ha of marsh during each round of surveys. A total of 765 Sharp-tailed Sparrows and 179 Seaside Sparrows were detected during all surveys.

Species Projections

Seaside Sparrow

The density of Seaside Sparrows were significantly influenced by geography but not by patch size (two-way ANOVA $F= 8.5$, $df = 2$, $p < 0.05$ and $F = 0.9$, $df = 3$, $p > 0.10$, respectively). There was no interaction between geography and patch size indicating that this result was consistent in each geographical zone ($F = 1.1$, $df = 6$, $p > 0.10$). This only significant difference was Seaside Sparrow density being three times greater on the Western Shore and Bayside compared to the Seaside (Table 2). Seaside Sparrow density was not significantly different between the Western Shore and Bayside. A population estimate for the Seaside Sparrow is found in Table 6.

Sharp-tailed Sparrow Complex

The density of Sharp-tailed Sparrows was not significantly influenced by geography or by patch size (two-way ANOVA . $F = 2.2$, $df=2$, $p > 0.10$, and $F = 1.1$, $df = 3$, $p > 0.10$, respectively). There was no interaction between geography and patch size indicating that this result was consistent in each geographical zone. However, Sharp-tailed Sparrow density was slightly greater on the Western Shore compared to the Bayside and Seaside (Table 2).

Subspecies and Form Breakdown

A total of 96 Nelson's Sparrows and 67 Saltmarsh Sparrows were captured using mist-nets. The relative proportion of each species captured within each geographic zone indicates the distribution of the two species varied with geography (Table 3). However, geographic comparisons are tenuous because of the relatively low number of birds captured. Nelson's Sparrows were captured much more frequently than Saltmarsh Sparrows on the Western shore but the two species were captured evenly between the Bayside and Seaside of the Delmarva Peninsula.

Among the Nelson's Sparrow subspecies, it appears that the interior forms (*A. n. nelsoni* and *A. n. alterus*) dominated the coastal form (*A. n. subvirgatus*) (Table 4). The interior subspecies ranged from 77 – 85 % of all Nelson's Sparrow captures. For the Saltmarsh Sparrow, captures were dominated by northeastern form (*A. c. caudacutus*) over the form that breeds on the Delmarva Peninsula (*A. c. diversus*) (Table 5). The composition of captured birds and densities determined through surveys were then projected within appropriate tidal salt marsh habitat in Virginia to give population projection at the species (Table 6) and subspecies (Table 7) levels.

Table 2. Density (birds/ha) ± SD of Seaside Sparrows and the Sharp-tailed Sparrow complex in the Virginia portion of the Chesapeake Bay and Seaside of the Delmarva Peninsula.

	Geographic Zones			
Species	**Western Shore**	**Bayside**	**Seaside**	**Total**
Seaside Sparrow	0.62 ± 0.58	0.55 ± 0.56	0.18 ± 0.33	0.43 ± 0.56
Sharp-tailed Sparrow complex	2.48 ± 1.98	1.36± 1.37	1.67 ± 1.75	1.83 ± 1.77

Table 3. Capture rates of Sharp-tailed Sparrow complex in the Virginia portion of the Chesapeake Bay and Seaside of the Delmarva Peninsula. Percentages indicate the relative proportion of captures, by species, within each geographic zone.

	Geographic Zones			
Species	**Western Shore**	**Bayside**	**Seaside**	**Total**
Nelson's Sparrow	20 (91%)	13 (39%)	53 (54%)	86 (56%)
Saltmarsh Sparrow	2 (8%)	20 (61%)	45 (56%)	67 (44%)
Total by geographic zone	22	33	98	153

Table 4. Capture rates (N) of Nelson's Sparrow forms in the Virginia portion of the Chesapeake Bay and Seaside of the Delmarva Peninsula. Percentages indicate the relative proportion of captures of each form within each geographic zone.

	Geographic Zones			
Subspecies	**Western Shore**	**Bayside**	**Seaside**	**Virginia**
A. n. nelsoni and *alterus* (interior)	14 (77%)	11 (85%)	42 (78%)	67 (82%)
A. n. subvirgatus	4 (23%)	2 (15%)	9 (22%)	15 (18%)
Total by geographic zone	18	13	51	82

Table 5. Capture rates (N) of Saltmarsh Sparrow forms in the Virginia portion of the Chesapeake Bay and Seaside of the Delmarva Peninsula. Percentages indicate the relative proportion of captures of each form within each geographic zone

	Geographic Zones			
Subspecies	**Western Shore**	**Bayside**	**Seaside**	**Total**
A. c. caudacutus	0 (0%)	16 (84%)	36 (86%)	52 (83%)
A. c. diversus	2 (100%)	3 (16%)	6 (14%)	11 (17%)
Total by geographic zone	2	19	42	63

Table 6. Populations Projections of the Seaside Sparrow and the Sharp-tailed Sparrow complex in the Virginia portion of the Chesapeake Bay and Seaside of the Delmarva Peninsula. Estimates are based on mean bird density and available habitat. Range calculated on the 95% confidence interval of mean bird density.

Species	**Available Habitat (ha)**	**Population Estimate (numbers of birds)**	**± 95 % Confidence Interval Range**
Seaside Sparrow			
Virginia	63,178	27,166	21,480 – 34,116
Western Shore	20,242	12,550	8,096 – 17,003
Bayside	10,225	5,623	3,415 – 7,873
Seaside	32,711	5,877	2,289 – 9,486
Sharp-tailed Sparrow complex			
Virginia	63,178	115,615	92,871 – 142,150
Western Shore	20,242	50,200	34,221 – 65,179
Bayside	10,225	13,906	8,486 -19,325
Seaside	32,711	52,991	35,224 – 73,599

Table 7. Population estimate of Saltmarsh Sparrow and Nelson's Sparrow based in subdividing total Saltmarsh Sparrow estimates by the percent captured.

Subpecies or Form	**Population Estimate**	**± 95 % Confidence Interval Range**
Saltmarsh Sparrow	50,870	40,863 – 65,246
A. c. caudacutus	42,222	33,916 – 51,913
A. c. diversus	8,648	6,946 – 10,362
Nelson's Sparrow	64,744	52,007 – 79,604
A. n. nelsoni & *alterus* (interior)	53,090	42,646 – 65,275
A n. subvirgatus	11,653	9,361 – 14,328

Discussion

The Chesapeake Bay and the Seaside of the Delmarva Peninsula appear to support a significant population of Seaside Sparrows, Nelson's Sparrows and Saltmarsh Sparrows. This was signified by the fact that all species and their forms were found with relatively high densities and that this region supports a relatively large amount of tidal marsh habitats. The Chesapeake Bay region supports 30% of the total salt marsh cover along the Atlantic Coast (Field et al. 1991). Whether or not Virginia supports a greater or lesser than expected percent of the total populations of these species than what would be expected by habitat availability remains unknown. There has never been a systematic population estimate of these species in any other state or region to determine the relative distribution of these species in winter. Virginia is near the northern range limit for Seaside Sparrows in winter but there are neither population estimates nor descriptions of the winter range of the *maritimus* form. Within the Chesapeake Bay region winter population estimates for Seaside Sparrow in the lower Chesapeake Bay are orders of magnitude smaller than during the breeding season (Wilson et al. 2006). This suggests that a large number of birds depart to more southerly wintering areas. Also, Seaside Sparrows in winter are distributed differently than during the breeding season. In winter, they are found less frequently on the Seaside of the Eastern Shore compared to the Chesapeake Bay shoreline. However, in summer, Seaside Sparrows can be found with similar abundance across these areas.

The composition of the Sharp-tailed Sparrow complex in Virginia was found to be more evenly represented by Nelson's and Saltmarsh Sparrows in this study than what has been previously suggested in the literature (Greenlaw and Woolfenden 2007). Greenlaw and Woolfenden (2007) concluded that Saltmarsh Sparrows were numerically dominant to Nelson's Sparrow in Virginia by examination of nine study skins collected in various locations throughout the state. The results presented in our study and previous work with these species (CCB unpublished banding data 2006-2013) indicate that ratio of each species using the Bay are relatively similar although there is variation between years. For instance, we found a much greater number of Nelson's Sparrows compared to Saltmarsh Sparrows on the Western Shore during this study but this pattern has been reversed in previous years. Reasons for seasonal variations in numbers between Nelson's and Saltmarsh Sparrows are unknown but could be expected to be influenced by weather and tides.

The dominance of the northeastern breeding Saltmarsh Sparrow, *A. c. caudacutus*, over the Mid-Atlantic breeding form, *A. c. diversus*, indicates a large influx of migrant Saltmarsh Sparrows into Virginia for the winter. *A. c. caudacutus* breeds from central New Jersey to Maine but the southern range limit for this form in winter is not well known. Previous population projections range from ~250,000 (Rich et. al. 2003) to ~30,000 individuals (Elphick et al. 2009). Our winter population estimate for *A. caudacutus* nearly doubles the most recent estimate. Studies to estimate population sizes and composition of the species forms like the one presented here are needed across the Mid-Atlantic and Southeastern U.S. to help determine the non-breeding distribution of this species complex and to better estimate the total population of the species.

Virginia represents the southern range limit for the breeding *A. c. diversus* population that also breeds north to the Delaware Bay and possibly into central New Jersey. In Virginia, this species only breeds within Accomack County and at a few isolated locations on the Western Shore (Watts 2004). In winter, numbers of *diversus* were captured in both the Chesapeake Bay and along the Seaside of the Delmarva Peninsula, suggesting a tendency for new arrivals in winter to occupy a broader geographical distribution in Virginia compared to summer. A lack of information on population size of this subspecies makes it impossible to frame the relative importance of Virginia to the overall species winter range.

It is apparent that the Chesapeake Bay supports relatively large numbers of both the coastal (*A. n. subvirgatus*) and inland/interior (*A.n. nelsoni* and *alterus*) forms of Nelson's Sparrows. The fact that the interior form was encountered more frequently may be a function of larger population size. The breeding population numbers of the interior form are typically estimated in millions of birds compared to the coastally restricted form of the northeastern U.S. that has breeding populations that are estimated in the tens of thousands. Interior Nelson's Sparrows breed along the Hudson Bay and in the northern prairie pothole region. The relatively high number of interior Nelson's Sparrow wintering here may be surprising given their non-breeding range includes vast areas across the mid-western U.S. and the Gulf of Mexico. The relatively large numbers of the coastal Nelson's Sparrow (~11,000 birds) suggests that Virginia may be a globally important wintering location. Determining the winter range of the coastal form throughout the remainder of the Atlantic Coast should be a priority for status assessment of this form rangewide.

Overall, this project helped to estimate population sizes for marsh species of special concern. These estimates provide an opportunity for relative comparison to other geographic regions so that conservation actions can be spatially prioritized. This study also provided a technique by which density values are obtained from a high frequency sampling technique while also using a unique double-pass rope drag technique refine estimates based on detection probability. The survey protocols developed for this project should be applied to other regions during winter.

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