Developing a geographic exposure profile of methylmercury availability in salt marshes of New England

(BRI 2005-04)

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March 17, 2005

Please cite this report as: Lane, O.P. and D.C. Evers. 2005. Developing a geographic exposure profile of methylmercury availability in salt marshes of New England. Report BRI 2005-04. BioDiversity Research Institute, Gorham, Maine.

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Abstract

In 2004 we conducted a mercury (Hg) sampling effort of Saltmarsh Sharp-tailed Sparrows (*Ammodramus caudacutus*) nesting in the estuaries at four National Wildlife Refuges across New England and additional sites in Maine. Our goal was to assess methylmercury (MeHg) availability to insectivorous birds. We sampled sites using sparrow blood and collected failed eggs from five estuaries of the Rachel Carson National Wildlife Refuge (NWR) in Maine, one site at Parker River NWR in Massachusetts, two sites at Ninigret NWR in Rhode Island, one site at Stewart B. McKinney NWR and a nearby off-refuge site Hammock River in Connecticut, and in Scarborough Marsh Wildlife Management Area (WMA) in Maine. Concurrent Tree Swallow (*Tachycineta bicolor*) sampling efforts were conducted at one of the Rachel Carson NWR sites in Wells and at Scarborough Marsh WMA to relate established Hg risks in swallows to the sparrows.

Mean site-specific sparrow blood Hg levels ranged from 0.23 to 1.09 ppm (wet weight). Sparrow blood Hg levels sampled in Parker River NWR and Ninigret NWR were significantly higher than the concentrations in sparrows sampled in Maine and Connecticut. Two plausible explanations are: (1) there are higher levels of Hg in the Parker River and Ninigret systems originating from waterborne and/or airborne sources and (2) sparrows in Parker River NWR in Massachusetts and Ninigret NWR in Rhode Island may forage at a higher trophic level than sparrows in Maine and Connecticut.

Blood Hg concentrations in Tree Swallows at two study sites were significantly lower than in Saltmarsh Sharp-tailed Sparrows, although, egg Hg levels tended to be similar. Swallow blood and egg Hg concentrations were significantly correlated. Additional sampling efforts are needed to further document (1) site-specific exposure profiles, (2) origin of Hg input, (3) Hg relationship between swallows and sparrows and (4) Hg effects in sparrows.

Introduction

Sharp-tailed Sparrows have been recently (1995) split into two species: a northern species, (*Ammodramus nelsoni*) with three subspecies (*A. n. nelsoni*, *A. n. alterus*, and *A. n. subvirgatus*) and the southern species, (*Ammodramus caudacutus)* with two subspecies (*A. c. caudacutus and A. c. diverus*). *A. n. subvirgatus* (hereafter Nelson's Sparrow) and *A. c. caudacutus* (hereafter Saltmarsh Sparrow) (Figure 1) are sympatric in coastal Maine, New Hampshire and northern Massachusetts (Hodgman et al. 2002, Shriver et al. 2005). Based on a previous study we concluded that Saltmarsh Sparrows were more numerous in the study area and had significantly higher blood mercury concentrations than closely related Nelson's Sparrow (Shriver et al. 2002). Consequently we focused our efforts on the Saltmarsh Sharp-tailed Sparrow.

Exposure to mercury can impact bird behavior, physiology, and reproductive success (Thompson 1996, Wolfe and Norman 1998). Extensive studies with Common Loons have documented these impacts in Maine (Evers et al. 2004). It is well known that freshwater wetlands generally serve as areas of high Hg methylation, thus making obligate birds especially vulnerable to high levels of Hg contamination (Evers et al. 2005). The role of saltmarsh habitats in methylating Hg and enhancing its bioavailability (Marvin-DiPasquale et al. 2003), however, is less documented, but is of increasing concern especially in urban areas.

Sharp-tailed Sparrows are obligate saltmarsh passerines with ≈ 95% of their global population breeding within the Northeast. Spending their entire annual cycle in saltmarsh habitats makes them excellent indicators of Hg contamination. According to Parners in Flight, Saltmarsh Sharp-tailed Sparrows are among the highest priority species in the northeast, and considered a “bird of conservation concern” by US Fish and Wildlife Service (USFWS) Region 5. These designations result from their near endemic status in our region, a lack of population trend data, and threats on their breeding and wintering grounds (Hodgman pers. com.). Saltmarsh Sparrows spend their entire lifecycle within the saltmarsh ecosystem. An estimated 98 percent of their global population nests in USFWS Region 5.

Between 1998-2000, we found 5 sparrows with beak and/or foot deformities at Scarborough Marsh WMA, and when we later analyzed the blood of Saltmarsh Sparrows from that site, we found elevated levels of Hg. In 2001, we expanded sampling to include blood from 75 sparrows from five Maine estuaries to determine relative differences in Hg levels. Sparrow blood samples from estuarine habitat in Rachel Carson NWR in Wells contained some of the highest Hg levels in Maine (Shriver et al 2002).

Concurrently, work in Maine and Massachusetts has shown that Tree Swallows are appropriate indicators of Hg exposure in wetlands. We included swallows in the study to compare Hg levels in the Saltmarsh Sharp-tailed Sparrows with the established risk concentrations from other studies conducted with Tree Swallows (Heinz, pers. comm). Because recent dosing studies have now identified lethal effects at 0.8 ppm (wet weight=ww), and lowest observed adverse effect levels (LOAEL) for Tree Swallow eggs at 0.1-0.4 ppm (ww), linking Hg exposure levels in Tree Swallows with those in Sharp-tailed Sparrows is of great interest. Tree Swallows nest in artificial boxes and can be easily attracted to breed on the targeted salt marshes.

For this study we predicted that Sharp-tailed Sparrow blood and egg Hg levels will be (1) more representative of the target area and (2) higher than the Tree Swallows’ blood and egg levels and (3) there is a correlation between the two species’ tissues. The purpose of this study was to determine Hg exposure and begin to assess risk to passerines breeding in Maine and other New England estuaries.

Figure 1. Nelson’s (left) and Saltmarsh Sharp-tailed Sparrows, Scarborough Marsh WMA, Maine, 2004.

Natural history

The Saltmarsh Sharp-tailed Sparrow has a limited range, occupying estuaries along the Atlantic Coast from Florida up to the southern coast of Maine where it overlaps with the Nelson’s Sharp-tailed Sparrow (Hodgman et al. 2002). Across its range the species is non-territorial and exhibits a bondless form of polygyny in which males provide no parental care (Greenlaw 1993, Greenlaw and Rising 1994).

The diet during breeding season consists mainly of animal matter: immature and adult insects and other arthropods (Greenlaw and Rising 1994, Merriam 1979). Tidal flooding causes most of nest failures but usually the birds renest within a short period of time. Young leave the nest 23-27 days after clutch initiation. Nestlings fledge between 8-11 days after hatching (Greenlaw and Rising 1994).

Because Saltmarsh Sparrows require nesting habitat that is becoming increasingly limited due to habitat fragmentation, rise in sea level, pollution and human encroachment into estuaries, the species' conservation calls for immediate attention.

Methods

Study area

The study encompassed six estuaries in Maine (Appendix I and II): 1) Scarborough Marsh Wildlife Management Area (hereafter Scarborough Marsh WMA) in Scarborough and 2) five estuaries in the Rachel Carson NWR: Furbish Road Marsh (hereafter Furbish Marsh) in Wells, Little River Marsh (hereafter Little River) in Wells and Kennebunk, Granite Point Marsh (hereafter Granite Point) in Biddeford, Goosefare Brook Marsh (hereafter Goosefare) in Old Orchard Beach and Saco, and Spurwink Marsh on Cape Elizabeth (hereafter Spurwink). We sampled one site in Massachusetts: Parker River NWR (hereafter Parker River) on Plum Island in Newburyport, two sites in Rhode Island: Ninigret NWR, Chafee and Sachuest Marshes, and two sites in Connecticut: Stewart B. McKinney NWR-Great Meadows Saltmarsh (hereafter McKinney) in Westbrook and Hammock River Marsh (hereafter Hammock River) in Clinton (this site is a part of a University of Connecticut study area) (Appendix I). Saltmarsh Sparrow blood samples were collected from all of the sites listed above. Tree Swallows were sampled from Scarborough Marsh WMA and Furbish Marsh in Maine.

Capture and sampling

All capture and blood sampling occurred during June and July 2004. We used two to four 12-m mist nets with 36 mm mesh size. We positioned the nets perpendicular to drainage ditches and tidal creeks regularly found in many of the estuaries. A team of 5-6 people "swept" the area of approximately 100-200 m^2 "rounding up" the sparrows and coaxing them to fly towards the nets. The birds were extracted from the nets and banded with a USFWS band. An umbrella was used for shade to prevent birds from overheating. Sex, age and breeding status were determined for each bird. Venipuncture of the cuteneous ulnar vein with a 26 gauge sterile disposable needle allowed collection of 1-2 capillary tubes of blood into heparinized tubes for Hg analysis. The capillary tubes were sealed with cretoseal and placed in 10 cc plastic vacutainer, labeled with date, site, species, age and sex information. All birds were released unharmed within 20-30 minutes of capture.

We placed 14 nest boxes in Scarborough Marsh WMA and 16 boxes in Furbish Marsh, to attract Tree Swallows. We collected one egg from each occupied box (unless the nest failed then we collected all eggs in the nest) and blood samples from nesting adult swallows for Hg analysis.

We opportunistically collected sparrow eggs and dead chicks from nests flooded during the high tide floods. Blood and egg samples were analyzed for total Hg at Texas A&M University, Trace Element Research Lab. All analyses are for total Hg because 95% of the total Hg is methylmercury in songbird blood (Rimmer et al. 2005). All blood and egg Hg concentrations are in parts per million (ppm) wet weight (ww). Feathers and dead chicks were archived at BioDiversity Research Institute (BRI) for future testing.

Statistical analyses

All statistical analyses were conducted using JMP 4.0 software with alpha=0.05. We used one-way Analysis of Variance (ANOVA) and Tukey-Kramer HSD pairwise comparisons tests to determine significant differences among sites and between species.
All means are reported as arithmetic means unless otherwise stated. When conditions of normal distribution of data were not met and/or variances were unequal a non-parametric Welch ANOVA test was used.

Results and Discussion

Sampling effort

From 11 June to 28 July, 2004 we collected blood samples for Hg analysis from 63 Saltmarsh Sharp-tailed Sparrows in Maine and 42 from other states (Table 1, Appendix I). Blood samples were also collected from 55 other individual birds representing 10 species in our study sites. Twenty three abandoned eggs from several marshes in Maine and New Hampshire were also collected and tested for Hg. We also analyzed 20 (8 from Scarborough and 12 from Wells) Tree Swallow blood samples and 21 (6 from Scarborough and 15 from Wells) eggs. Nest box occupancy by Tree Swallows was 50% (7/14) in Scarborough Marsh WMA and 56% (9/16) in Furbish Marsh. Typically, the nest box occupancy rate by Tree Swallows increases in the years following the installation season.

The highest density of sparrows within our study appeared to be at Scarborough Marsh WMA in Maine, followed by Furbish Marsh and Goosefare of the Rachel Carson NWR and the lowest appeared to be at the Chafee site at Ninigret NWR, Rhode Island and Parker River NWR in Massachusetts. The last two locations were the most difficult capture sites as it required more effort to catch our target sample size of sparrows.

Morphological measurements

We conducted a oneway analysis of variance (ANOVA) of bird weight in Maine, where both Nelson’s and Saltmarsh Sparrows are sympatric, and found that Saltmarsh Sparrows’ (20.3 +/- 0.2 g, n=62) mean weight was significantly greater than Nelson’s (17.3 +/- 0.3 g, n=28) (ANOVA df=89, F=93, $P<0.0001$), which is consistent with the findings from previous studies (Shriver, et al. 2005).

Table 1. Summary of bird blood sampling efforts from 11 New England salt marshes, June-July, 2004 (AHY=after hatch year=adult).

Location	Site	Species	Sex M	Sex F	Age AHY
Rachel Carson NWR, ME	Furbish Marsh	Saltmarsh Sharp-tailed Sparrow	11	4	15
		Nelson's Sharp-tailed Sparrow	3	3	6
	Goosefare Brook	Saltmarsh Sharp-tailed Sparrow	11	2	13
		Nelson's Sharp-tailed Sparrow	5	2	7
		Hybrid Saltmarsh/Nelson's	1		1
	Granite Point	Saltmarsh Sharp-tailed Sparrow	1	2	3
		Nelson's Sharp-tailed Sparrow	1		1
		Hybrid Saltmarsh/Nelson's	1		1
	Little River-Wells	Saltmarsh Sharp-tailed Sparrow	6	1	7
		Nelson's Sharp-tailed Sparrow	2	1	3
		Hybrid Saltmarsh/Nelson's	2		2
		Least Sandpiper	2		2
		Semipalmated Sandpiper	5		5
	Spurwink Marsh	Saltmarsh Sharp-tailed Sparrow	6	4	10
		Nelson's Sharp-tailed Sparrow	5	1	6
		American Goldfinch	1	1	2
		Barn Swallow			2
		Bobolink	1		1
Total for Rachel Carson NWR, ME		Saltmarsh Sharp-tailed Sparrow	35	13	**48**
		All other species			**39**
Scarborough Marsh WMA, ME		Saltmarsh Sharp-tailed Sparrow	7	8	15
		Nelson's Sharp-tailed Sparrow	4	1	5
Total for Scarborough Marsh WMA, ME		Saltmarsh Sharp-tailed Sparrow	7	8	**15**
		All other species			**5**
Total for Parker River NWR, MA	Plum Island	Saltmarsh Sharp-tailed Sparrow	6	4	**10**
Ninigret NWR, RI	Chafee Marsh	Saltmarsh Sharp-tailed Sparrow	3	3	6
	Sachuest Marsh	Saltmarsh Sharp-tailed Sparrow	5	4	9
		Song Sparrow	1		1
Total for Ninigret NWR, RI		Saltmarsh Sharp-tailed Sparrow	8	7	**15**
		All other species			**1**
McKinney NWR, CT	Great Meadows	Saltmarsh Sharp-tailed Sparrow	9	6	15
		Seaside Sparrow	2	1	3
		Marsh Wren	1	1	2
		Common Yellowthroat	1		1
		Bobolink	1		1
Total for McKinney NWR, CT		Saltmarsh Sharp-tailed Sparrow	9	6	**15**
		All other species			**7**
Hammock River, CT		Saltmarsh Sharp-tailed Sparrow	2		2
		Seaside Sparrow	3		3
Total for Hammock River, CT		Saltmarsh Sharp-tailed Sparrow	2		**2**
		All other species	3		**3**
Grand Total		Saltmarsh Sharp-tailed Sparrow			**105**
		All other species			**55**

We also found that culmen length (from end of nares to tip of the bill) (ANOVA df=84, F=44, P<0.0001) and total bill length (df=86, F=33, P<0.003) were significantly longer in Saltmarsh than Nelson's Sparrow. We compared other bill measurements (bill width and depth) and found no statistically significant differences between species (width: df=83, F=0.25, P<0.6; depth: df=83, F=1.06, P<0.3) (Table 2). Shriver (2002) found that Saltmarsh Sparrows' bill was significantly wider than Nelson's, however unlike Shriver's results, our data analysis does not indicate significant bill width differences between species.

Table 2. Morphological variables (bill measurements in mm, weight in g) measured on sympatric Saltmarsh and Nelson's Sharp-tailed Sparrows in Maine, 2004 (n=birds measured).

	Bill mean +/-sd				Weight +/-sd
Species	Length	Culmen	Width	Depth	
Nelson's	13.1 +/-0.1 (27)	8.8 +/-0.4 (26)	4.3 +/-0.05 (26)	5.35 +/-0.2 (26)	17.3 +/-0.3 (28)
Saltmarsh	13.5 +/-0.1 (60)	9.4 +/-0.4 (59)	4.3 +/-0.04 (59)	5.29 +/-0.3 (59)	20.3 +/-0.2 (62)

Male Sharp-tailed Sparrows tend to have longer wing chords than females (Greenlaw 1993). We found that wing chord was significantly longer in male Nelson's and Saltmarsh Sparrows than in females (Table 3) (ANOVA, df=28, F=19, P<0.0002; df=102, F=92, P<0.0001 respectively).

Table 3. Mean wing chord measurements (mm) in Saltmarsh and Nelson's Sharp-tailed Sparrows in New England, 2004 (n=birds measured).

Species	Wing chord mean +/-sd	
	Male	Female
Nelson's	57.8 +/-0.4 (21)	54.6 +/-0.6 (8)
Saltmarsh	58.0 +/-1.4 (65)	55.4 +/-1.1 (38)

Comparisons among salt marsh birds blood mercury concentrations

Saltmarsh Sharp-tailed Sparrows

We found the lowest Hg concentrations in the sparrows from Hammock River in Connecticut and the highest in Parker River NWR, Massachusetts (Table 4, Figure 2). Using oneway ANOVA we detected statistically significant differences in blood Hg among sites (df=103, F=17.6, P<0.0001). Tukey-Kramer HSD pairwise comparisons test indicates significant site differences and showed that Chafee Marsh of Ninigret NWR and Parker River NWR sparrows had significantly higher blood Hg levels than sparrows from other sites. Sparrows from Sachuest site in Ninigret NWR and Little River in Wells have significantly higher Hg concentrations than Hammock River, Scarborough Marsh WMA and Spurwink.

Table 4. Mean blood Hg concentrations in adult Saltmarsh Sharp-tailed Sparrows, sampled across four NWR systems in New England, 2004. (Sites arranged in increasing order of Hg).

State	Site*	Mean Hg (ppm, ww)	SD	Hg range (ppm, ww)	n
CT	Hammock River	0.23	0.02	0.22-0.24	2
ME	RCNWR - Spurwink Marsh	0.45	0.10	0.26-0.60	10
ME	Scarborough Marsh WMA	0.47	0.16	0.23-0.82	15
ME	RCNWR - Goosefare Brook	0.50	0.12	0.32-0.75	13
CT	McKinney NWR	0.54	0.11	0.39-0.73	15
ME	RCNWR - Granite Point	0.54	0.11	0.46-0.66	3
ME	RCNWR - Furbish Marsh	0.56	0.09	0.33-0.69	14
RI	Ninigret NWR – Sachuest Marsh	0.72	0.11	0.54-0.87	9
ME	RCNWR - Little River	0.74	0.08	0.64-0.84	7
RI	Ninigret NWR - Chafee	1.08	0.22	0.86-1.36	6
MA	Parker River NWR	1.09	0.38	0.67-1.68	10

*RCNWR=Rachel Carson NWR

One likely reason for high Hg levels in sparrows from the Parker River NWR Sparrow is that sampling efforts were concentrated in the salt marsh situated between the Merrimack and Parker Rivers (Appendix 3). Both potentially carry Hg-polluted waters from interior watersheds to the coast. Merrimack River, flowing through New Hampshire and Massachusetts is well known as a historical source of Hg. Mercury that has been deposited in the sediment is likely still present and may continue to methylate and enter the aquatic food chain. Parker River NWR is located in the northeastern region of the state that is also a well-known biological hotspot for Hg (Evers et al. 2005).

Other saltmarsh birds

We opportunistically sampled five Seaside Sparrows (*Ammodramus maritimus*) in Connecticut and found their blood Hg levels to be similar to Saltmarsh Sparrow levels from the same sites (Figure 2). Nelson's Sparrow blood Hg levels are known to be lower than the sympatric Saltmarsh Sparrows (Shriver et al. 2002) and we documented similar patterns with this study (Table 4). We also collected blood samples from other species opportunistically caught during mist-netting efforts. Saltmarsh Sparrow Blood Hg concentrations tended to be higher than the other 10 species tested (Table 5).

It is likely that Saltmarsh Sparrows had significantly higher blood Hg levels (Shriver et al. 2002) because they feed at a higher trophic level or consume different prey base then sympatric Nelson's Sparrows. For example, based on limited stomach analyses data, the diet of Saltmarsh Sparrows (from New England) had 24 % amphipods by volume during breeding season and Nelson's (in New Brunswick) had higher insect percent by volume but no amphipods in their diet (U.S. Fish and Wildlife Service data, in Greenlaw and Rising 1994). George et al. (2001) found that amphipods contained higher concentrations of Hg than higher on the food chain odonates and crayfish. Contaminants collect in "modern mud" (i.e., mud buildup over the last century) so bottom-dwelling animals that dwell in mud habitats tend to accumulate contaminants.

Shriver (2002) found that in the areas of overlap the Saltmarsh Sharp-tailed Sparrows had 25 % of their alleles from the Nelson's Sparrow. Shriver also found that "hybrids" resembled Saltmarsh Sparrows closer than the Nelson's. When comparing Maine Sharp-tailed Sparrows to the other states where there is no hybridization with Nelson's the genetic difference should be considered.

There are several factors that may explain differences in interspecies Hg levels: (1) As body mass increases so does MeHg concentration in insectivorous birds (Evers et al. 2005). This finding holds true for several species in this study with the exception of Seaside Sparrow, which has body mass greater than the Saltmarsh Sparrow but Hg levels are similar. The blood Hg levels in the sandpipers (also heavier than sparrows) were lower but they likely reflect multiple feeding sites because of migration; (2) Food chain length also affects the amount of MeHg available to insectivorous birds. It is likely that Saltmarsh Sparrows are feeding at a higher trophic level than other birds in the estuary. Species such as the Bobolink and Common Yellowthroat, had comparatively lower blood Hg levels than Saltmarsh Sparrows within a study site, which indicates a diet with a shorter food chain length and less of an ability for MeHg biomagnification.

Table 5. Mean blood mercury concentrations in species opportunistically sampled in 2004*. Sites are arranged in geographical order-North to South.

State	Site	Species	Age	n	Mean Hg +/-sd
ME	Scarborough Marsh WMA	Nelson's Sparrow	adult	2	0.31 +/-0.06
ME	RCNWR - Spurwink Marsh	Bobolink	adult	1	0.02
		Barn Swallow	juvenile	1	0.17
		Nelson's Sparrow	adult	1	0.32
ME	RCNWR - Granite Point	Nelson's Sparrow	adult	1	0.51
		Hybrid Sharp-tailed Sp.	adult	1	0.44
ME	RCNWR - Goosefare Brook	Nelson's Sparrow	adult	7	0.51 +/-0.10
		Hybrid Sharp-tailed Sp.	adult	1	0.44
ME	RCNWR - Little River	Least Sandpiper	adult	2	0.15 +/-0.001
		Semipalmated Sandpiper	adult	4	0.31 +/-0.13
		Nelson's Sparrow	adult	1	0.42
ME	RCNWR - Furbish Marsh	Nelson's Sparrow	adult	3	0.35 +/-0.02
RI	Ninigret NWR-Sachuest Marsh	Song Sparrow	adult	1	0.12
CT	McKinney NWR-	Common Yellowthroat	adult	1	0.05
	Great Meadows Unit	Bobolink	adult	1	0.05
		Marsh Wren	adult	2	0.24 +/-0.003
		Seaside Sparrow	adult	3	0.56 +/-0.14
CT	Hammock River	Seaside Sparrow	adult	3	0.26 +/-0.11

*more Nelson's data are pending

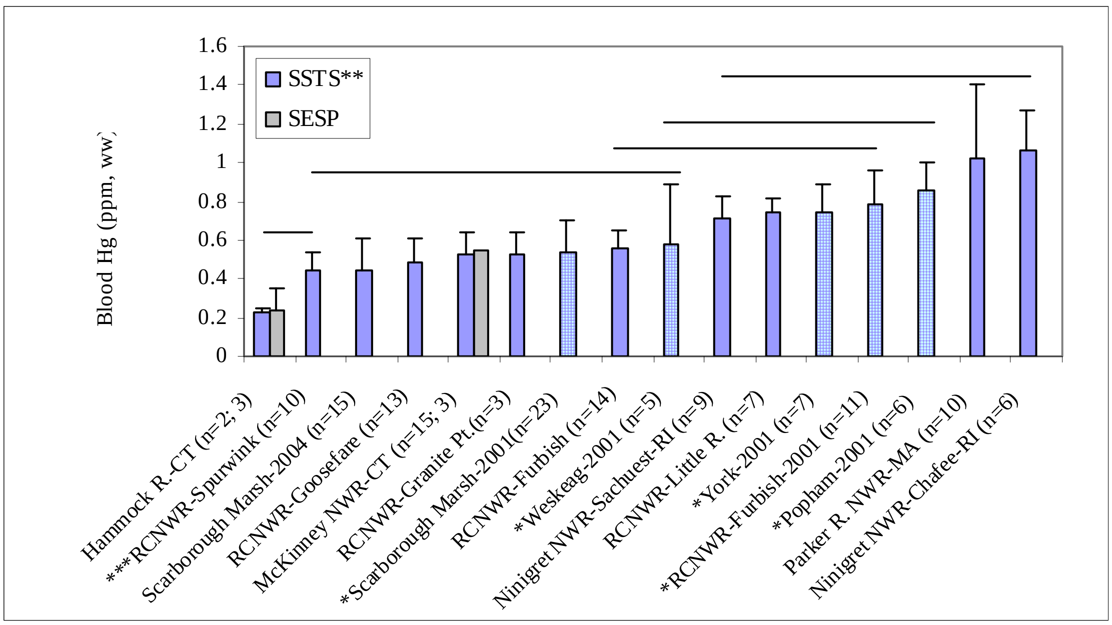
Comparisons between Tree Swallows and Saltmarsh Sharp-tailed Sparrows

Blood mercury

Mercury concentrations in Tree Swallow blood were significantly lower than in the Saltmarsh Sparrows from the same sites based on one-way ANOVA (Furbish Marsh: df=25, F=28, P<0.0001; Scarborough Marsh WMA: df=22, F=9.8, P<0.005) (Figure 3).

The mean blood Hg levels in both sites are consistently 75% higher in Saltmarsh Sparrows versus Tree Swallows. The difference in blood mercury levels between the species is likely a reflection of their foraging habits. Tree Swallows are likely feeding on prey that are lower on the food chain therefore have lower Hg concentrations. In other studies flies (Diptera) made up about 70% of adult Tree Swallows' diet; egg-laying females also consumed mayflies (15%) and females during nestling stage preyed on Odonata (Dragonflies and Damselflies 10%) and a variety of small terrestrial prey (Blancher and McNicol 1991). Food of aquatic origin constituted 65% of the nestling diet by mass in Ontario (Blancher and McNicol 1991). During the breeding season in Ontario Tree Swallows consumed small insects (<1 cm): mostly adult flies (order Diptera) and small leafhoppers (order Homoptera) (Quinney and Ankney 1985).

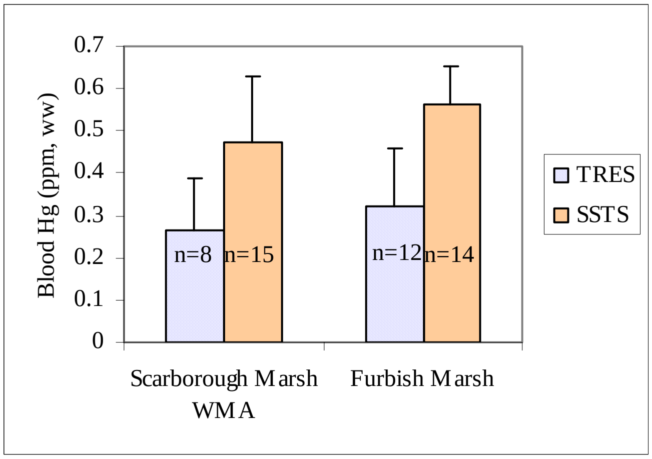
Figure 2. Blood Hg concentrations (geometric mean +/- sd) in adult Saltmarsh Sharp-tailed Sparrows sampled in 2001 and 2004 in Maine and other New England States. n=birds sampled. Lines indicate statistically similar Hg levels



*Data used to calculate the means for these sites were used in Shriver et al. 2002.
**SSTS=Saltmarsh Sharp-tailed Sparrow; SESP=Seaside Sparrow
***RCNWR=Rachel Carson NWR.

In a study conducted in New York State, McCarty and Winkler (1999) found at least 11 orders of insects in the diet of Tree Swallow nestlings, with insects in the 3-5 mm range making up the largest proportion of the diet. Diptera (Nematocera and Brachycera) were the most frequent items followed by Hemiptera and Odonata (McCarty and Winkler 1999). Adult Tree Swallows with damselflies (Odonata) in their bills were observed feeding the nestlings on the Sudbury River in Massachusetts (Lane, pers. obser. 2003). We do not have information on foraging habits of Tree Swallows in estuaries.

Figure 3. Blood mercury concentrations in Tree Swallows and Saltmarsh Sharp-tailed Sparrows sampled in June-July, 2004 in Maine.



*TRES=Tree Swallow, SSTS=Saltmarsh Sharp-tailed Sparrow

We speculate that prey items in Tree Swallow diet likely contain less Hg than the prey consumed by Saltmarsh Sparrows. Tree Swallows' estimated foraging radius is approximately 400 m from the nest box (Quinney and Ankney 1985) and their foraging area might be larger than the Saltmarsh Sparrows'.

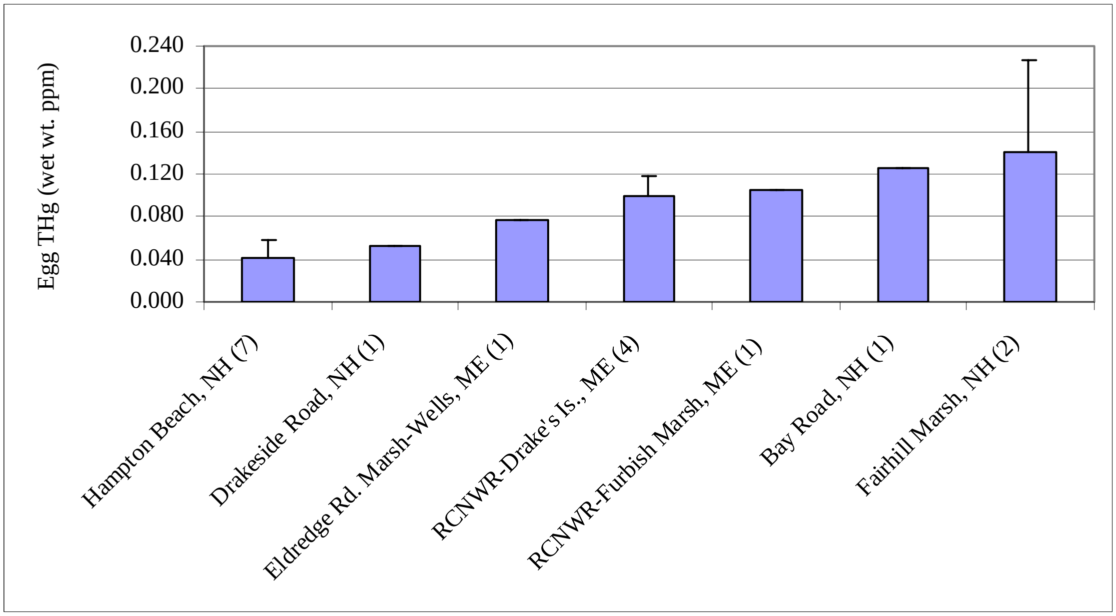
Saltmarsh Sparrows forage entirely in the salt marsh (Greenlaw and Rising 1994, Merriam 1979). On Long Island, New York Merriam (1979) found that the two most common insect orders in Saltmarsh Sharp-tailed Sparrow's diet were Diptera, ranging between 13 % in June to 47% of all items in July (predominantly adults and larvae of Stratiomyidae) and Hemiptera, ranging between 4% in June to 37% in July) (nymphs and adults of Miridae). Other invertebrates found in the diet of nestling Sharp-tailed Sparrows were Homoptera (Deplhacidae) ranging between 0 and 34%, the Araneida (spiders), ranging between 3% in July to 56% in June, and amphipods (between 5% in first half of July to 15 % in the second half of the month (Merriam 1979).

Egg mercury

We collected one egg from each box occupied by a nesting pair of Tree Swallows from Scarborough Marsh WMA and Furbish Marsh. We also collected failed Saltmarsh Sharp-tailed Sparrows eggs from various sites in Maine and New Hampshire. A total of 20 Tree Swallow eggs were analyzed for Hg and 17 Saltmarsh Sparrow eggs from seven estuaries were opportunistically collected and tested.

In general, Hg levels in the eggs were low (Figure 4). Based on a Hg dosing study (Heinz pers. comm.) conducted on Tree Swallow eggs the lethal LOAEL in swallow egg =0.8 ppm (ww) and sublethal effects are estimated at 0.4 ppm (ww) (were detected at as low as 0.1 ppm, further experiments are necessary to more accurately identify the sublethal concentration). All eggs tested in this study are well below 0.4 ppm and the lethal LOAEL.

Figure 4. Mean (+/-sd) egg mercury concentrations from flooded out Saltmarsh Sharp-tailed Sparrow nests collected in Maine and New Hampshire in 2004, (n) =egg sample size.



We found a positive correlation between female Tree Swallow blood and egg Hg levels (Figure 5). In a previously funded EPA study we also found a positive relationship between adult female swallow blood and egg Hg levels (n=45, r^2=0.49) (BRI unpubl. data). We are unable to correlate sparrow blood and eggs because we do not have Hg values from the eggs and blood from the same bird.

Based on our small sample size of eggs collected from Rachel Carson NWR in Wells-Furbish Road, there was no significant difference in Hg levels between Tree Swallow and Saltmarsh Sparrow eggs (Table 6), (F=0.12; df=12, P=0.8). We found a significantly higher blood Hg levels in the Sparrows vs. Swallows but the egg Hg concentrations were not significantly different between the species. Therefore, contaminant levels measured in eggs might underestimate the total Hg exposure to the species. Interpreting Sharp-tailed Sparrow egg contaminant levels should be done with caution and eggs might not be the best tissue to use in estuarine contaminant studies. It is possible that at the time of egg laying the females' body burden of Hg is not at high enough levels to be depurated into the eggs.

Figure 5. Relationship between egg and female blood mercury in nesting Tree Swallows in two estuaries in Maine, 2004.

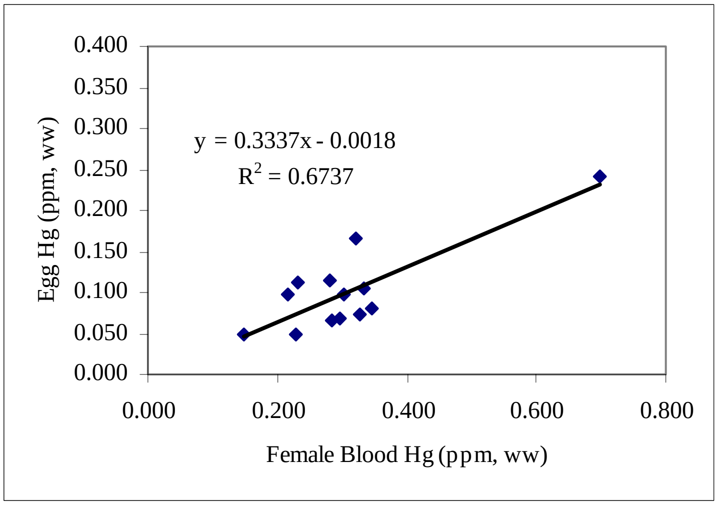


Table 6. Mean mercury concentrations (ppm, ww) in Tree Swallow and Saltmarsh Sparrow eggs collected in Maine, 2004.

	Mean egg Hg +/- sd (n)	
Site	Tree Swallows	Saltmarsh Sharp-tailed Sparrows
Furbish Marsh-RCNWR	0.11 +/- 0.06 (9)	0.10 +/- 0.02 (4)
Scarborough Marsh WMA	0.09 +/- 0.03 (6)	--

Conclusions and Recommendations

Based on the results of one year scan sampling of Saltmarsh Sharp-tailed Sparrows we conclude that:

1. Bird blood is an appropriate tissue to use to evaluate the Hg exposure to insectivorous birds in salt marshes.
2. Saltmarsh Sharp-tailed Sparrows have elevated blood Hg levels across the sampling sites and are at potential risk in Parker River NWR in Massachusetts and Ninigret NWR in Rhode Island.
3. It appears that sparrow eggs may not be the best indicator tissue to use in assessing Hg exposure for Saltmarsh Sharp-tailed Sparrows.

We recommend to:

1. Continue sampling Saltmarsh Sparrows at the sites with the highest Hg levels to increase the sample size.

2. Collect sparrow blood samples from additional sites in estuaries near possible point sources of Hg.
3. Conduct a vigorous nest search to collect eggs abandoned after high tide flooding.
4. Continue to collect Tree Swallow blood and egg samples for Hg analysis at the established in 2004 sites.
5. Place Tree Swallow boxes in Parker River NWR to collect samples for Hg analysis and to determine reproductive success.
6. Collect prey samples in the study estuaries for Hg analysis.

Acknowledgments

Funding for this project was provided by US Fish and Wildlife Service, Maine Department of Inland Fisheries and Wildlife and Maine Department of Environmental Protection. We are grateful to Kate O'Brien, Graham Taylor, and the staff of Rachel Carson NWR for their logistical support and help in the field. Kate O'Brien provided photographs for this report. We thank Tom Hodgman and Greg Shriver for their expert technical advice. We thank the following individuals for their help and support: Kate Laskowski for her assistance in the field; Dr. Kim Babbit and Megan McElroy and field crew from UNH for collecting failed eggs; biologists: Nancy Pau at Parker River NWR, Sara Williams at Steward B. McKinney NWR and Suzanne Paton at Ninigret NWR; Carina Gjerdrum and Chris Elphick from UCONN for providing sparrow blood from Hammock River site in CT; and all the volunteers who came out to help catch birds, especially Frank Dehler for his many hours of assistance and valuable help. Many thanks to Bob Taylor and his team at Texas A&M University for providing lab analysis. BRI biologists Theresa Daigle and Melissa Duron were a tremendous help in the field and in the office.

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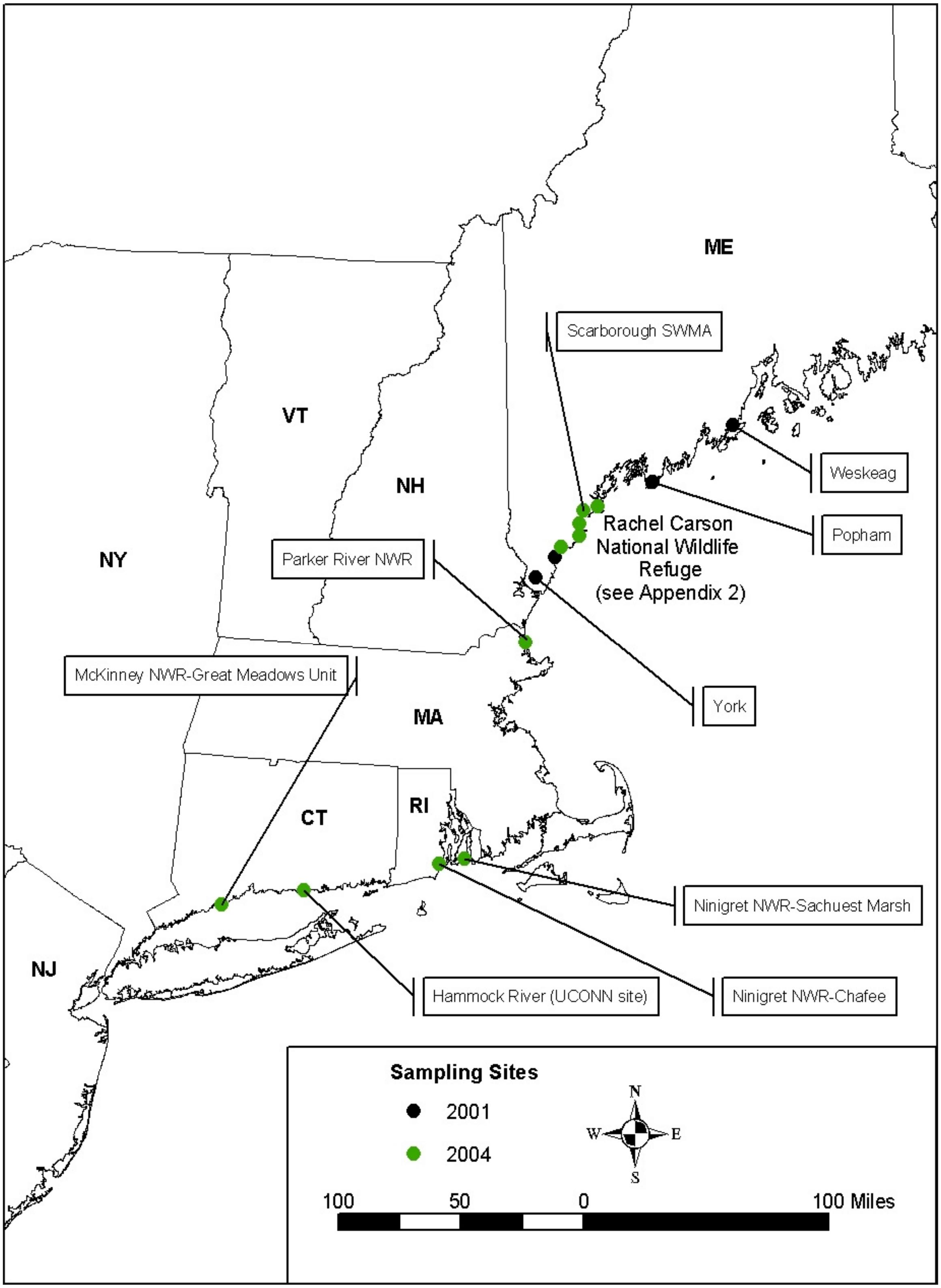
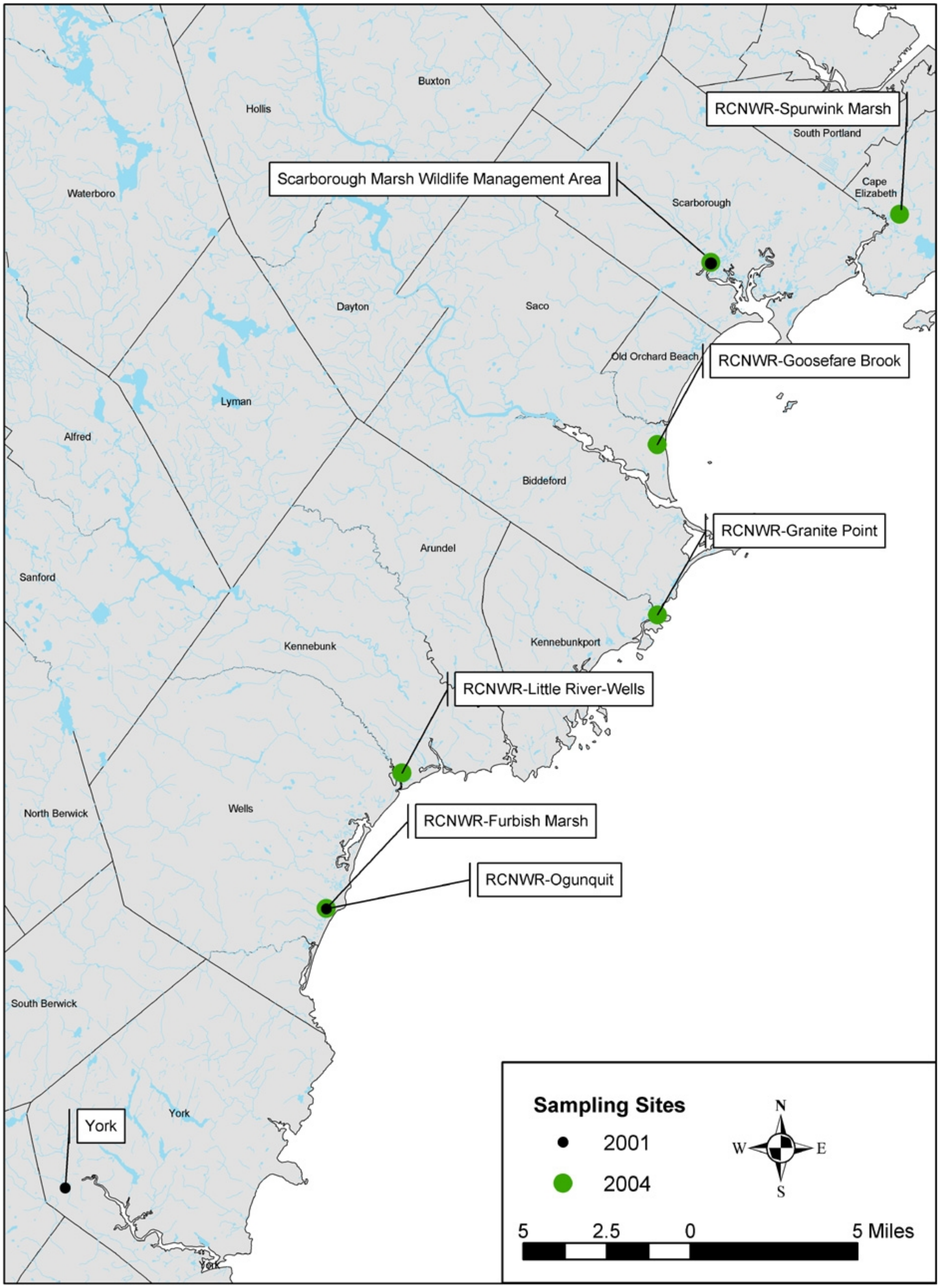
Appendices

Appendix I. Saltmarsh Sharp-tailed Sparrow sampling locations in New England, 2004.



Appendix II

Saltmarsh Sharp-tailed Sparrow sampling locations in the Rachel Carson NWR and other locations in Maine, 2001 and 2004.



Appendix III. Saltmarsh Sharp-tailed Sparrow sampling location in Parker River NWR, Massachusetts, 2004 (map provided by Nancy Pau).