Monomoy Refuge Banding Station
Fall Migration Monitoring
2018 Report

Prepared by James Junda

December 2018

About Monomoy Refuge Banding Station

Monomoy Refuge Banding Station (MRBS, located 41.559 N, 69.995 W) was founded in 2011 by James Junda with the cooperation and assistance of staff at Monomoy National Wildlife Refuge (NWR). It is operated by both volunteers and highly trained professional banders. It is a valuable addition to the collection of banding stations on Cape Cod, being the most easterly and only station located on a barrier island. The two closest stations are Wing Island Banding Station in Brewster (30 km to the NE), Wellfleet Bay Wildlife Sanctuary (30 KM SSE) and Manomet Bird Observatory (70 km to the ENE). Operations are based upon the protocols of other constant effort banding stations in the United States and Canada with an emphasis on standardized research protocols. In addition to collecting and analyzing scientific data to assist in management decisions, MRBS serves to increase public interest in Monomoy NWR.

Fall Migration Monitoring

Fall migration monitoring is a standardized study undertaken annually. It provides the basis for long-term trend analysis of migrating birds using the refuge and is designed to be comparable with the methodology of other fall migration banding stations. The protocol involves regular monitoring including standardized census, banding, and incidental observations taken each day staff is present at the station. The fall migration season extends from August 15 to October 31. This period encompasses the majority of fall passerine migration, providing us with a thorough view of the process while allowing us to exit the island before poor weather limits banding opportunities.

2018 Season Coverage

In 2018, the fall migration season started on August 14 and ended on October 29, for a total of 75 days. We were present on the island for 75 days, operating nets on 59 days for a total of 4141.49 hours up from 1721.31 in 2017 (season started on late September 26th), 2014 (3709.99), 2013 (3087.02), 2012 (2557.88), and the trial season of 2011 (930.45). We conducted census a total of 63 times, 25 at Lighthouse Beach, 18 at Big Station and 20 at Powder Hole. Coverage of MRBS in 2018 was very high from August 1-September, when were able to band on 40/45 (89%) of days. From October 1-31, coverage was significantly lower due unstable weather associated with late fall; we only banded on 22/31(71%) of days, often with a very limited number of nets.

Equipment

Mist nets (12x2.5m, 30mm mesh) were used for all trapping. The standard setup included 15 nets in four groups (A, C, D, F). Details of net allocations and locations as well as age and manufacturer are included in the Net Productivity section. Census was completed using high quality models of Zeiss Angled Spotting Scopes with magnification of 60x (a significant upgrade over the Alpen 20-60x spotting scope used in previous seasons) and personal binoculars supplied by each participant.

Weather

2018 was a season that can easily be broken down into two periods: early (August/September) and late (October). The early period was categorized as good weather with low capture rates. The late period was categorized by numerous days of NW wind and colder weather. This period also had a very heavy migration, but our effort was limited by the number of nets we could open due to wind. Migration waves followed a typical pattern: a storm would be followed by a period of high captures, followed by a period of reduced captures until a cold front brought in another wave of migrants.

Yearly Banding Effort

Monomoy is a very exposed banding station, with its location on a small island surrounded on three sides by water and its habitat of mostly open areas with small groves on trees and marsh. This makes its operation very dependent on weather conditions. Additionally, our time spent on the island varies greatly by season (Table 1), from our trial season in 2011, expanded season in 2012, government shutdown impacted 2013 (we missed 19 days in September/October), full length 2014, no 2015 or 2016, late start 2017 (we started in late September) and finally another full season in 2018. When comparing among seasons, it is important to bear these differences in mind. Direct comparison of 2013, 2014 and 2018 are reasonable, as they are all mostly full seasons. 2011, 2012 and 2017 are best compared to each other and the other seasons on relative variables (for example, rank of captures, not absolute number of captures). This must be done with caution, as species makeup varies across the fall and some seasons include more late or early effort.

	2011	2012	2013	2014	2017	2018
Captures (species)	934 (70)	1787 (79)	2999 (86)	3323 (92)	1952 (62)	2634 (90)
Species observed	120	162	182	174	119	190
Net hours	930.45	2557.88	3087.02	3709.99	1721.31	4141.49
Days banding	18	36	49	55	26	59
Days census	0	33	58	56	33	63
Captures/100 net hours	107.47	81.79	98.19	89.66	113.40	63.08

Table 1- Summary of effort, results and capture rates of migration monitoring at MRBS for 2011-2014, 2017, 2018.

We had by far our slowest season in 2018, with only 63.08 captures per 100 net hours. This is 80% the rate of the next slowest year (2012). Figure 1 shows the absolute number of birds banded daily for all years of operations (2011-2014, 2017 and 2018). It clearly demonstrates 2018 having the lowest capture rates of all years, especially in August and September when it was lower on almost every day.

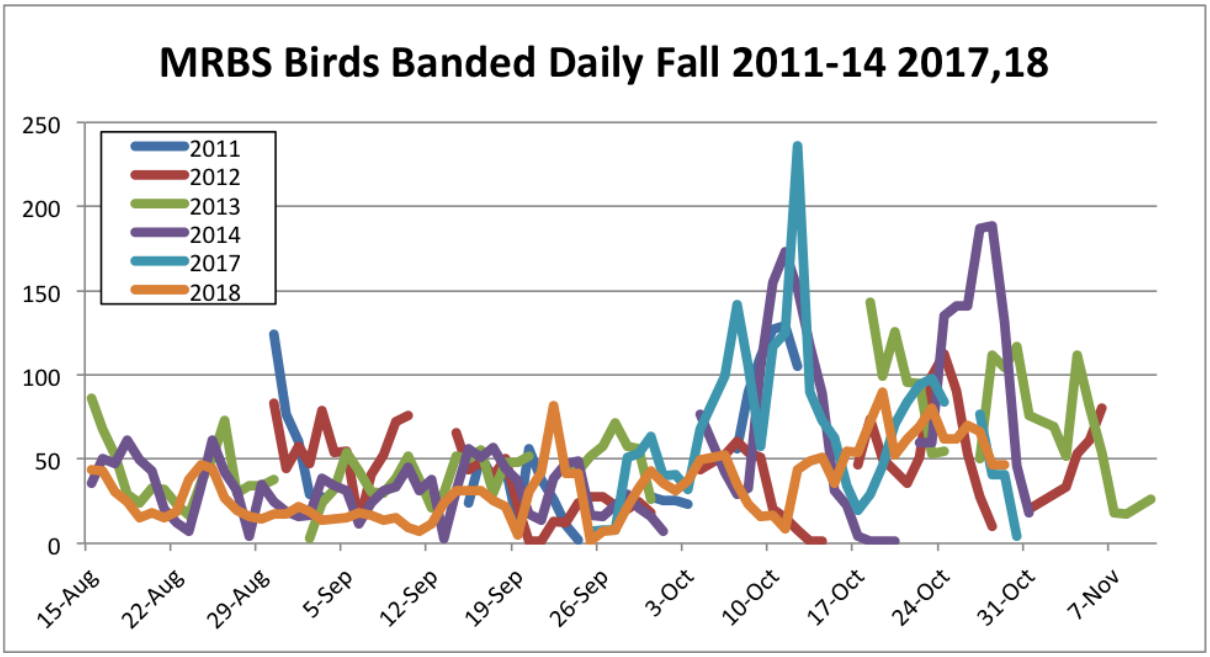

Figure 1- Number of birds banded daily for all years of operation (2011-2014, 2017, 2018) at MRBS. 2018 was the slowest season, especially noticeable in August and September. Across all seasons, October is the busiest month with the majority of migration happening in one or two peaks.

Banding 2018

During fall 2018 operations, we captured 2081 individuals 2606 times, representing a total of 90 species (Appendix A): 2068 newly banded birds, 502 local recaptures and 50 unbanded. Figure 2 breaks this down into the number of birds banded daily, standardizing the effort by correcting to 100 net hours.

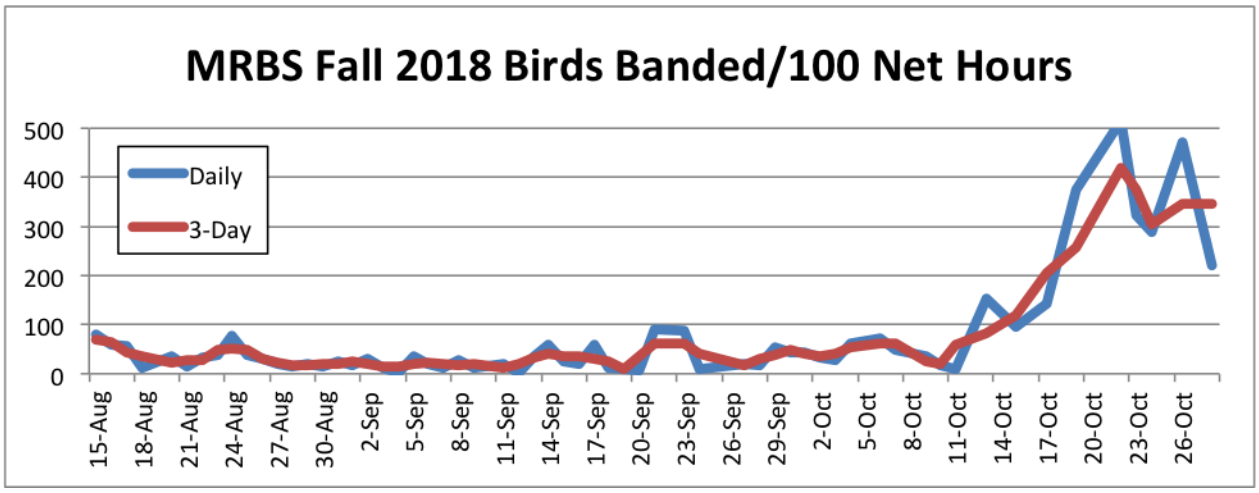

Figure 2- Number of birds banded daily per 100 net hours at Monomoy Refuge Banding Station during fall 2018 operations. Blue line is the daily captures, while the red line is the three-day running average. Banding captures peaked in late October, with long stretches of NW winds pushing in the largest wave of sparrows we have ever encountered at the station. Capture rates were so high in late October that we have split the chart into a before October 12/after October 12 chart to better visualize the data in Figures 3 and 4.

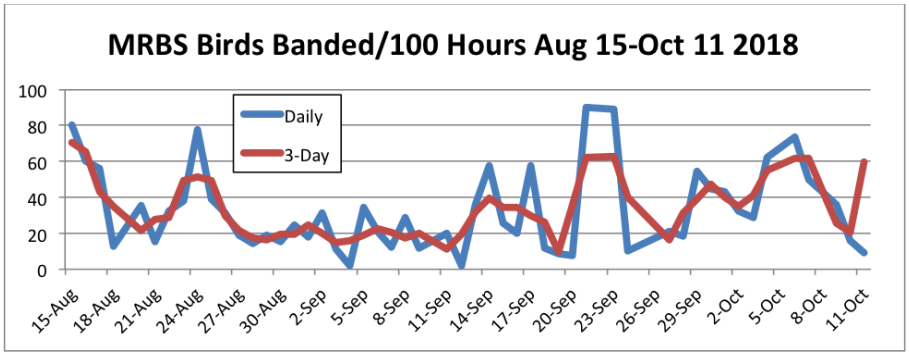

Figure 3- Number of birds banded daily per 100 net hours at Monomoy Refuge Banding Station Aug 15 – Oct 11, 2018. Blue line is the daily captures, while the red line is the three-day running average. After a busy push in mid-August driven by large numbers of Common Yellowthroats, we experienced a very slow September averaging only 20 birds banded a day for the first half and only 30 per day for the second half. Capture rates increased to about 40-50 a day for the first 10 days of October.

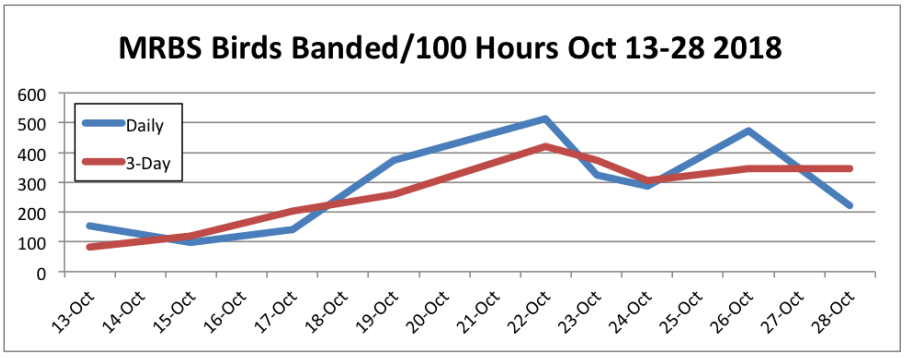

Figure 4- Number of birds banded daily per 100 net hours at Monomoy Refuge Banding Station during fall 2018, but after October 12th, allowing for a clearer view of capture rates during the last few weeks of 2018 when an explosion of sparrows caused capture rates to skyrocket. Blue line is the daily captures, while the red line is the three-day running average. On many days in late October 2018, we were only able to operate 2-4 nets only for a portion of the day (see effort), but still captured large numbers of birds. The combination of low net effort and high capture rates lead to the spectacular banded/100 net hours rates and offers an accurate picture of the extreme number of sparrows present in the last half of October 2018.

Capture rates followed a typical pattern in 2018. Starting with a bump in late August, mostly driven by local breeders and juveniles in molt, capture rates dropped to 20 birds a day for the first half of September. The rate increased to about 30 birds a day for the second half of the month with a migration wave from 21-23. We averaged about 40 birds a day until October 13, when effort plummeted and high capture rates in limited nets lead to the extreme pattern seen Figure 2. Figure 3 accurately represents the captures for the first part of the season up to October 11 and shows the daily variation more clearly than Figure 2. Figure 4 only shows the season from October 13-28 to clarify this portion of Figure 2.

We experienced four banding peaks, August 23-24, September 21-23, October 13-19, and October 22-28, each corresponding with the passage of a cold front and corresponding NW winds. On August 23-24, we banded 103 birds, a wave dominated by Common Yellowthroats (35) and Yellow Warblers (15), with the two species making up 39% of captures. On September 21 and 23, we did not actually experience a migration peak, but just happened to get a flock of tree swallows in our nets representing 107 of 160 captures over this period. The two waves in October (719 total captures) were similar, both dominated by Yellow-rumped Warblers (214 captures 30% of total) and Golden-crowned Kinglets (57 captures, 8%). They varied in that there were more Red-breasted Nuthatches (51) and Brown Creepers (22) from October 13-19 and more White-throated Sparrows (45), Slate-colored Juncos (33) and Hermit Thrushes (19) from October 22-28. Overall, our October capture rates were down as well, as we fell from over 800 Yellow-rumped Warblers a year in the previous 3 seasons of operation to 253 banded in 2018. This was partially offset by the large numbers of sparrows, nuthatches, creepers, kinglets and Blackpoll Warblers present in October.

2018 a Note on Effort by Date

The weather in Fall 2018 greatly impacted our effort in the last half of October (Figure 5), with near constant NW winds limiting our ability to open a full array of nets. These winds not only restrained our effort, but also pushed in large numbers of sparrows that migrate during this period. Even with limited effort, we were able to catch a lot of birds in as few as two nets, or a larger array open for only a few hours. When correcting for effort (per 100 net hours), our data begins to become less relevant as the small number of nets and high captures imply 700 bird days with 100+ species. While this is obviously incorrect, these numbers reflect the very high volume of birds at the station on these days and should be considered to be inflated but pertinent.

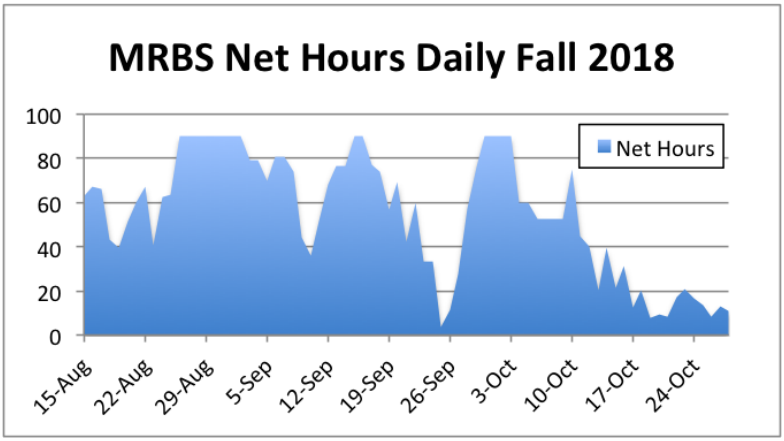

Figure 5- Net effort by date at MRBS in fall 2018. Strong NW winds in the last half of October greatly limited effort, allowing us to only operate a 2-4 nets for a limited amount of time on most days.

Species Makeup

With 90 species captured in fall 2018 season, Monomoy continued its pattern of high diversity and rare birds. After a slight bump on the second day, we hovered around 6-12 species a day until September 20th (Figure 6). From September 21 through October 11, diversity increased with the overlap of early warblers and later migrant warblers and sparrows. For the last three weeks of October, the species per 100 net hours became very high at 50-120, but this was a result of reduced net effort and very high capture rates. These diversity rates should be considered an artifact of the data and an overestimate of the diversity on site. We banded four new species at MRBS in fall 2018: Black-billed Cuckoo, Connecticut Warbler, Kentucky Warbler and Common Redpoll, bringing our five-year total to 118 species banded.

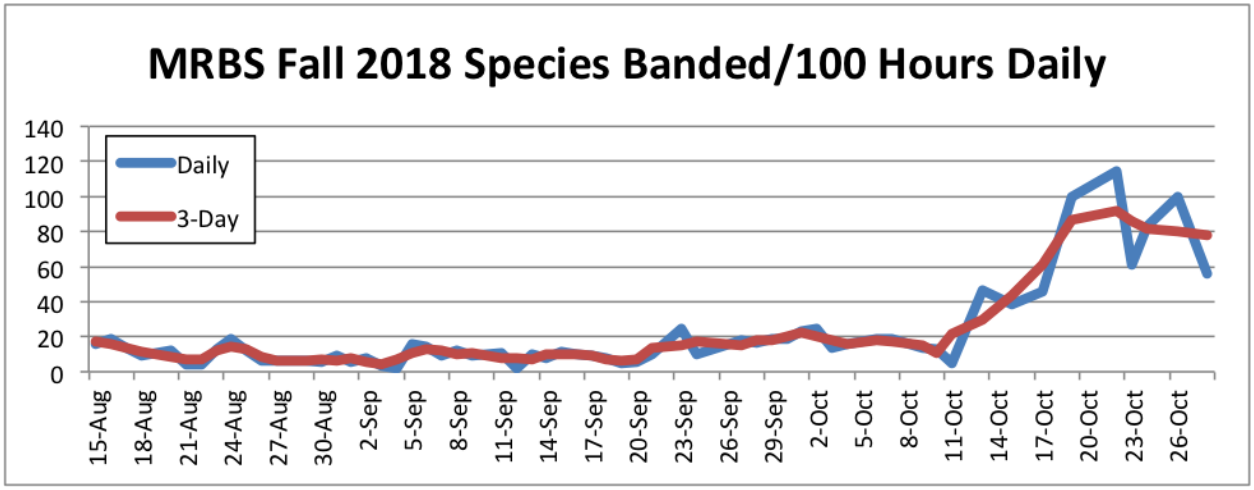

Figure 6- Number of species banded per 100 net hours daily at MRBS during Fall 2018 operations. Blue line represents daily species total, while the red line represents a running 3-day average. Species richness was generally low for August and September before skyrocketing in the second half of October. This corresponds with the unusually slow September and unusually busy late October. To assist in visualization, the data has been split into the slow period Aug 15-Oct 11 and the busy period Oct 13-28 (Figure 7, 8).

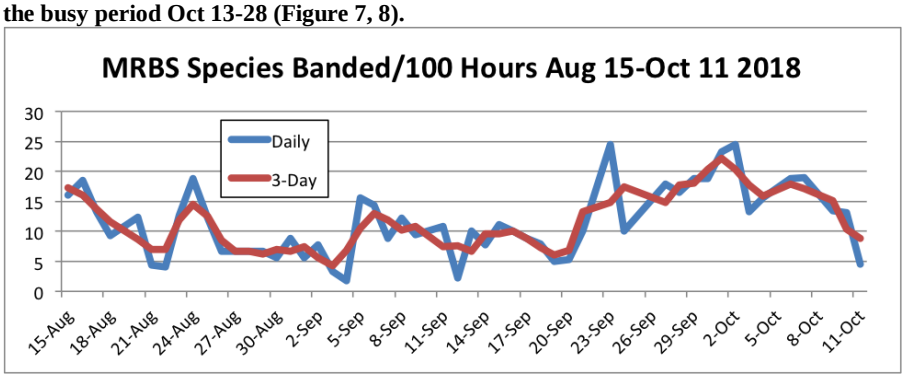

Figure 7- Number of species banded per 100 net hours daily at MRBS during from August 15 to October 11. Blue line represents daily species total, while the red line represents a running 3-day average. We had a diverse day to start the season, but experienced low diversity all through the slow September periods before increasing late September and early October.

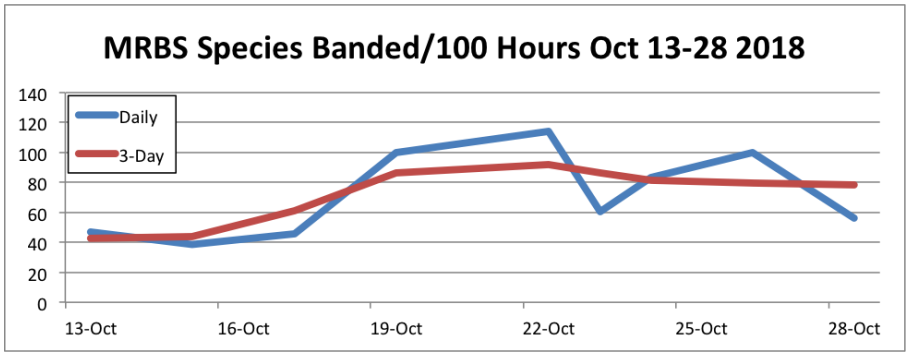

Figure 8- Number of species banded per 100 net hours daily at MRBS for Oct 13-28 2018. Blue line represents daily species total, while the red line represents a running 3-day average. Species richness was very high in late October, as we had limited net hours and high capture rates driven by long periods of NW winds and a good sparrow breeding season.

Common Captures

Next, we will look at some of the more common species encountered to better understand how the island is used by various birds. Table 2 lists the top 20 most common species captured in Fall 2018, as well as those species rankings and captures from 2011-2014, 2017. Yellow-rumped Warbler (253) was our most numerous capture, as it was each previous year, but with less than a third of the captures in each of the previous three seasons of operation.

	2018	2017 (Total)	2014 (Total)	2013 (Total)	2012 (Total)	2011 (Total)
1. Yellow-rumped Warbler	253	**(1)**871	**(1)**881	**(1)**800	**(11)**360	**(1)**275
2. Common Yellowthroat	249	**(16)**11	**(3)**196	**(3)**174	**(9)**47	**(5)**27
3. Tree Swallow	228	**(3)**79	**(2)**360	**(2)**291	**(2)**286	**(2)**158
4. Red-breasted Nuthatch	190	**(0)**0	**(21)**20	**(52)**2	**(3)**162	**(0)**0
5. Golden-crowned Kinglet	94	**(2)**103	**(7)**71	**(8)**82	**(5)**72	**(9)**17
6. Blackpoll Warbler	89	**(5)**46	**(18)**30	**(16)**27	**(21)**16	**(7)**22
7. Song Sparrow	59	**(4)**57	**(9)**58	**(5)**86	**(7)**51	**(5)**27
8. Savannah Sparrow	57	**(26)**6	**(9)**58	**(4)**162	**(4)**83	**(3)**64
9. White-throated Sparrow	57	**(10)**29	**(16)**33	**(23)**19	**(19)**18	**(11)**14
9. Cedar Waxwing	50	**(7)**37	**(5)**104	**(6)**85	**(16)**30	**(10)**15
11. Gray Catbird	49	**(11)**28	**(6)**77	**(11)**38	**(14)**31	**(14)**11
12. Slate-colored Junco	49	**(9)**31	**(4)**162	**(7)**84	**(5)**72	**(12)**12
12. Palm Warbler	43	**(6)**38	**(8)**70	**(13)**34	**(10)**46	**(12)**12
12. Yellow Warbler	41	**(0)**0	**(12)**42	**(9)**40	**(28)**8	**(15)**9
15. Brown Creeper	39	**(40)**3	**(27)**14	**(35)**9	**(21)**16	**(33)**3
15. Red-eyed Vireo	39	**(14)**21	**(14)**40	**(9)**40	**(11)**33	**(8)**20
17. Cape May Warbler	36	**(24)**7	**(20)**25	**(20)**22	**(33)**6	**(15)**9
18. White-crowned Sparrow	35	**(30)**4	**(48)**5	**(42)**4	**(32)**7	**(26)**5
19. Ruby-crowned Kinglet	30	**(8)**32	**(11)**50	**(12)**35	**(24)**14	**(29)**4
20. Prairie Warbler	28	**(43)**2	**(15)**36	**(21)**21	**(28)**8	**(33)**3
Season Net Hours	**4141**	**1721**	**3710**	**3087**	**2558**	**930**

Table 2- Top 20 most common species captured at MRBS in Fall 2018, including ranking (in bold) and totals for 2011 to 2014 and 2017. The shaded columns represent seasons with full effort (2013,2014,2018) and offer the best season for comparing capture numbers, for other season it is more enlightening to look at the relative ranking among species. The net hours for each season are listed on the bottom of the table.

Common Yellowthroat was our second most common capture, outpacing our previous two complete years by at least 20% and reflecting our higher than usual effort in August. Tree Swallows fell to third, but Tree Swallow capture rates are somewhat random and based upon a flock being in the right section of the island and hitting the net, not upon abundance of migrants. Red-breasted Nuthatches had a huge year, with individuals present on the island every day. Red-breasted Nuthatches are pine nut eating birds that are subject to cyclic food shortages and irruptive migrations. Red-breasted Nuthatches irruptions are precursors to finch irruptions, with relatively large numbers of Purple Finches (27 captured), Common Redpolls (2) at the station with Pine Siskins, Evening and Pine Grosbeaks appearing throughout the Northeast later in fall/winter. Golden-crowned Kinglets slid in ranking, but held strong in capture numbers, reflecting another good breeding year. Blackpoll Warblers had a huge year, essentially doubling any previous years' total. 2017 was the previous highest year; this species is on an upswing, perhaps benefiting from the spruce budworm outbreak in the eastern boreal forest. Song Sparrows held steady, as they tend to have smaller yearly swings than some other species. Savannah Sparrows were on par with 2014, but down from the peak of 2011-2013. White-throated Sparrows almost doubled any previous

season and reflect the large sparrow migration encountered across Cape Cod in late October. Cedar Waxwing numbers were strong, but their numbers continue to fluctuate each fall, seemingly driven by yearly variation in food resources (fruit) on the island. Gray Catbirds held steady and local fledglings were captured in the fall, confirming breeding on the island. Brown Creepers were way up, easily doubling any previous total, likely reflecting a successful breeding season but possibly inflated by the steady NW winds driving the strong October migration. White-throated Sparrows had a huge year across Cape Cod as well as on Monomoy, with our 2018 total beating all previous years combined by 20% and reflecting both a stellar breeding season and a strong migration on Cape Cod! Although Slate-colored Junco numbers were up from last year, they were down from previous years, even with the strong October migration, bucking the trend observed with the other boreal sparrow species. Cape May Warbler was up, outpacing any previous season by 30%. This spruce budworm specialist had become a much more present migrant on Cape Cod in the last two years but has always been present on Monomoy in the fall, even in the low periods of its population cycle. Tennessee Warblers are another spruce budworm specialist increasing in population, with 5 captured in 2018 and only one captured in all previous seasons combined. Ruby-crowned Kinglet, Red-eyed Vireo, Palm, Prairie and Yellow Warblers held steady with the other complete seasons (2013,14).

The relative variation in abundance among species from year to year is extremely interesting and can lead to larger questions of competition among species. Pine nut crop failures may lead to species that are dependent upon them (birds and mammals) expanding their foraging niches, perhaps forcing out sparrows and other species that do not feed directly on pine nuts. Cape May Warbler and Blackpoll Warblers are dominant to Yellow-rumped Warblers, when these species are increasing in numbers yellow-rumps are forced to forage in lower quality habitat, thereby reducing productivity. This is just another of the myriad of interactions that drive the wild swings in passerine breeding success from year to year.

Uncommon Captures

On the other end of the spectrum are the birds encountered only once or twice in a season. These birds may not pass through the refuge in large numbers (or may be present, but not captured often), but still shed light on avian habitat use. Species only banded twice this fall are: Acadian Flycatcher, Alder Flycatcher, Common Redpoll, Dickcissel, Downy Woodpecker, Eastern Kingbird, Magnolia Warbler, Scarlet Tanager and Swainson's Thrush. Species banded only once are: Black-billed Cuckoo, Bay-breasted Warbler, Blue-winged Warbler, Canada Warbler, Clay-colored Sparrow, Connecticut Warbler, Chestnut-sided Warbler, Eastern Towhee, Hooded Warbler, Kentucky Warbler, Lark Sparrow, Lincoln's Sparrow, Mourning Warbler, Northern Mockingbird, Rose-breasted Grosbeak, Summer Tanager, Townsends Solitaire (second for station!), Veery, Warbling Vireo, White-eyed Vireo, Wilson's Warbler, Winter Wren and Yellow-bellied Flycatcher.

Returns and Foreign Recaptures

We had seven returns (birds banded in previous years and recaptured this year) in 2018 representing 3 species, all of which breed at the station: 4 Song Sparrows, 2 Savannah Sparrows and one Common Yellowthroat. The four Song Sparrows were initially banded in 2017, two as hatching-year and two as after-hatching-year. One Savannah Sparrow was banded on September 1st 2012 as a Hatching-year and has not been recaptured since its original banding. This savannah sparrow is 6 years old in 2018. The other Savannah Sparrow was banded as an after-hatching-year in 2017. The Common Yellowthroat was banded as an after-hatching-year on September 4th 2013, making it at least 5 years old in 2018. It was also captured on September 2nd 2014, but has not been recaptured since.

We had a single foreign recapture in 2018, a Common Yellowthroat captured on the 5th of September. It was undergoing flight feather molt and was classified as an after-hatching-year Male. Sue Finnegan at Wing Island Banding Station originally banded this bird on September 26 2017 as hatching-year male and it likely breeds on Cape Cod, if not on Monomoy National Wildlife Refuge.

Net Productivity

We assessed the productivity and usage of all nets (see map Appendix B) and summarized the data in Table 3. Nets are in four distinct groups: A-Nets (1,2,3,5) are located in a marshy area with a few (<10) 4m tall conifers, the nets are in a mix of dry and wet habitat amongst the pines, C Nets (1-4) are located in a grove of about 10-15 2-8m tall conifers just north of the lighthouse, D Nets (1-4) are located in a patch in a wet patch of cranberries and Phragmites surrounded by a small grove 4m tall pines, F Nets (1-3,5) are strung in a row adjacent to the dense thicket growing on the S side of the lighthouse.

All nets were three season old Ecotone 12x2.6m 30mm nylon nets. Net A5 was added just past the end of A3 to take the place of A3, when it became too flooded on October 6th and A5 was run for the remainder of the season.

Table 3- Net effort and capture rates for newly banded and recaptures during fall 2018 banding operations at Monomoy National Wildlife Refuge.

Net	Net hours	Banded	Recaps	Total Captures	Banded /100 Net Hours	Recaptures /100 Net Hours
A1	278.83	87	23	113	31.2	8.2
A2	278.83	162	38	201	58.1	13.6
A3	235.82	104	23	129	44.1	9.8
A5	26.99	20	6	27	74.1	22.2
C1	309.15	145	31	179	46.9	10.0
C2	316.32	180	46	229	56.9	14.5
C3	291.65	137	60	204	47.0	20.6
C4	296.49	173	54	234	58.3	18.2
D1	258.48	198	6	215	76.6	2.3
D2	269.98	134	47	182	49.6	17.4
D3	279.82	299	61	363	106.9	21.8
D4	282.48	150	36	188	53.1	12.7
F1	265.98	117	34	153	44.0	12.8
F2	267.98	93	19	114	34.7	7.1
F3	258.15	10	4	14	3.9	1.5
F5	258.15	50	13	63	19.4	5.0
Total	**4175.10**	**2059**	**501**	**2608**	**49.3**	**12.0**

The net hours (effort) varied by up to 17% (when A3 and A5 are combined) among nets from A3 and F5 (258.15) to C2 (316.32). Nets could also be closed piecemeal in reaction to weather conditions, generally wind, which happened almost every day. The least protected nets (A and D) were most likely to be impacted by wind and therefore have the lowest hours. Nets were to be closed if the volume of birds captured became too great to handle any additional captures, this happened only a single day with a large volume of sparrows in the C nets. D3 had the highest capture rates followed by D1, with Common Yellowthroats and Yellow-rumped Warblers dominating the captures at these nets.

These nets provide a good level of coverage, but we propose the addition of a three new nets that would improve capture rates and allow us to target a few productive areas (see Appendix B), without adding to the time need to walk the loops. 1) F6 can be linked to F5 and place along the bushes abutting the lighthouse, completing our coverage of this area and an important (and observed) flight path of birds. It would also replace F3 as slower net that will need to be abandoned due to installation of solar panels. 2) A5 and 13 should both be kept these nets complete the coverage of this area and require no extra walking time. 3) D5 should be added beyond D3/4 between the conifers and continuing into the marsh, we often hear birds in the area that we do not capture in the nearby nets.

I. Census

One or more observers conducted a standardized check of one of three key migrant locations daily when on site: Powder Hole (41.555 N, 70.008 W), Lighthouse Beach (41.560 N, 69.990 W) and Big Station Pond (41.5503 N, 70.008 W).

The census schedule is split into two portions, Early Season (peak shorebird migration) and Late Season (peak seabird migration). During the Early Season (up to October 5), Powder Hole is surveyed every other day and Lighthouse Beach every fourth day. During the Late Season (after October 5), Lighthouse Beach is surveyed every other day and Powder Hole every fourth day. Big Station is surveyed every fourth day throughout both periods.

Early Season	**Late Season**
Powder Hole	Lighthouse Beach
Big Station	Powder Hole
Powder Hole	Lighthouse Beach
Lighthouse Beach	Big Station
Powder Hole	Lighthouse Beach
Big Station	Powder Hole
Powder Hole	Lighthouse Beach
Lighthouse Beach	Big Station

Observers stand in a predetermined and consistent location at each site and, using a high-powered Zeiss 20-60 Angled Spotting Scope, upgrading from the Alpen 20-60x80 Angled Spotting Scope used in previous seasons and personal binoculars supplied by each participant, count every bird within the census location boundaries.

Census Location Descriptions

Powder Hole - Any bird identifiable to species (by sight or sound) on the water, land or air from tip of small peninsula on south shore between the two pools.

Lighthouse Beach - Any bird identifiable to species (by sight or sound) on the water, land or air from the seaward edge of the largest dune overlooking the beach along the trail from the Monomoy Lighthouse, **BUT NO FURTHER** than the bay formed by the curving beach 1000m to the North, the outer edge of the rough water formed by the shoal approximately 1000m offshore.

Big Station - Any bird identifiable to species (by sight or sound) on the water, land or air from small hill next to the two bird boxes directly east of Big Station/Little Station Pond Intersection.

Powder Hole: a total of 58 species were observed during Powder Hole census in Fall 2018. We observed an average of 26 species per day for August, before diversity declined throughout September to about 13 species a day for October. The highest species richness was observed during the first two surveys on August 19th and 22nd with 31 species and the lowest count was on 2-Oct with ten species (Figure 8). The most abundant species were Black-bellied Plover, Great Black-backed Gull, Herring Gull, Semipalmated Sandpiper and Semipalmated Plover, each of which were present in good numbers each survey, with shorebird numbers declining into October (Table 4). Common Terns averaged over 200 individuals per count (with a scattering of Roseate Terns) for August and early September before being completely absent on every survey from the end of September through October.

Species only observed at Powder Hole in 2018 include: Dunlin, Red Knot, Pectoral Sandpiper, Hudsonian Godwit, Marbled Godwit, American Golden Plover, Artic Tern and Saltmarsh Sparrow.

Species	Days Observed	Mean # Daily
1. Black-bellied Plover	20	176
2. Great Black-backed Gull	20	138
3. Herring Gull	20	101
4. Sanderling	19	8
5. Semipalmated Plover	19	78
6. Double-crested Cormorant	18	18
7. Semipalmated Sandpiper	18	109
8. Ring-billed Gull	15	7
10. Greater Yellowlegs	14	17
11. Northern Harrier	13	1
12. Snowy Egret	13	13
13. Least Sandpiper	12	4
14. Great Blue Heron	11	1
15. Willet	10	1

Table 4- The 15 species observed on the most number of days at Powder Hole in fall 2018. Some species were present each day throughout the season, while many shorebird species were common at the start and were not observed at later dates as they migrated south.

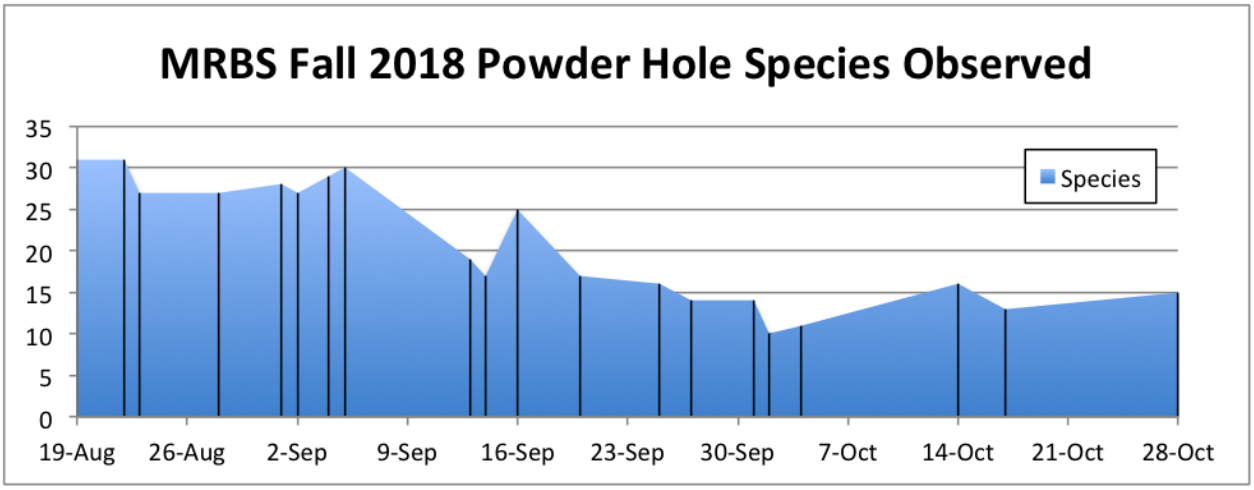

Figure 8- The number of species observed during census of Powder Hole area of Monomoy NWR in fall 2018. Species richness peaked early in the year and declined throughout the fall as shorebird migration slowed and with most shorebird species have departed for southern wintering sites.

Lighthouse Beach: a total of 49 species were observed at Lighthouse Beach in 2018, with a mean of 12 species per day (Figure 9). Great Black-backed and Herring Gull were the two species present for every survey, but Northern Gannet and the four species of large seaducks were the most abundant species (Table 5). Eiders and scoters were present for each survey from late September onward, with numbers varying from 100s to 1000s each day. These seaduck numbers were up over 2017, following the pattern of low numbers on odd years and high numbers on even (Table 6), a pattern that demands more study. Double-crested Cormorants and Northern Gannets were both present for most surveys, with cormorants present in moderate numbers each survey and over 4500 gannets counted during a single survey on 24-Oct and were only present in small numbers before peaking in late October. Shearwaters were present in large numbers in late August with numbers far out pacing previous seasons.

Species unique to Lighthouse Beach in 2018 include: Parasitic Jaeger, Pomarine Jaeger, Manx Shearwater Baird's Sandpiper, American Pipit, and Red-throated Loon.

Species	Days Observed	Mean # Daily
1. Great Black-backed Gull	18	38
2. Herring Gull	18	20
3. Northern Gannet	13	724
4. Surf Scoter	13	861
5. White-winged Scoter	13	359
6. Black Scoter	12	427
7. Common Eider	12	1868
8. Double-crested Cormorant	12	15
9. Common Loon	11	6
10. Sanderling	9	4
11. Common Tern	8	20
12. Great Shearwater	7	64

Table 5- The 12 most abundant species encountered at Lighthouse Beach in 2018, including the mean daily captures. Seaducks dominated the count, while the Great Black-baked and Herring Gulls were present each day. Shearwaters appeared on the list for the first time, reflecting the large numbers present in fall 2018, but not in previous years.

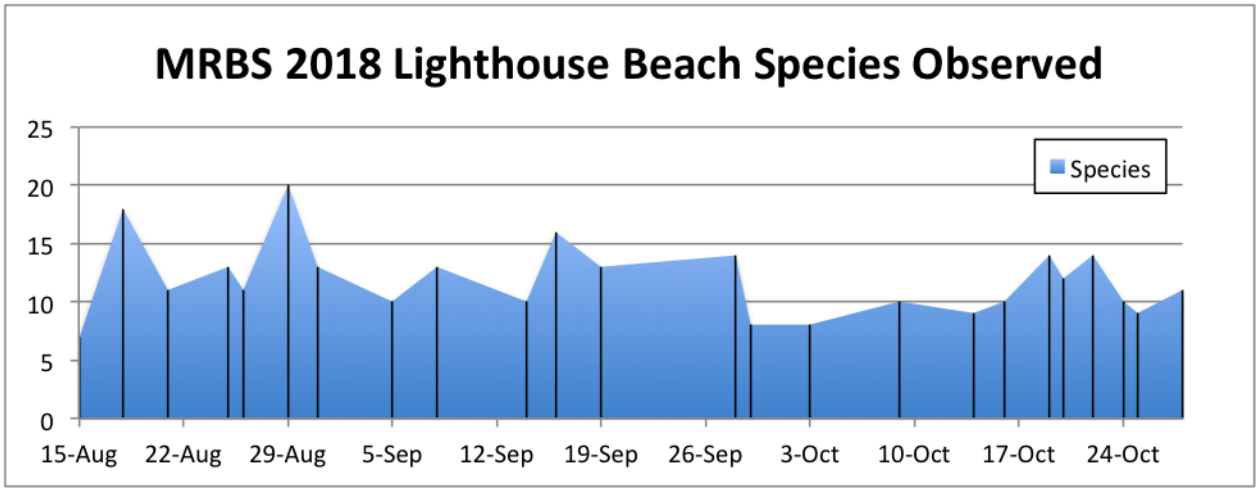

Figure 9- Species richness at Lighthouse Beach in 2018. Richness stayed heavy as shearwaters and terns departed and seaducks and loons arrived in greater numbers.

Species	2012	2013	2014	2017	2018
Common Eider	7176	317	7578	390	1868
White-wing Scoter	1804	59	2145	62	359
Black Scoter	586	23	1943	59	427
Surf Scoter	590	16	1336	123	861

Table 6- Annual variation in October seaduck numbers during Lighthouse Bluff surveys in 2012-14 and 2017, 2018. Numbers are usually 10x higher on even number years, a pattern not yet understood.

Big Station Pond: a total of 64 species were observed in 2018 with a mean of 16 species observed per survey (Figure 10). Great Black-backed and Herring Gulls were present for each survey (Table 7). Diversity increased slightly as more ducks arrived later in the fall. Although diversity was fairly steady the abundance of waterfowl present greatly increased throughout the fall with an influx of species breeding on site and new species arriving in large numbers (Figure 11). This pattern seems to indicate that duck numbers would continue to increase into November and indicating the value of a longer survey period to accurately gauge the winter population.

Species only observed at Big Station in 2018 include: American Widgeon, Green-winged Teal, Ring-necked Duck, Northern Shoveler, Lesser Scaup, Greater Scaup, Bufflehead, Wood Duck, Mute Swan, American Coot and Common Gallinule.

Table 7- The 15 most common species encountered at Big Station Pond in 2018, including the mean number present daily. Gulls are present each day, but a solid group of duck species are present most days with more individuals of most species arriving later in fall.

Species	Days Observed	Mean # Daily
1. Great Black-backed Gull	18	46
2. Herring Gull	18	38
3. Gadwall	17	23
4. Mallard	17	28
5. Double-crested Cormorant	16	16
6. American Black Duck	14	13
7. Northern Pintail	14	9
8. Green-winged Teal	13	5
9. Northern Harrier	13	1
10. American Widgeon	12	8
11. Northern Shoveler	12	14
12. Ring-necked Duck	12	15
13. Canada Goose	10	22
14. Great Blue Heron	10	1
15. Ruddy Duck	10	17

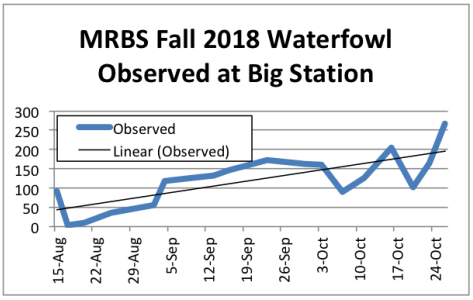

Figure 10- The total number of all species waterfowl (ducks, geese, swans) observed at Big Station during fall 2018 census. Abundance increased throughout the fall and likely continued to increase into November after the observation period ended.

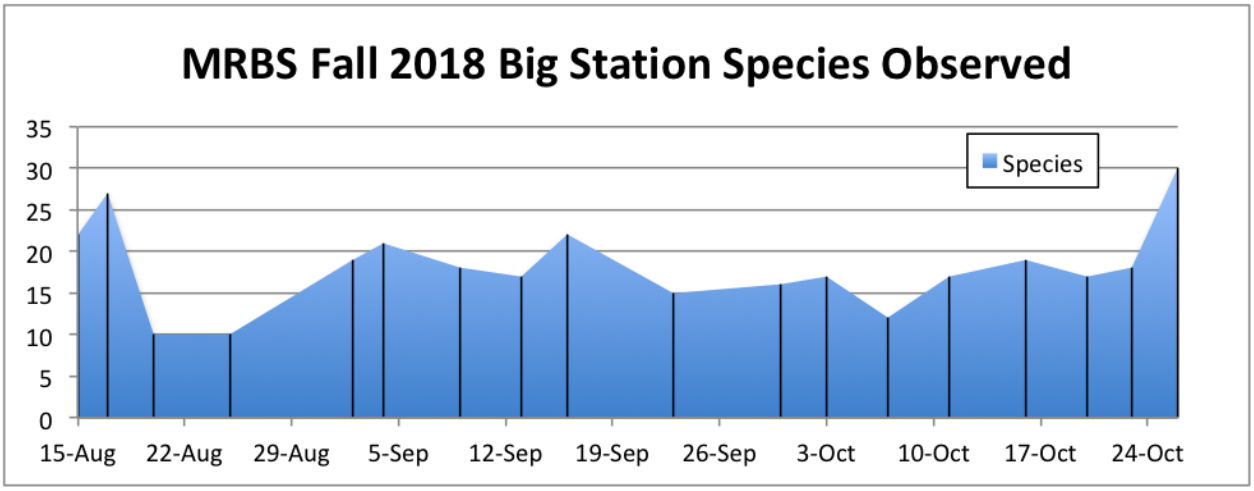

Figure 11- Species richness at during census at Big Station Pond in 2018. Richness increases as more ducks species arrive later in the fall.

General Observations

Birds observed on the island, but not during one of the three organized censuses, are recorded as General Observations. These observations give us a chance to record birds not seen during census or captured during banding, such as owls, nighthawks and raptors. It also accounts for birds present on days banding is not possible, outside the banding window or during hikes around the island. We had 10 species only observed as General Observations in 2018: Common Nighthawk (2), Barn Owl (2), Black-crowned Night-heron (1), Solitary Sandpiper (3), Killdeer (>10), American Kestrel (5-10), Horned Lark (several flocks), Eastern Meadowlark (1), House Finch (2), and Blue Grosbeak (1). Of these seven only two were new to the station Barn Owl and Eastern Meadowlark.

The Barn Owl(s) spent about a week scoping out the area around the lighthouse in late October, mostly a single owl seen at night moving around outside the lighthouse keepers building, but on one occasion two individuals were seen during the day. We also saw a Snowy Owl on several occasions (including a couple Lighthouse Beach surveys). This bird was seen all summer long feeding first at the tern colony and later on Piping Plovers near the south end. It seemed to use the dunes SE of the lighthouse as a daytime roost and was not spotted after late September.

General Observations also give us an opportunity to record species present around the station on a daily basis. In 2018, this included: Great Black-backed Gull, Herring Gull, and Northern Harrier. Species present on over 90% of days include: Red-breasted Nuthatch, Gadwall and Double-crested Cormorant. Common Terns, Gray Catbird, Common Yellowthroat and Song Sparrow were present every day before each migrated south for the winter.

Each day, we endeavored to count the size of the Tree Swallow flock on the island. The numbers started at 100-500 a day for the last two weeks of August, up to 200-1000 a day for the first two weeks of September. The numbers rise to about 2000-5000 a day for the last two weeks of September, peaking at 7000 on 18 September. Numbers decreased to about 20-200 a day for the first couple weeks of October and down to 5-50 for the last two weeks of October. Four Tree Swallows were observed on October 28, the last day of organized counts.

Summary

Fall 2018 was our most complete season of migration surveying at MRBS. After not being on site for two years prior to 2017, it was great to spend a whole season collecting data on the diverse bird assemblage present on South Monomoy. Although the capture rates were lower than previous years, we captured four new species and experienced strong migrations among several species.

Our daily surveys were very effective in documenting the other groups of birds using South Monomoy as a stopover site. The upgrade to a Zeiss spotting scope greatly improved our visual surveys, allowing us to more accurately identify distant birds. This combined with a strong fall seaduck migration at Lighthouse Beach and good water flow in and out of Powder Hole facilitated some great counts at these sites.

The addition of the banding station at Wellfleet Bay Wildlife Sanctuary allows comparison between the two stations and synchronicity in outreach between Wellfleet Bay and Monomoy National Wildlife Refuge. We continued our outreach campaign with daily postings on Twitter and Instagram, as well as posting our censuses on eBird daily. These social media sites increase the presence of the station and sanctuary on the internet, improving awareness and visits to the Refuge. We are at almost 1000 Instagram followers and receive interactions on every post. Daily updates on boards at both visitors' centers also helped promote the stations to visitors to these popular spots. Finally, we received a visit from Lee Roscoe and the Cape Cod Times, who published a wonderful front-page feature about out project on Labor Day weekend.

This season, the project was funded in part through a crowdfunding campaign on Experiment.com. In total, 30 backers pitched in to provide food and supplies to the teams on Monomoy. The crowdfunding platform gave us an opportunity to present the project fully, with videos, pictures and full details. It also gave us some visibility in a vibrant community of scientists. We will continue to update backers with our findings, which will also be available on our website and through updates on social media.

Moving Forward

We had a wonderful sixth season in fall 2018, very promising in terms of captures, counts and outreach. We settled on a good plan for switching out banding teams on the island, and as a result we were active every day from August 14-October 29. We plan on following this switch out plan moving forward, thereby maximizing our survey time. We suggest adding three additional nets (A3, D5, F6) to increase our captures by targeting areas observed to be heavily used by songbirds.

We hope to take advantage of the MOTUS towers on the refuge to undertake movement projects focusing on Tree Swallows or Savannah Sparrows. By placing transmitters on multiple Tree Swallows in a single flock, we can study flock stability, as well as migration rate and route as these birds pass south through one of the denser arrays of MOTUS towers along the Atlantic seaboard. Savannah Sparrows could be equipped to study local movement on the refuge as well as departure timing and migration rate and route.

Acknowledgements

First and foremost, we thank our skilled and dedicated banders for their hard work and perseverance throughout the fall. Thank you Valerie Bourdeau, Mikayla Thistle and Frankie Tousley, who braved the harshness of Monomoy and Wellfleet Bay. Thanks to Kate Iaquinto and Matt Hillman at Monomoy NWR for supporting the project with both time and boat transportation. Without your support, we would not be able to collect this valuable data. Thank you to all our Experiment.com backers for making the project possible. Finally, thanks to the Friends of Monomoy for their financial support, we look forward to working more closely with them in the future.

Appendix A- List of All Species Captured at Monomoy

Table 8- A list of the 118 species banded from 2011-2014 and 2017, 2018 at MRBS. Totals are broken down by season, with the number of individuals banded per season listed.

	Species	2011	2012	2013	2014	2017	2018
1.	Acadian Flycatcher	0	0	1	1	0	1
2.	Alder Flycatcher	0	0	1	0	0	3
3.	American Goldfinch	1	33	26	2	2	16
4.	American Pipit	0	0	1	0	0	0
5.	American Redstart	4	8	26	26	4	9
6.	American Robin	35	33	2	22	11	24
7.	American Tree Sparrow	0	0	2	0	0	0
8.	Bank Swallow	0	1	1	0	0	0
9.	Baltimore Oriole	6	22	18	43	7	10
10.	Barn Swallow	0	2	0	1	0	0
11.	Black-and-White Warbler	6	3	32	1	0	7
12.	Bay-breasted Warbler	0	1	1	1	1	1
13.	Blue-gray Gnatcatcher	0	1	1	0	0	0
14.	Brown-headed Cowbird	0	3	0	0	0	0
15.	Blue-headed Vireo	7	6	15	12	25	20
16.	Bicknell's Thrush	0	0	0	0	1	0
17.	Blackburnian Warbler	2	0	1	0	0	0
18.	Blue Grosbeak	1	1	3	0	0	0
19.	Blackpoll Warbler	22	16	27	3	46	89
20.	Bobolink	0	2	0	0	0	0
21.	Brown Creeper	3	16	9	14	3	39
22.	Brown Thrasher	0	5	0	5	2	3
23.	Black-throated Blue Warbler	1	4	8	7	4	3
24.	Black-throated Green Warbler	5	5	11	1	11	14
25.	Black-throated Gray Warbler	0	1	0	0	0	0
26.	Black-billed Cuckoo	0	0	0	0	1	1
27.	Blue-winged Warbler	0	0	2	1	0	1
28.	Carolina Wren	0	0	0	1	0	0
29.	Canada Warbler	1	0	0	1	0	1
30.	Clay-colored Sparrow	0	0	0	2	3	2
31.	Cedar Waxwing	15	3	85	14	37	50
32.	Chestnut-sided Warbler	0	0	2	3	4	1
33.	Chipping Sparrow	4	16	13	17	9	5
34.	Cape May Warbler	9	6	22	25	7	36
35.	Common Grackle	0	0	0	0	1	0
36.	Common Redpoll	0	0	0	0	2	2
37.	Common Yellowthroat	27	47	175	196	11	249

	Species	2011	2012	2013	2014	2017	2018
38.	Connecticut Warbler	0	0	0	0	1	1
39.	Dickcissel	1	0	1	0	0	2
40.	Downy Woodpecker	0	3	2	1	0	2
41.	Eastern Kingbird	1	0	1	0	0	2
42.	Eastern Phoebe	0	2	2	9	7	11
43.	Eastern Towhee	2	3	4	1	5	1
44.	Eastern Wood Pewee	1	5	3	2	0	3
45.	European Starling	0	3	1	0	0	0
46.	Field Sparrow	0	1	5	2	2	3
47.	Fox Sparrow	0	1	0	3	0	0
48.	Great-crested Flycatcher	0	0	1	0	0	0
49.	Golden-crowned Kinglet	17	72	82	71	13	94
50.	Gray-checked Thrush	2	1	1	0	0	0
51.	Gray Catbird	11	31	38	77	28	49
52.	Hairy Woodpecker	1	0	0	2	0	0
53.	Hermit Thrush	6	11	12	14	4	23
54.	House Finch	0	0	0	2	0	0
55.	House Sparrow	3	2	1	1	0	0
56.	Hooded Warbler	0	0	0	1	0	1
57.	House Wren	0	1	5	2	4	0
58.	Indigo Bunting	6	11	2	6	1	4
59.	Kentucky Warbler	0	0	0	0	1	1
60.	Lark Sparrow	1	0	2	1	0	1
61.	Least Flycatcher	2	2	12	5	0	11
62.	Lincoln's Sparrow	3	1	1	0	4	1
63.	Magnolia Warbler	1	3	11	15	8	2
64.	Marsh Wren	0	0	0	1	0	0
65.	Mourning Warbler	1	0	5	0	0	1
66.	Yellow-rumped Warbler	275	36	8	881	871	253
67.	Hybrid Myrtle	0	0	0	1	0	0
68.	Nashville Warbler	5	4	15	1	6	6
69.	Northern Cardinal	1	27	5	1	0	5
70.	Northern Mockingbird	1	5	3	3	0	1
71.	Northern Parula	1	4	1	6	8	4
72.	Northern Waterthrush	6	1	25	8	1	9
73.	Northern Rough-winged Swallow	0	0	1	0	0	0
74.	Northern Saw-whet Owl	0	2	0	0	0	0
75.	Orange-crowned Warbler	1	0	2	8	3	4
76.	Ovenbird	0	1	3	2	0	0
77.	Palm Warbler	12	46	34	7	44	43
78.	Philadelphia Vireo	0	1	13	0	2	6
79.	Pine Siskin	0	49	0	16	0	0
80.	Pine Warbler	7	11	2	8	2	23

	Species	2011	2012	2013	2014	2017	2018
81.	Prairie Warbler	3	8	21	36	2	28
82.	Purple Finch	0	17	2	32	0	27
83.	Rose-breasted Grosbeak	0	1	2	7	5	1
84.	Red-breasted Nuthatch	0	162	2	2	0	190
85.	Red-bellied Woodpecker	2	4	3	5	3	8
86.	Ruby-crowned Kinglet	4	14	35	5	32	30
87.	Red-eyed Vireo	2	33	4	4	21	39
88.	Rusty Blackbird	2	0	1	0	0	1
89.	Red-winged Blackbird	2	1	3	1	0	4
90.	Savannah Sparrow	64	83	162	58	6	57
91.	Slate-colored Junco	12	72	84	162	31	49
92.	Scarlet Tanager	1	1	2	7	2	2
93.	Song Sparrow	27	51	86	58	57	59
94.	Sharp-shinned Hawk	0	0	2	2	0	0
95.	Summer Tanager	0	0	0	0	1	1
96.	Swamp Sparrow	0	0	9	9	27	4
97.	Swainson's Thrush	4	3	0	2	1	2
98.	Tennessee Warbler	0	0	0	2	0	5
99.	Townsends Solitaire	0	1	0	0	0	1
100.	Tree Swallow	158	286	291	36	79	228
101.	Veery	1	1	3	2	0	1
102.	Warbling Vireo	0	1	0	6	0	1
103.	White-breasted Nuthatch	2	2	0	2	0	0
104.	White-crowned Sparrow	5	7	4	5	4	35
105.	White-eyed Vireo	0	0	0	1	0	1
106.	Willow Flycatcher	0	0	4	0	0	0
107.	Wilson's Warbler	2	1	12	9	2	1
108.	Winter Wren	1	0	0	1	4	1
109.	White-throated Sparrow	14	18	19	33	29	57
110.	White-winged Crossbill	0	6	0	0	0	0
111.	Yellow-breasted Chat	7	4	0	1	1	4
112.	Yellow-billed Cuckoo	8	3	0	1	4	6
113.	Yellow-bellied Flycatcher	3	7	12	4	0	1
114.	Yellow-bellied Sapsucker	0	2	2	4	2	12
115.	Yellow Warbler	0	8	4	42	0	41
116.	Yellow-shafted Flicker	0	31	35	2	11	14
117.	Yellow-throated Vireo	0	0	0	2	0	0
118.	Yellow-throated Warbler	1	0	0	0	0	0
	Total	**65**	**80**	**83**	**86**	**58**	**85**

Appendix B: Maps of Monomoy Refuge Banding Station

Figure 12- Monomoy Refuge Banding Station net locations, with the 2017 addition of Net A5 and the proposed additions of D5 and F6 in 2019 (blue).

Appendix B: Maps of Monomoy Refuge Banding Station

Figure 13- Monomoy Refuge Banding Station and Census Locations