Interim Report
Federal Aid in Wildlife Restoration
W-70-R-3
F18AF01010

"Species of Greatest Conservation Need (SGCN) - Birds Research and Management"

Final Report
January 1, 2019 – December 31, 2021

NJ Department of Environmental Protection

DIVISION OF FISH AND WILDLIFE
ENDANGERED AND NONGAME SPECIES PROGRAM
P.O. BOX 420
TRENTON, NJ 08625

NEW JERSEY DIVISION OF
Fish and Wildlife

SPORT FISH & WILDLIFE RESTORATION

Project 1. SGCN Birds Conservation and Management

The objectives of this grant are to:

1. Conduct surveys of beach and marsh birds to determine species occurrence, abundance, population trend, productivity, and habitat use. Conduct research as necessary to determine threats, habitat use, population status, and to obtain information necessary to prepare and implement recovery plans. Manage breeding and migrating sites to enhance populations.
2. Conduct surveys of migrating shorebirds to determine species abundance, population trend, and habitat use. Conduct research as necessary to determine threats, habitat use, population status, and to obtain information necessary to prepare and implement recovery plans. Manage migration stopover sites to improve conditions to support population recovery.
3. Conduct surveys of secretive and coastal marsh nesting birds to determine species occurrence, abundance, population trend, and habitat use. Conduct research as necessary to determine threats, habitat use/preferences, and for information needed to prepare and implement recovery plans. Manage breeding sites to enhance populations.
4. Conduct surveys of raptors to determine species occurrence, abundance, population trend, productivity, and habitat use. Conduct research as necessary to determine threats, habitat use, population status, and to obtain information necessary to prepare and implement recovery plans. Implement management to enhance populations.
5. Conduct surveys of non-raptor land birds to determine species occurrence, abundance, population trend, productivity, and habitat use. Conduct research as necessary to determine threats, habitat use, population status, and to obtain information necessary to prepare and implement recovery plans. Implement management to enhance populations and progress toward recovery.

Objective 1 – Beach & Marsh Birds

Beach nesters

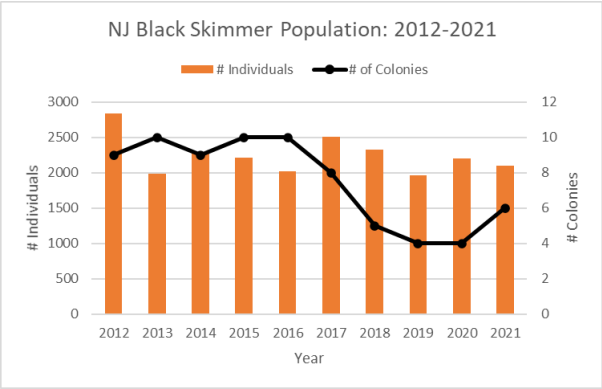
Prepared by: Christina Davis, Environmental Specialist II

Project Leaders: Christina Davis and Emily Heiser

The portions of this job applying to Piping Plover are also supported by ESA Section Six funding and state funds.

Key Findings:

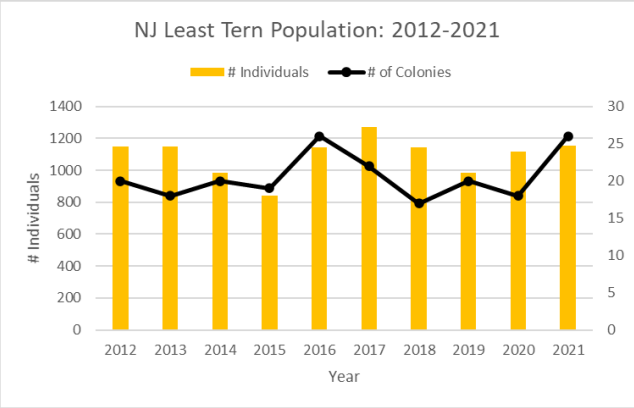
Black Skimmer



- Black skimmer breeding bird counts were conducted approximately every week at active sites from arrival (mid-May) until nesting ceased (September) on beaches along the entire Atlantic coast. Marsh islands were surveyed just one time, during the 2021 aerial survey, and breeding could not be confirmed with this method. Active sites (save one that was visited 1x/week due to logistical issues of access) were visited 3-7x/week for management and outreach for the duration of the nesting season and. Patrolling and public outreach simultaneously occurred with each site visit.
- A total of 1,963 (2019), 2,197 (2020), and 2,099 (2021) adults were documented at the active sites.

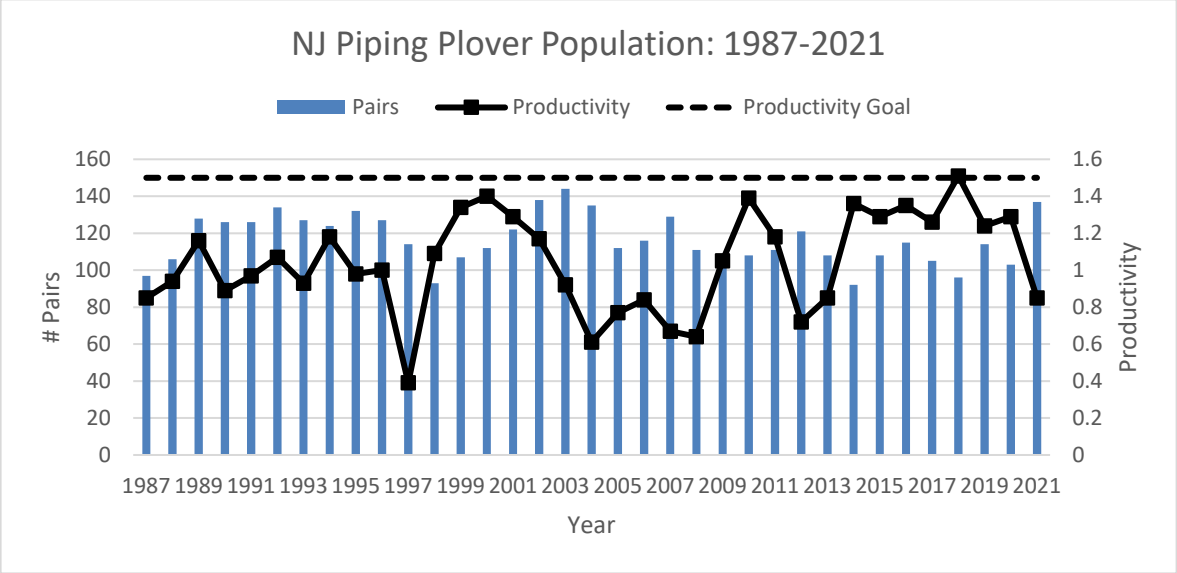
- As habitat conditions continued to become less suitable, the proportion of nesting skimmers at Seaview Harbor Marina (SHM) in Longport continued to decline. In 2012, it peaked at 89% of the known NJ population and was 67%, 61%, and 37% in 2019-2021, respectively. Sixty-nine (69) individuals were tallied at seven marsh islands during the 2021 aerial survey of the Atlantic Coast marsh islands, but nesting was not confirmed so they are not included in state breeding population numbers for that year.
- A peak count of 717, 530, and 502 incubating adult black skimmers were at active sites in 2019, 2020, and 2021, respectively. The incubation number was lower than might be expected given the number of adults present each year and was almost certainly lower than number nesting. As is generally the case, vegetation at SHM and Stone Harbor Point blocked observers from garnering the most accurate count of these ground nesters but walk-through colony counts have not shown to be effective in NJ.
- A total of 403, 511, and 1,362 black skimmer fledglings were produced statewide in 2019, 2020, and 2021, respectively.
- NJDFW and The Wetlands Institute worked cooperatively to band 221 black skimmers in 2019-2021. Five adults were also outfitted with GPS pin-point tags in 2021 and provided the first ever spatial data on movements of this species during the breeding season in NJ.
- During the reporting period, 242 individuals banded in NJ in 2016-2021 were observed either on migration or wintering grounds. Skimmers banded in NJ were observed in CT, NY, MD, VA, NC, SC, GA, and FL. Notably, resights also came from Nova Scotia and Mexico.

Least Tern



- Least tern breeding bird surveys were conducted every week from mid-May until the end of August at beaches along the entire Atlantic coast. Active colonies (≥ one pair with eggs) were visited 3-7x/week for management and outreach for the duration of the nesting season (the only exception was one site in 2021 that was visited 1x/week due to logistical issues of access). Patrolling and public outreach simultaneously occurred with each site visit.
- A total of 987 (2019), 1,118 (2020), and 1,153 (2021) adults were tallied at the peak census period.
- A peak count of 624, 586, and 584 incubating adult least terns were tallied at active sites in 2019, 2020, and 2021, respectively.
- A total of 398, 124, and 301 least terns were produced statewide in 2019, 2020, and 2021, respectively.
- The population was distributed fairly evenly throughout the state in each year.

Piping Plover (*Full Piping Plover reporting can be found in NJ E-1-43*)



- A total of 114 (2019), 103 (2020), and 138 (2021) piping plover pairs nested in New Jersey. The 2021 pair count was the second-highest ever recorded since listing and is attributed to the above-average productivity in recent years and the likely influx of plovers from surrounding states.
- Pairs nested at 27, 20, and 28 sites statewide in 2019, 2020, and 2021, respectively. The distribution continues to heavily favor the federal properties in the north and central part of the state, but growth was continued to be observed in the south in Cape May County (15 pairs in 2021 vs. 3 in 2018).
- Each site was visited 3-7x/week for monitoring, patrolling, and public outreach. Over the reporting period, the project increased its intern and volunteer programs, leading to more opportunities for public outreach.
- Statewide pair-nest success (the percentage of pairs that successfully hatch at least one nest) was 83%, 69%, and 64% in 2019, 2020, 2021, respectively.
- The statewide productivity rate was 1.24, 1.29, and 0.85 fledglings/pair in 2019, 2020, and 2021, respectively. These are all below the federal recovery goal of 1.5 fledglings/pair.
- NJDFW continued to use predator exclosures with 49%, 44%, and 46% nesting attempts exclosed in 2019, 2020, and 2021, respectively. The exclosed hatch rate for NJDFW nests was 74%, 93%, and 54% in 2019, 2020, and 2021, respectively. The NJDFW unexclosed hatch rate was 18%, 39%, and 22% for 2019, 2020, and 2021.The majority of unexclosed nests that failed were lost to predators. The abandonment rate for NJDFW exclosed nests was 15%, 7%, and 17% in 2019, 2020, and 2021. However, almost half of the NJDFW abandonments in 2021 were storm related, and both adults were confirmed alive after the abandonment.
- All banded plovers observed in New Jersey, or that were banded in New Jersey and reported elsewhere, were carefully documented in an Access database, which as of the end of the reporting period has nearly 1700 records.
- In 2019 and 2020, all GPS data loggers that were attached to piping plovers in 2018 were successfully removed (at the end of their useful life). No problems were detected with this attachment method and no injuries reported related to the units themselves (abrasion, cuts, etc). However, the vast majority of the recovered units malfunctioned and did not provide the data that was anticipated.
- Significant events over the reporting period were the COVID pandemic and a three-day nor'easter in 2021 that negatively heavily impacted most of the NJ nesting sites and the breeding birds using them.
- Weekly updates were sent to all landowners while active nesting took place at their sites. Beach management plans were created and updated, as needed, along the coast and in conjunction with partners at USFWS.
- All species' data was added to the long-term statewide database and submitted to the NJ DEP Biotics database for inclusion in the Landscape Project. This data can be used to produce a status assessment and a a recovery plan for piping plovers.

- Staff participated in the federal piping plover/least tern meeting that occurred in 2020, organized a NY/DE/NJ meeting in 2020, and organized NJ state meetings in 2019, 2020, and 2021.

Conclusions:

- Over the reporting period, the more even distribution of **black skimmers** across multiple colonies was a positive trend.
- The resight rate of banded skimmers continued to be high and provide valuable information on migration and wintering activities. Initial data (final data not available during this reporting period) from individuals outfitted with transmitters is promising to provide even more specific data about the movements of birds during the breeding season.
- The statewide **least tern** breeding population continued to be relatively stable, but the lack of productivity from most sites was a concern. Predators continue to be the overwhelming limiting factor for higher productivity. Although predation management is occurring at many locations in the state, the colonial nature of this species means it only takes a few individual predators keyed into a nesting area to cause significant damage.
- The species continues to be distributed rather evenly across sites and the state, in terms of location and number of individuals in colonies, and this is a positive note for this species. However, there is often a lopsided proportion of where fledglings are produced, with a few sites carrying the majority of production, and additional efforts to increase productivity at more sites should be undertaken.
- After seven consecutive years of strong reproductive success for **piping plover**, productivity took a steep dive in 2021. This was especially difficult as the work that went into producing the chicks from the last few years was paying off with a significant pair increase and staff hoped to produce an eighth year of success. However, the combination of the nor'easter and other weather events coupled with predator pressure proved to be too much. Looking back at the years 2014-2020, flooding was the cause of nest failure 11-21% of the time. In 2021, it caused the loss of 36% of nests.
- Although the increase in pair number and sites was welcomed in 2021, the unpredictable fluctuations in those metrics continue to be a cause for concern. The low number of unpaired adults mimics recent year's trends of being combined with higher pair number, which is positive, but with the lower productivity rate in 2021, there are concerns that the lower pair number/higher unpaired adult trend will continue in 2022 and beyond.
- Over the reporting period, the majority of plovers nested at two federal sites (Gateway NWA – Sandy Hook and EB Forsythe NWR). The recolonization and activation of many new sites in 2021 was encouraging, but many of these areas are already highly recreated, causing concern about their long-term viability. Cape May County continued its upward trend with fifteen pairs at seven sites in 2021. Although still far from its peak of 43 pairs in 2002, it is significantly up from 2018 when there were three pairs at just one site.
- Along with flooding and storms, predators were a major factor during the reporting period, in terms of hatch success and fledge rates. Where possible, managers increased the amount of predation management that took place, with mixed results. Even at a given site, one species might have had a fairly successful year while another failed entirely. Although it is known that predation management can increase productivity, determining species-specific strategies continues to be a challenge.
- Increasing the number of interns and volunteers on the project did lead to more effort on the part of staff (training, coordination, etc.), but the positive contributions they made were more than worthwhile.

Recommendations:

- Resume periodic monitoring of back bay island complexes to determine the status of breeding skimmers in this habitat and to ensure that large numbers are not being excluded from the state population numbers.
- Continue intensive monitoring of population and reproductive success, including causes of nest failure and brood loss. Encourage research projects focusing on improving reproductive success for all three species by reaching out to potential collaborators, supporting their proposals and providing technical guidance as needed.
- Continue to incorporate management strategies for piping plovers, black skimmers and least terns into comprehensive beach management plans for municipalities and state parks in the coastal zone.
- Continue to refine a comprehensive predation management plan (including components such as removal, aversion, and reducing site attractiveness) as it is a primary means forward to recover these species and

address predator issues. Work within and among DEP Divisions to obtain permission and create action plans for state lands, encourage federal partners to do the same, and work on initiatives to complete more aggressive and/or focused predator management on municipal lands.

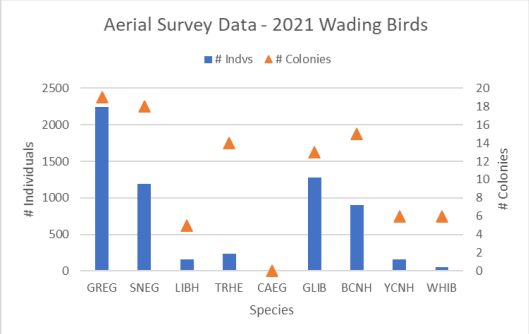
- Lead and/or coordinate large-scale restoration efforts to improve beach nesting bird habitat. Targeted sites include Malibu Beach WMA and Stone Harbor Point and carefully selected marsh islands. Conduct smaller efforts to manage vegetation as needed (for example, at Seven Presidents Oceanfront County Park, Belmar – Shark River Inlet, and Barnegat Light Restoration Area).
- Continue to work with regional partners to ensure that NJ is making the best decisions possible when it comes to predator exclosures. Encourage research projects that will make decisions relating to exclosure deployment clearer.
- Continue to band plovers and skimmers, where possible, and investigate banding least terns. A banding project on least terns to help understand population dynamics is desired, as consistently (perceived) low rates of productivity are not translating into an expected population reduction/crash.
- Continue to track banded plovers and skimmers and use this data to better understand survivorship and make progress towards understanding the distribution of these species and the population instability in recent years (plovers).
- Engage and seek out data and research on the impacts of sea-level rise, subsidence, and man-made efforts to stabilize the coastal zone in an effort to ensure habitat persists in the coming decades for these highly vulnerable species.
- Continue to coordinate management with municipalities and county, state, and federal landowners.
- Continue to incorporate breeding data into NJ DEP's Landscape Project and Biotics database.

Marsh Birds

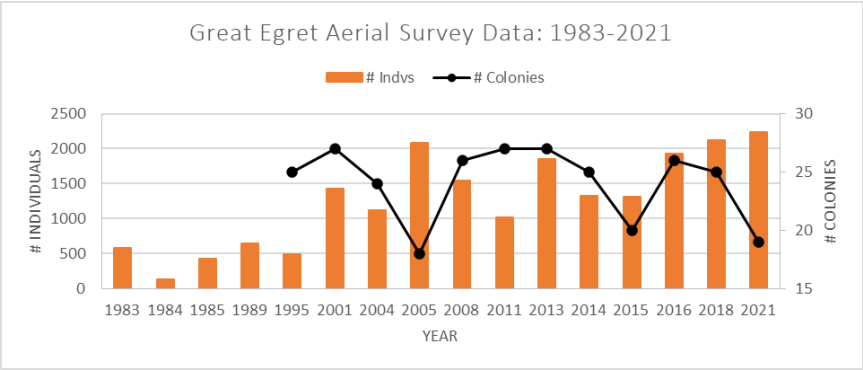
Prepared by: Christina Davis, Environmental Specialist II
Project Leader: Christina Davis

Key Findings:

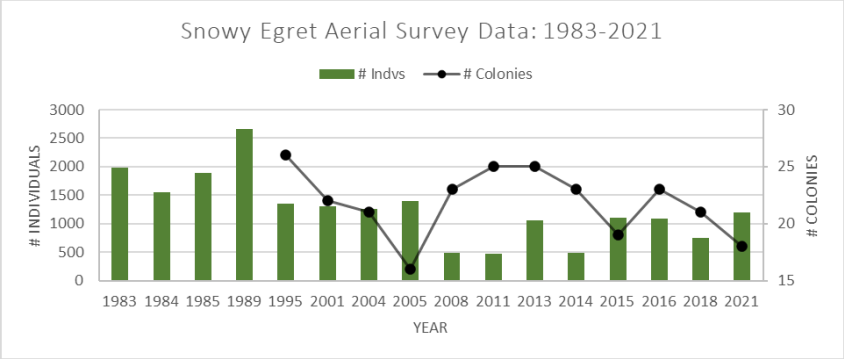
- 6,251 individual wading birds were counted on the 2021 aerial survey (which was the only survey of the 2019-2021 segment) in 25 colonies. Of the 6,215, 2,242 (36%) were great egrets, 1,190 (19%) were snowy egrets, 1,279 (20%) were glossy ibis, 901 (14 %) were black-crowned night-herons, 154 (3%) yellow-crowned night-herons, 157 (3%) little blue herons, 236 (4%) tricolored herons, 0 (0%) cattle egrets, and 56 (1%) white ibis.



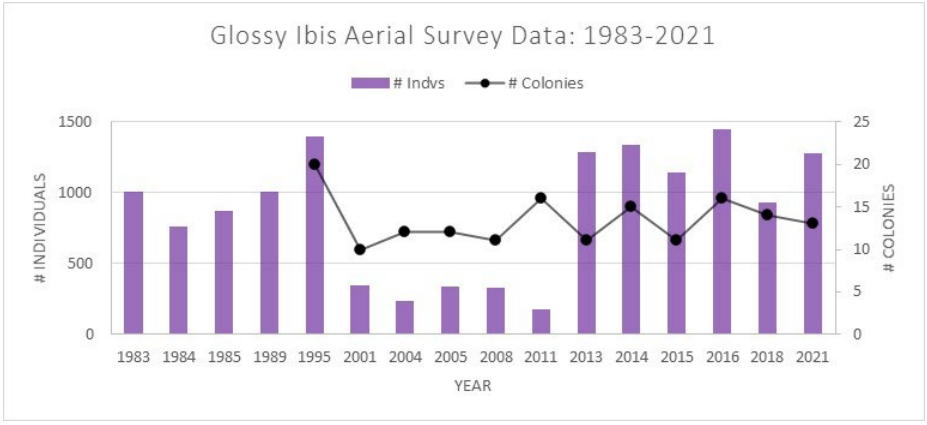
- There were 2,242 individual great egrets observed in 19 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



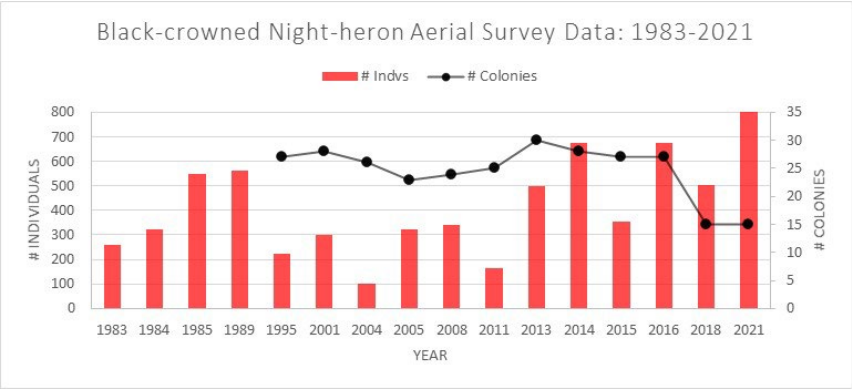
- There were 1,190 individual snowy egrets observed in 18 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



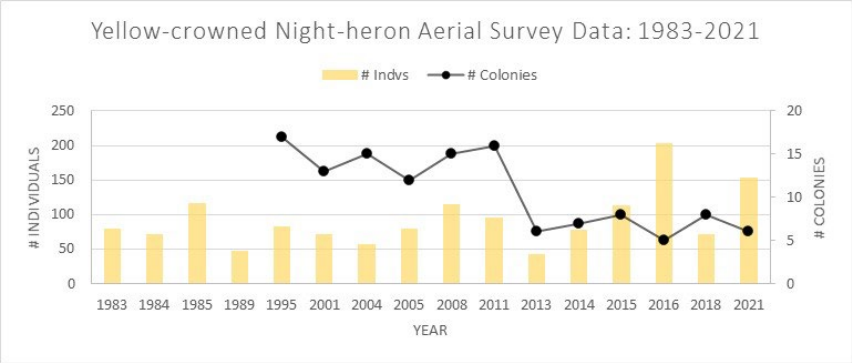
- There were 1,279 individual glossy ibis observed in 13 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



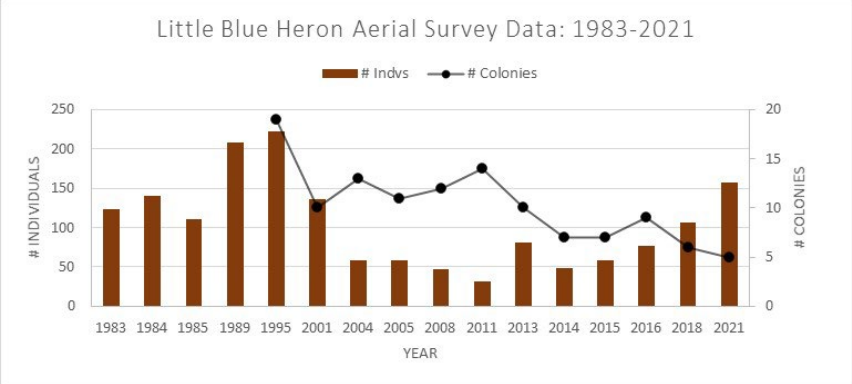
- There were 901 individual black-crowned night-herons observed in 15 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



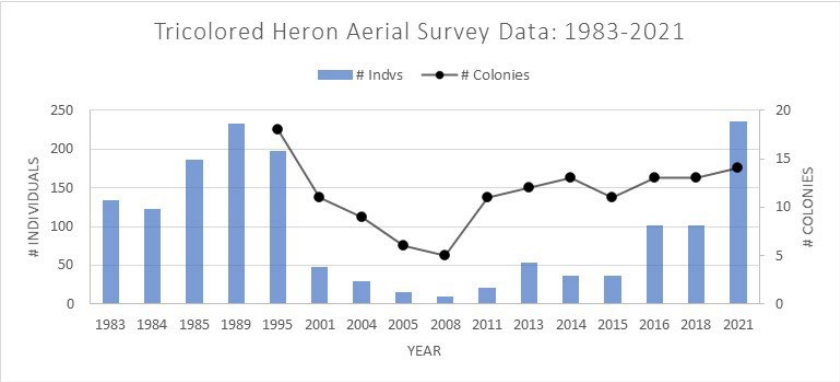
- There were 154 individual yellow-crowned night-herons observed in 6 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



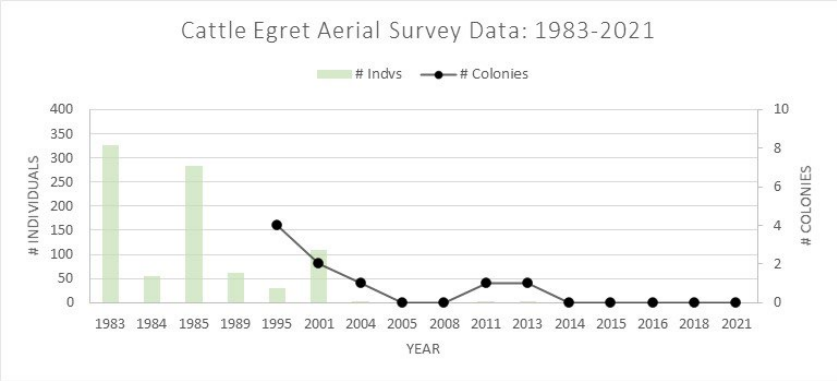
- There were 157 individual little blue herons observed in 5 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



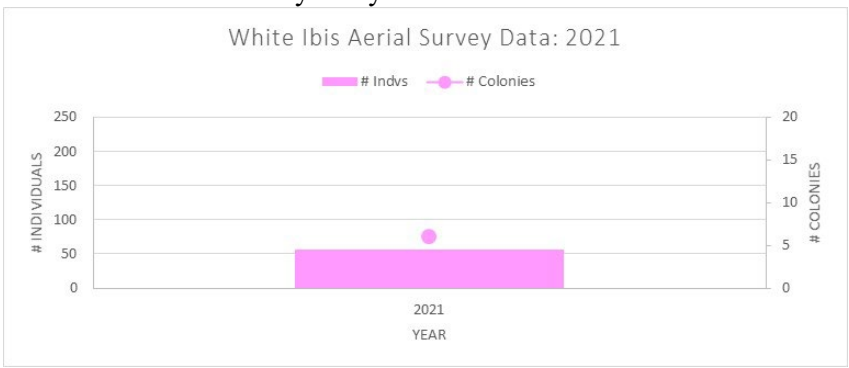
- There were 236 individual tricolored herons observed in 14 colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.



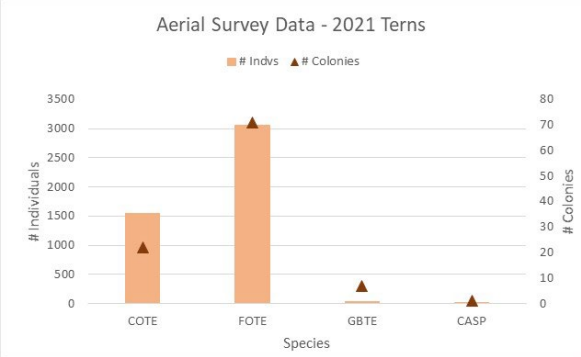
- There were zero cattle egrets observed in zero colonies. Due to changes in methodology, please note that colony data is not available prior to 1995.

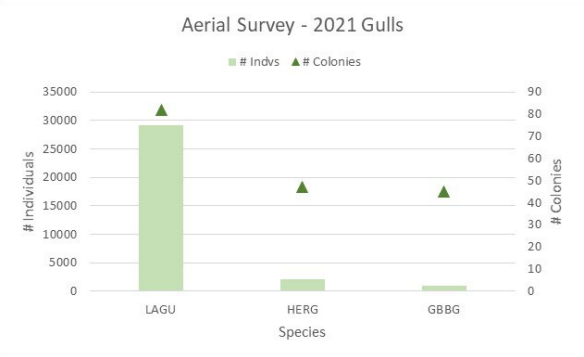


- For the first time in the history of the aerial survey, white ibis were confirmed nesting. Reports from the public indicate that nesting was confirmed in 2020 in at least one colony (Ocean City – Visitors Center), but there was no aerial survey that year.



- Although the focus of this objective is long-legged colonial waterbirds, surveyors also took the opportunity to census coastal marsh-nesting tern and gull species. Surveyors counted 1,540 common terns in 22 colonies, 3,061 Forster's terns in 71 colonies, 34 gull-billed terns in 7 colonies and 4 Caspian tern in 1 colony. 29,179 laughing gulls in 82 colonies, 2,107 herring gulls in 47 colonies and 1,042 great-black backed gulls in 45 colonies were also tallied.





- The continuation of the active colony of double-crested cormorants (which both compete with wading birds for nesting space and destroy habitat substrate with their caustic droppings) at one of the largest, and longest running, colonies in the state, Gull Island (near Stone Harbor) continued to be a source of grave concern for state biologists. By 2021, the cormorants expanded their use of the site to all 3 sub-colonies, rather than just the one they were originally utilizing. The trees in these sub-colonies have now all been killed by the caustic droppings of the cormorants.
- Interruptions of work due to COVID-19 prevented the completion of the ground survey. This survey relies heavily on volunteers and there were long periods of time during multiple field seasons in which volunteer activities were suspended due to the pandemic. In addition, staff time to focus on the ground survey was reduced while attending to issues related to the pandemic. However, a small subset of ground surveys was conducted, primarily of Yellow-crowned night-herons. Although this data is not complete enough to contribute significantly to understanding of the state's population, it was critical in helping biologists address management issues.
- Data analysis was undertaken by Stockton University undergraduate interns. This represented a first step in analysis and highlighted how much needs to be done on this issue. Students looked at a subset of species and geographic location.
- Staff remained involved in a consulting role with habitat modification efforts taking place in the marshes in Cape May County (Ring Island, Great Flat, Gull Island, Sturgeon Island).
- All data was submitted to the Biotics database for inclusion in the Landscape Project.

Conclusions:

- The aerial survey of the Atlantic coastal marshes by helicopter continues to be the most efficient way to survey the large area in a short period of time. Downsides include that it represents a snapshot of the season and can only be considered an inventory count (versus a census) and that dark-plumaged bird numbers are likely underestimated since they blend into the surrounding vegetation so well (Kushlan 2011). However, in 2021, the survey took place in a helicopter with increased visibility and observers reported this improved detectability and quality of the count.
- In 2021, wading bird as well as gulls and tern counts were conducted. Due to constraints of the survey, it continues to be difficult to determine trends and population estimates and few statistically sound conclusions can be drawn. In addition, the impacts of a strong nor'easter over Memorial Day weekend likely affected the number of gulls and terns as they were in the process of renesting (wading birds were counted just before the storm). Nonetheless, the survey provides the only comprehensive dataset on the NJ Atlantic coast wading birds and some trends are apparent. A number of species populations appear to be rising or stable (see charts above). Prior to the nor'easter, the warm and calm weather of spring 2021 was especially conducive to breeding and increases in numbers this year may have been a result of this boon.
- The snapshot technique is useful to show occupancy and distribution, however, which will become increasingly important as sea level rise and subsidence continue to change the coastal landscape. In 2013, there were 43 occupied colonies (defined as one or more pairs nesting) and in 2021 there were 25. There has been a gradual decline in the number of colonies (with some variability) and it appears from visual examination of the habitat that this is at least partially due to erosion/increase of flooding at and in nesting areas. A long-term trend of eroding and disappearing islands is noticeable, especially in the Barnegat Bay

and around Atlantic City. Some islands that are on maps have disappeared entirely; others exist as shrinking versions of themselves. A complete analysis of this trend has not yet been undertaken, but in looking at aerial photos from years past, the change is evident. The snapshot survey also provides critical information used for environmental review, where presence/absence and suitable habitat can surpass individual counts in levels of importance. The trend among wading birds appears to be mimicking that of other coastal avian groups, like beach-nesting birds, where the number of individuals is not necessarily declining, but they are being funneled into ever smaller numbers of active sites.

- For the first time in the history of the aerial surveys, white ibis was confirmed as a breeding wading bird in NJ. It appears to be part of a natural northward movement of this species along the Atlantic coast and remains to be seen if this species will outcompete other wading bird species for the shrinking amount of available habitat.
- The cormorants at Gull Island are an issue because the caustic defecation causes the nesting trees and shrubs to die, rendering them unusable by all species in a matter of years. At this time, although the numbers of cormorants continue to increase, the numbers of wading birds have not yet been affected. However, they have all been forced to nest on the ground while the cormorants use what remains of the trees, leaving the wading bird nests and chicks more susceptible to flood events.
- Determining the best method to survey this species continues to present a challenge. Although aerial surveys are the most efficient method to survey the marsh colonies, as well producing dataset with the least amount of disturbance/destruction (ground perimeter counts are not as reliable and walk-through counts impossible due to nesting substrate), they are cost prohibitive to repeat within a season. Without repeated measures, no population estimates can be produced. However, some strides were made in 2021 with the replacement of the costlier Bell Jet helicopter with a Robinson 44. At roughly one-third the cost, it may be possible to conduct multiple surveys within a season in the future.
- Due to the limited nature of the habitat analysis project, there are not statewide/species-wide conclusions that can be made. However, the work suggested that some species, in some areas, may be expanding their use of habitat at active colonies, even other sites become inactive. This may help explain how some species populations are remaining stable, even as the number of active colonies decline but much more research is needed before that could be hypothesis could be tested.

Recommendations:

- Continue the aerial survey effort until such time that a superior method is devised. Conduct multiple survey each season to better estimate populations.
- Continue to investigate alternative survey methods to the aerial survey, including the practicality of using drones. At this point, nebulous regulations for flying aircraft and concerns for the safety of the birds are leading ENSP to proceed cautiously but as protocols are developed, this may become a viable option.
- Examine the variables that may be impacting the future status of wading birds including 1) investigating the role eroded/flooded marshes are having in site selection and function and 2) fine-tuning techniques to control the cormorant colony to ensure it does not permanently alter the nesting habitat and leave it unsuitable.
- Continue to conduct ground surveys, as possible, and continue to investigate data analysis and habitat modification opportunities.
- Attend regional waterbird meetings to create partnerships with other states to find solutions to declining populations. These meetings are critical to establishing and maintaining cooperative efforts and to the continued exchange of information.
- Continue to incorporate breeding data into the Landscape Project and NJ DEP's Biotics database.

Kushlan J. A. 2011. Heron count protocols: inventory, census, and monitoring of herons. Heron Conservation. www.HeronConservation.org Accessed 2 October 2018.

Objective 2 – Migrating Shorebirds

Prepared by: Amanda Dey, Principal Zoologist

- Delaware Bay Peak Count - Peak abundance of red knots in Delaware Bay (aerial/ground counts) had been low and relatively stable for much of the last decade, 2009 to 2016 (24,000 to 21,128) and varied more between 2017 and 2021 (Figure 1). Horseshoe crab egg resources, which influence red knot abundance, remained low, patchy and unpredictable year-to-year.

  Peak red knot abundance declined in 2017 (17,969); resighting of marked red knots (in NY, MA) indicated some birds left the Bay early to seek food elsewhere (delayed spawning and low egg resources). This departure was detected in estimates of time-specific stopover population size by Lyons (2017). In 2018 and 2019, peak numbers of red knots were higher (32,930 and 30,880, respectively) as more birds remained in the bay to take advantage of widely distributed surface eggs available through the stopover period. In 2020, low and patchy egg resources presumably led to lower red knot abundance (19,397 on May 24); by May 26, red knot and ruddy turnstone numbers fell by 70 and 40 percent, respectively.

  In 2021, despite widely available egg resources starting early in May, we recorded the lowest number of red knots (6,880 individuals), ruddy turnstones (10,785), and other shorebirds in our surveys. All shorebird species were nearly absent from >5 miles of normally good foraging beaches (USFWS 2016) on the Cape May bayshore and shorebird concentrated primarily in two areas, Goshen Creek-Dennis Creek area in the north and Norbury's Landing in the south.

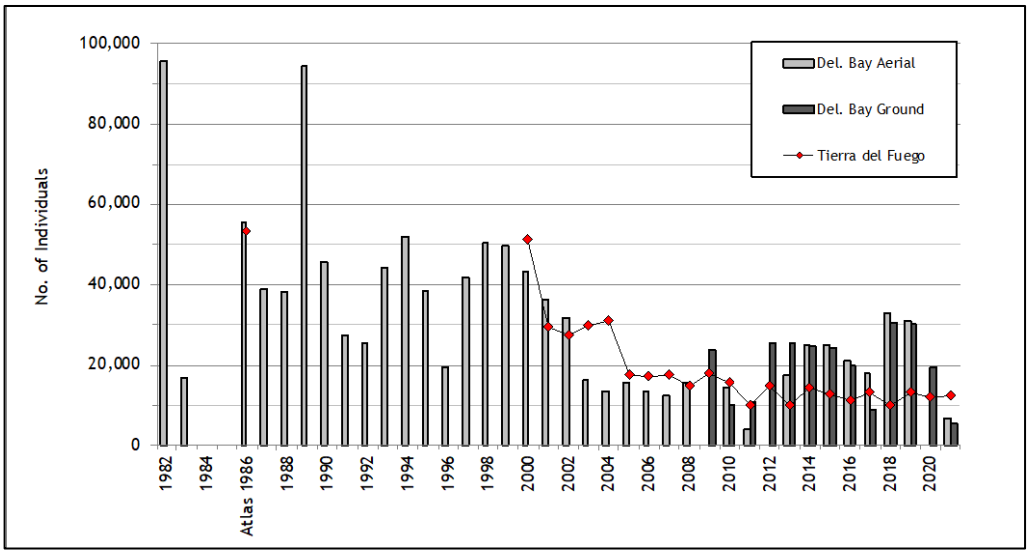


Figure 1. Peak aerial and ground counts of red knots in Delaware Bay during spring stopover, 1982-2020 (light gray and dark gray bars, respectively); aerial count of red knots in Tierra del Fuego (line) 1986-2019. Sources: Delaware Bay aerial survey, NJ Division of Fish and Wildlife, DE Division of Fish and Wildlife, NJ Audubon; Tierra del Fuego Aerial Survey-Atlas 1986, Morrison, R. I. G. and R. K. Ross; 2000-2020.

- Superpopulation Estimate for Red Knot Stopover Population – In 2021, the superpopulation estimate for red knots in the Delaware Bay stopover was 42,271 (95% CI: 35,948-55,210), similar to estimates of previous years (Table 1). The estimate is derived from bay-wide resightings of individually-marked red knots using a Jolly-Seber mark-recapture model that accounts for turnover (Lyons et al. 2016).

  Table 1. Superpopulation estimate (mark-resighting method). Source: Lyons (2021), Table 4. Memorandum to the Delaware Bay Adaptive Resource Model (ARM) Working Group. Stopover (passage) populationa estimate using mark-resight methods compared to peak-count index using aerial- or ground-survey methods. The mark-resight estimate of stopover (passage) population accounts for population turnover during migration; peak-count index is a single-day count and does not account for turnover.

Year	Stopover population[a] (mark-resight *N*)	95% CI Stopover population *N*	Peak-count index [aerial (A) or ground (G)]
2011	43,570	(40,880 – 46,570)	12,804 (A)[b]
2012	44,100	(41,860 – 46,790)	**25,458 (G)[c]**
2013	**48,955**	**(39,119** – 63,130)	**25,596 (A)[d]**
2014	44,010	(41,900 – 46,310)	24,980 (A)[c]
2015	60,727	**(55,568 – 68,732)**	24,890 (A)[c]
2016	**47,254**	**(44,873** – 50,574)	**21,128 (A)[b]**
2017	49,405[e]	**(46,368** – 53,109)	**17,969 (A)[f]**
2018	**45,221**	**(42,568** – 49,508)	32,930 (A)[b]
2019	**45,133**	**(42,269 – 48,393)**	30,880 (A)[g]
2020	40,444	**(33,627 – 49,966)**	**19,397 (G)[c]**
2021	**42,271**	**(35,948** – 55,210)	**6,880 (A)[h]**

[a] passage population estimate for entire season, including population turnover
[b] 23 May
[c] 24 May
[d] 28 May
[e] Data management procedures to reduce bias from recording errors in the field; data from observers with greater than average misread rate were not included in the analysis.
[f] 26 May
[g] 22 May
[h] 27 May

- Red Knot Weight Gain – Red knot weights are statistically linked to horseshoe crab surface egg density (eggs/m^2 in top 5 cm of sand). Sufficient red knot weight gain (≥180 grams) on Delaware Bay is statistically linked to adult survival (Baker et al. 1994) and Arctic productivity (Duijns et al. 2017). The proportion of red knots reaching 180 grams (P180) at time of normal departure (May 26-28) is useful as an index of shorebird foraging conditions (Figure 2). The proportion of red knots reaching ≥180 grams was 0.46, 0.43, and 0.35 in 2018-2020, respectively. In 2021, P180 was 0.44.

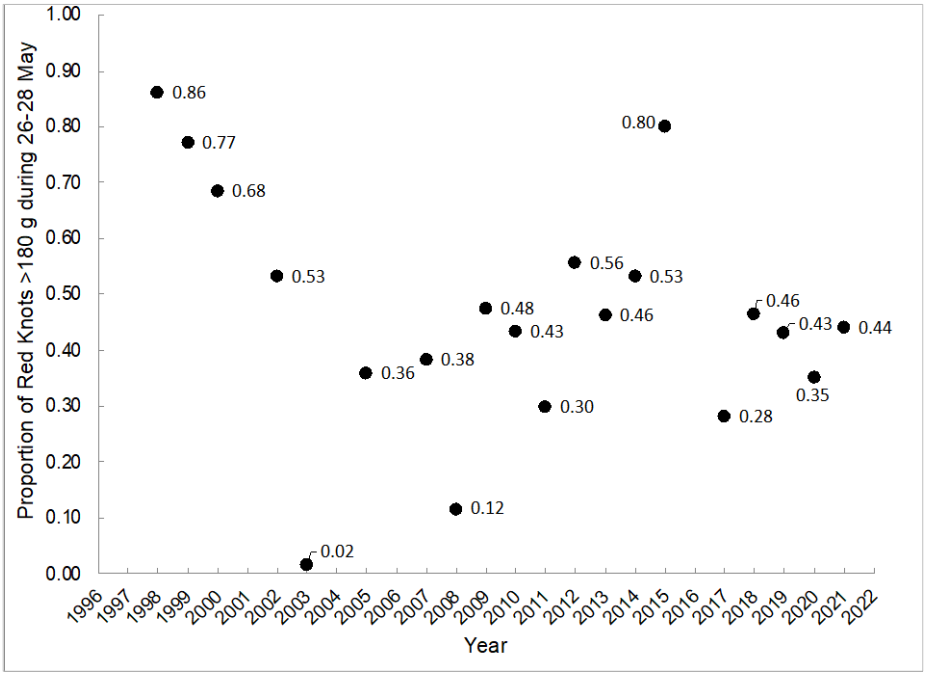


Figure 2. The proportion of red knots reaching ≥180 grams (P180) at time of departure from Delaware Bay (May 26-28) excluding capture data from Mispillion Harbor, DE. Source: NJ and DE Divisions of Fish and Wildlife.

- Index of Food Availability – Surface horseshoe crab egg density (eggs/m^2 in top 5 cm of sand) rose slightly in 2021, but the average density measured 11,565 in 2015-2021 (range 9,219-14,509 eggs/m^2). Surface egg density remains below historic densities observed prior to crab overharvest in the 1990s (~44,000 eggs/m^2 in 1991; Botton et al. 1994; Figure 3).

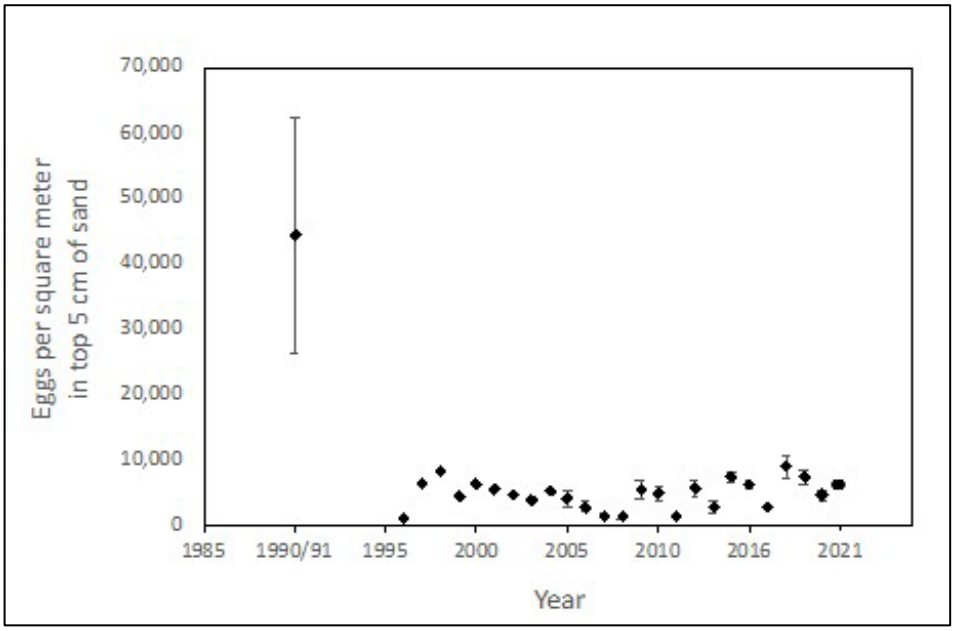


Figure 3. Surface egg densities on NJ beaches: Historic 1990-1991 (Botton et al. 1994), unpublished report to NJDEP 1996-1999 (Botton and Loveland), NJDFW unpublished data 2000-2021 (NJ Division of Fish and Wildlife).

- Beach Protection – Shorebird stewards were recruited, trained, and fielded at 13 beaches during the peak stopover period to help prevent human disturbances to foraging shorebirds. The Shorebird Steward project was funded in 2020-2021 under grant NJ E-1 Section 6 federal aid to endangered species.
- There was anecdotal evidence of shorebird harassment by peregrine falcons, but no data were available on locations or sighting frequency, nor data identifying peregrines by age class or bands. Peregrines that have been identified by NJDFW at beach-nesting bird colonies during spring-summer, 2019-2021, have been sub-adult, non-breeding birds. After a study found a correlation of reduced knot density and peregrine nests within 3km of knot foraging beaches (Watts and Truitt 2021), NJDFW removed the last peregrine nest structure located within 3km of Delaware Bay shore, leaving one known nest structure that is >4km distant.
- There were no habitat enhancement or restoration projects carried out in 2021 under this grant.

Conclusions:

- The red knot peak stopover population (aerial survey) is apparently stable but remains approximately 65% below historic peak abundance in 1989. The red knot population estimate (using mark-recapture) has varied around 45,000 individuals since 2011.
- Horseshoe crab eggs are the basis for the shorebird stopover in Delaware Bay, and egg density fluctuates annually at reduced levels, averaging 11,000 in 2015-2021 compared to 44,000 in the 1980s. We estimate that 50,000 eggs/m^2 on half of spawning beaches is necessary to spur red knot recovery (Niles et al. 2009).
- Management of human disturbance is an important component of red knot recovery work because northbound red knots (coming from South America) are most time-constrained and most reliant on abundant eggs at the end of May to make large, rapid weight gains prior to Arctic breeding.
- Horseshoe crab spawning habitat restoration (by other organizations), and shorebird steward site management to reduce disturbance to shorebirds, appear to have improved foraging conditions for red knots/shorebirds despite lack of increase in female crab abundance and egg resources. New Jersey's volunteer Shorebird Steward Program, supported by NJ Conservation Police, enjoys widespread support and cooperation from Bayshore communities and visitors.

Recommendations:

- Continue NJ and DE long-term collaboration on red knot/horseshoe crab research and conservation efforts. Ensure annual red knot data are provided to the ASFMC such that shorebird biologists continue to have a cooperative role in horseshoe crab management and restoration, and USFWS has annual recovery metrics necessary for annual status assessment and recovery planning.
- Continue protection of important shorebird beaches to give red knots and other shorebirds maximum foraging time on all resource beaches. Continue to support this volunteer program of Shorebird Stewards.
- Support restoration of beach habitats to improve spawning and shorebird foraging opportunities, by removing of rip-rap and buried rubble, and placement of intertidal shell bag reefs that attenuate wave energy, reduce beach erosion, and promote good spawning habitat.

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Objective 3 – Secretive Marsh Birds

Prepared by: Christina Davis, Environmental Specialist II

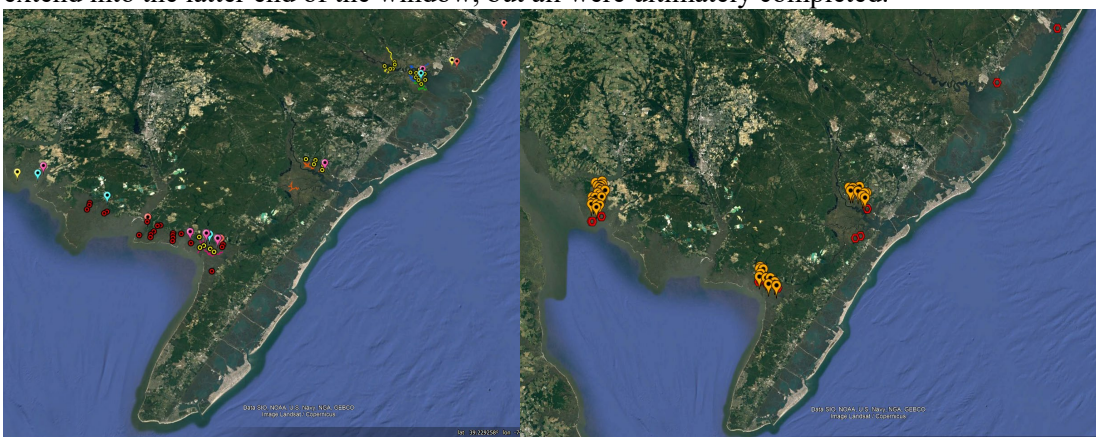
Project Leader: Christina Davis

Key Findings:

- A focused black rail survey was initiated in 2015 and continued 2019 and 2021 (2020 was cancelled due to the COVID pandemic) as concerns heightened over the security of the black rail population along the eastern seaboard, and particularly the mid-Atlantic.
- ENSP biologists continued to use the GIS-based Marsh Zone Map (publicly available from the Saltmarsh Habitat & Avian Research Program website) as well as ground truthing areas to select points for call-playback surveys and acoustic recording unit deployment.
- Each point was located at least 400m from any other and coded as either "water" or "road". Points were also segregated into their Watershed Management Areas (Mullica, Great Egg Harbor, Cape May and Maurice-Salem- Cohansey). Both "water" and "road" based points were surveyed.
- Call-playback survey protocol was compatible with that being used elsewhere along the east coast. It consisted of a combination of passive listening and recordings (of black and Virginia rails). The survey window in 2021 was 1 May– 15 July and three surveys (at least 7-10 days apart) were taken at each point. The survey period was ten minutes (plus a two-minute settling period prior) and calls were recorded in the minute they occurred. Surveys took place between 10pm and 3am, in low wind conditions with little/no precipitation and on a rising or high tide (to allow boat access in shallow waters). Black rail data was given the priority, but rail calls of all species were recorded by observers. Site and weather data were recorded for each point as well.
- Staff deployed six (2019) and nine (2021) Wildlife Acoustics acoustic recording units (ARUs), rotating them every two weeks from late April to mid-July. Locations were selected by ground truthing in suitable habitat (and occasionally to capture calls that were first detected by birders). In 2019, units were set to "listen" from 10pm-

4am and in 2021 they were set for the first 10 minutes of each hour from 10pm-3am. Data files were reviewed through an automated process available through Wildlife Acoustics SongScope and Kaleidoscope software. In 2019, 16 locations were surveyed in 2019 with ARUs and 18 locations were surveyed in 2021.

- In 2019, observers experimented with "troll" routes. These were water-based routes where the boat engine was either shut off or idled and observers played call and listened as they floated through a pre-selected area. The goal was to cover more overall area than could be completed with points alone.
- In 2021, and separate from the call-playback and ARU surveys, volunteers were recruited to conduct passive listening surveys to increase the area that was covered this year. ENSP has limits on resources for staff and contractors and this was an attempt to increase the area surveyed. Sites were self-selected by volunteers but ENSP staff directed which nights (based on ideal weather) volunteers should survey.
- ENSP staff carried out the surveys with the assistance of one seasonal employee per season, six contracted freelance biologists per season and eight volunteers (2021 only) at a combined 65 water-based points, 29 road-based call-playback points, 27 troll lines, and 20 passive-listening volunteer locations.
- In 2019, 20 of the water-based survey points were surveyed the prescribed three times. Two points were surveyed two times and three points were surveyed just once. Poor weather and mechanical boat failure accounted for the lost survey nights. In 2021, all 40 of the water-based survey points were surveyed the prescribed three times. Poor weather, mechanical boat failure, and logistical issues did force the survey to extend into the latter end of the window, but all were ultimately completed.



Location of 2019 (left) and 2021(right) call playback points, troll routes, and ARU locations

- No black rail were detected in 2019 and four were detected in 2021. One was on a call-playback survey, two were captured on ARU (one during normal surveys, one was placed after a report of a rail calling in the area), and one was via the volunteer survey. Least bittern, clapper rail, and Virginia rail were also heard.
- Paired survey points were not implemented as it was determined to be useful when the population is as low as it is in New Jersey and presence data is so scarce.
- All data was submitted to the NJDEP Biotics database for inclusion in the Landscape Project.
- Staff participated in the black rail status assessment, which ultimately led to this species being federally listed as threatened in October of 2020.

Conclusions:

- Nighttime continued to be the best time to survey this species in New Jersey, but this comes with many logistical challenges. Important components for successful boat-based surveys included an familiarity with the waterways (accomplished through daylight recon trips), appropriate lighting system and spotlight on the boat, reliable GPS or electronic mapping system (such as Google Earth on smartphone) to follow in real time, and ability to track weather through radar during the survey. Challenges included having only one boat operator, and limited to nights with good weather *and* the correct tides. Road-based points are much easier, logistically, but don't provide as good access to habitat as water-based points.
- A dedicated seasonal employee on this project allowed the ARU component to be more fully realized than in the past. ARUs are showing their promise to increase the amount of area that can be surveyed (and the amount of time each area can be surveyed) during a busy survey season when only a handful of nights

provide conditions suitable for water-based surveys. The downside is that there can be an immense amount of data to analyze. To address this, in 2021 staff adjusted the ARU schedule so that there was one hour of data/unit collected each night, versus six hours in 2019. Automated review was again used in 2021, but there continues to be concern that this may "miss" some hits if the software is not successful at "finding" the black rail calls. The units themselves continued to function well, were easy to operate, and were dependable in the marsh environment.

- Troll routes were not as successful as hoped for. When the boat's engine was cut, it did not float as well with the tide as anticipated and when it was idling at low speed, surveyors reported it was louder than ideal listening conditions would dictate. There were also concerns that the sound was discouraging birds from calling, as they may have perceived it as disturbance.
- The return of black rail detections in 2021 offered a modicum of relief over the results of 2018 and 2019, when no black rails were detected. However, it is important to note that four black rails (plus any that were detected by the USFWS NWR partners, who conducted separate surveys) with unknown breeding status and outcome is meager evidence of a positive trend. The only conclusions we can draw are that black rail are not yet extirpated from the state and that birds were calling during the breeding season.
- Experience with this survey allowed ENSP to expand its effort to it most comprehensive yet. This is still not a true statewide survey, but the Refuge effort allowed ENSP to shift focus to areas that were previously not included in efforts from 2015-2019, and volunteers helped cover new areas as well. The western-most area of ENSP coverage was an especially important addition as black rails were detected there.

Recommendations:

- Since boat-based surveys are critical in accessing and surveying this species' habitat, consider hiring additional boat operators so that evenings with good conditions (clear and still, high tide) could be maximized by utilizing multiple crews. Without more crews, the number of points that can be surveyed in one season is limited.
- Continue to deploy ARUs and purchase additional units.
- Continue to focus survey efforts on the southern region of the state and prioritize boat-based surveys. Use road-based surveys to complement boat-based and to cover as much habitat as possible. Expand survey area in Delaware Bay marshes. Work with conservation partners in the state to continue to expand coverage and recruit additional volunteers to do the same.
- Continue engagement with the Black Rail Working Group to help determine what management actions can be taken to help recover this species. Participate in planning of habitat restoration projects to improve suitability of potential breeding sites.
- Continue to incorporate breeding data into the Landscape Project and NJ DEP's Biotics database.

Objective 4 – Raptors

Prepared by: Kathleen Clark, Supervising Zoologist, William Pitts, Senior Zoologist

Habitat protection and planning:

- Maps of bald eagle nests were updated, and formatted for entry into the Biotics database. We initiated another roost study that uses data on telemetered eagles through fall, 2021; a GIS intern will complete the data compilation in January 2022, which will be followed by remote ID of new roosts that will be slated for ground surveys in 2022. Telemetry data will also be used to assess the habitats that the Landscape Project values for eagle nesting and roosting (primarily under NJ T-11-T-4).

Population monitoring of bald eagles:

The Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP) biologists, Conserve Wildlife Foundation (CWF) staff, and volunteer observers located and monitored bald eagle nests and territories. Two hundred and forty-seven nest sites were monitored during the nesting season, of which 222 were documented to be active (with eggs) and 25 were territorial or housekeeping pairs. Twenty-seven new eagle pairs were found this season, while other nests went inactive or pairs moved and were not found. One hundred-

seventy-seven nests (82%) of the 215 known-outcome nests produced 296 young, for a productivity rate of 1.37 young per active/known-outcome nest. Thirty-seven nests (17%) failed to produce young. The Delaware Bay region supports roughly half of all NJ nests. The mean productivity rate since 2010 was 1.31 young per active nest, indicating the population is likely to continue growing. Staff banded nestlings at two nests, and banded several other hatching-year eagles that passed through rehabilitation centers. Eagle blood samples were archived; analysis of eagle blood samples will begin in 2022.

Staff documented mortalities of 48 birds: electrocution (7), impacts with vehicles (6), impact with train (3), impact trauma (3), fell from nest (1); West Nile Virus (3); eagle-eagle combat (5); poisoning (2), lead toxicosis (2); and unknown circumstances (16).

Nest sites that were deemed vulnerable to human disturbance were posted and checked regularly, and field volunteers distributed brochures to landowners and interested citizens; the brochures describe bald eagle nest protections and recommended practices for conservation. No Eagle Project volunteer meetings were held due to Covid restrictions on gatherings. About 80 Eagle Project nest monitors recorded nest observations using NestStory program that facilitated data compilation by the project leader; the program also enabled tracking of time and mileage that documented 3,840 hours and 36,915 miles in the 2021 season. Weekly email communications were sent to all cooperators with project updates.

Population monitoring of other raptors:

- **Continue to monitor the nesting by peregrine falcons statewide, and collect/report data to the USFWS per the Peregrine Falcon Post-Delisting Monitoring Plan.** Record the location of all nests, and record their active status and nest outcome. Identify threats to falcons and nest success, including weather, predators, parasites, and contaminants. Band nestling peregrine falcons following national and regional protocols. Coordinate with other states in the mid-Atlantic and Northeast to report and track marked birds.

ENSP biologists and volunteers monitored nesting statewide, documenting 44 total pairs, of which 39 were known active (with eggs). Successful pairs remained the same as 2020, with 28 producing 74 young, for a productivity rate of 1.95 (known) young per active nest and a success rate of 71%. A brief summary of data collected during the 2021 nesting season follows:

- The coastal region (Atlantic and Delaware Bay coasts) supported 17 pairs that produced 2.18 young/nest and 50% of the young produced statewide. Most coastal nests are on towers and buildings.
- The Delaware River region (Burlington County and north) supported five pairs that produced 2.80 young per nest (14 young). Most nests are on bridges, with one building also in this region.
- The urban region of northeastern NJ supported eight nests that produced 1.50 young/nest with 12 young fledged. Most of these nests are on bridges with two on buildings.
- Natural cliff and quarry sites in northern NJ supported nine pairs that produced 1.38 young/nest (11 known fledged) and had the lowest success rate at 63%. These nests are on natural cliffs and, more recently, on inland quarry walls.

In 2021, we banded 52 of the 74 young produced, using a USGS band and a bicolor (black over green) band engraved with an alpha-numeric code. The 22 young we were unable to band fledged from sites that could not be accessed at the appropriate time.

In recent years we documented nestling mortalities that resulted from lead-poisoned prey, leading us to take blood samples at 16 sites in 2018-2021. The results ranged from <0.01 to 1.40 ppm. Urban samples (N=29) averaged 0.070 ppm and non-urban (N=37) averaged 0.017 ppm. Lead as a cause of nestling mortality seems to be a recent but spotty problem that we will be monitoring to understand the risk and possible sources of lead for urban peregrines.

In 2021, pairs that nested on natural and quarry cliffs increased to 10 occupied, nine that nested, and produced 11 chicks from 8 known-outcome sites. Nesting in natural-type sites including active and abandoned quarries has increased, but limited access can make close monitoring difficult or impossible. Weather and

intense storms did not, for the most part, play a role in causing widespread failures at cliffs, however, nest success and productivity remains lower than the other regions.

In 2021 we continued to use a small, mobile camera unit to photograph peregrines at accessible nests to read the leg bands on 21 adults, and an additional 17 adults were identified using optics and photographs. A minimum of 16 adults were unbanded and therefore unidentifiable to origin and age. Two of the previous oldest birds (15) were gone this year, the oldest female now at 13 years of age. The median age of males and females was 7.0, for 16 males and 18 females. The information that these identifications provide is valuable for relating peregrine origin and age to nest success, site fidelity and turnover rate in the population. An analysis of these data will begin in 2022.

Staff and project volunteers continued to use our online data management system, *NestStory*™. NestStory enables us to track all nests through each nesting season, and to track individually-marked birds resighted here and elsewhere. Banding and resighting data will be used in the coming year to study the population demography and dispersal.

- **Ospreys: accommodate citizen science by providing for a public platform (www.osprey-watch.org)** where all nests in NJ are listed and data (occupancy, success) can be entered. Oversee licensed bird banders (subpermittees under NJ Station permit #22803) who check osprey nests for nest success and banding nestlings.

ENSP partner, Conserve Wildlife Foundation of NJ (CWF), has helped coordinate nest surveys for the 2019-2021 period. In 2021, CWF and volunteers documented 703 occupied nests, which is the most ever recorded in New Jersey. Eighty-six percent were located along the Atlantic Coast, 10% along Delaware Bay, and the remainder were in the northern region from the Meadowlands to the Delaware River. Staff and volunteers recorded production of 883 young from 532 active/known-outcome nests for a rate of 1.66, below the five-year average but well above the 1.0 minimum needed to sustain the population. Two hundred-nineteen osprey nestlings were banded during nest checks.

The Delaware Bay nesting colony, with 10% of the state's population, overcame a history of reduced productivity related to contaminants (Steidl et al. 1991), and now has a 20-year trend of higher productivity than the overall Atlantic Coastal population. The availability of nest platforms likely limits population growth in this area, but suitable trees are plentiful, unlike the Atlantic Coast.

Literature cited:

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- **American kestrels: Using staff and trained volunteers and cooperators, maintain a nest box program that serves as a study platform for monitoring nest occupancy and success, marking adults and nestlings, and providing birds for telemetry studies.**

ENSP staff oversaw their 16th nest box season in 2021. Over the span of the project, an average of 181 boxes were monitored annually (min= 83, max= 259), which yielded an average of 54 nesting attempts (min=18, max = 97) and an average of 38 successful boxes (min=14, max=78), as defined by nestlings that reached the bandable age of 14-22 days. Over the past three years, an average of 245 boxes were monitored annually with an average of 87 nesting attempts and 69 successful boxes. With improvements to monitoring techniques, predator guards, and box placement, the success rate went from an average of 59% over the initial five years of the project to 78% over the last five years.

Another shift since 2015 has been increased partnership in placing and monitoring boxes. In the first two years working with Natural Lands (NL) only a modest number of boxes were placed and active, but with an increase

in their involvement in southern New Jersey, the award in 2019 of a Conserve Wildlife small grant to Friends of Hopewell Valley Open Space (FoHVOS), and an additional partnership with Raritan Headwaters (RH), partners have surged to account for almost half of the monitored and successful boxes in 2021-21.

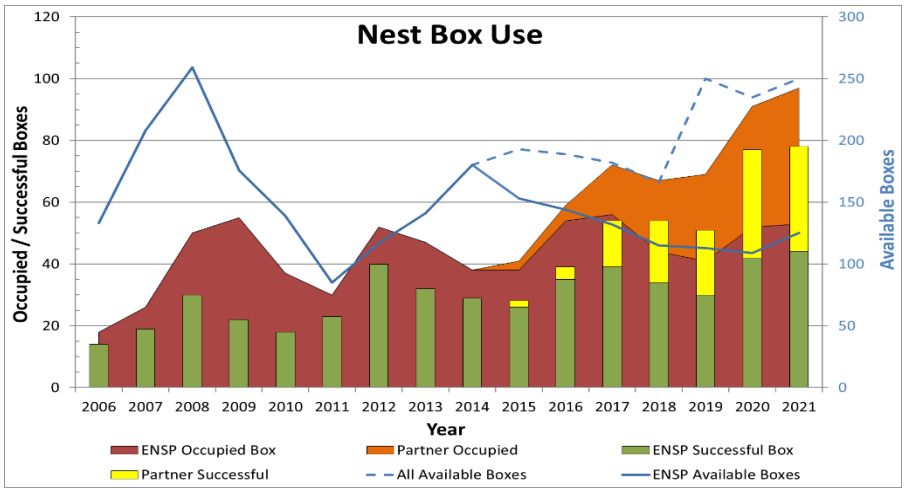

Figure 1. Nest box availability, use, and success in NJ, 2006-2021.

As with higher nest availability and success rates over the past several years, so too has the productivity of the project increased over this span. Since 2006, 2,286 nestlings have been banded, of which 809 (35%) of those have been banded between 2019-2021.

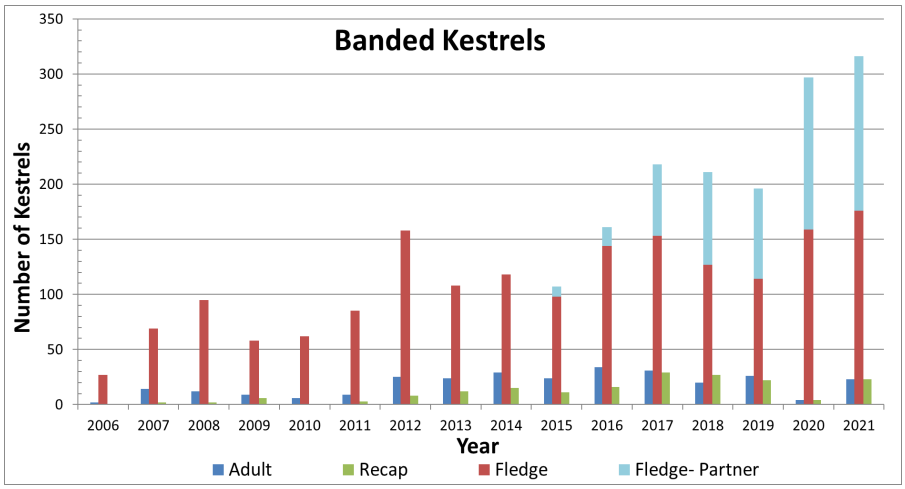

Figure 2. Kestrels banded in NJ, 2006-2021.

Despite gains from the nest box project over the years, indices from South Jersey winter raptor counts and the Breeding Bird Survey (BBS) continue to be at or near historically low numbers; both show declines of about 90%. The peak winter raptor count for kestrels in 1986 was 168 birds encountered and the low came in 2016 at just 6 counted; the 2021 count found 16 kestrels (90.5% decline). Similarly, the BBS index has fallen to 0.092 in 2019 from a high in 1966 of 0.862 (89.3% decline).

ENSP has developed or participated in research to better understand these declines including: 1) video monitoring of prey abundance during the nesting season, 2) year to year survivorship of banded birds, 3) migratory and wintering habits of NJ nesting birds, and 4) research of gene flow among populations throughout North America.

1. Analysis of video at nests (2019 and 2021) is being finalized, but interesting preliminary data showed that kestrels from the region of Ringoes-Hopewell heavily utilized the Brood X cicada emergence in 2021 (Fig. 3a) compared to a different nest box in 2019 (Fig. 3b).

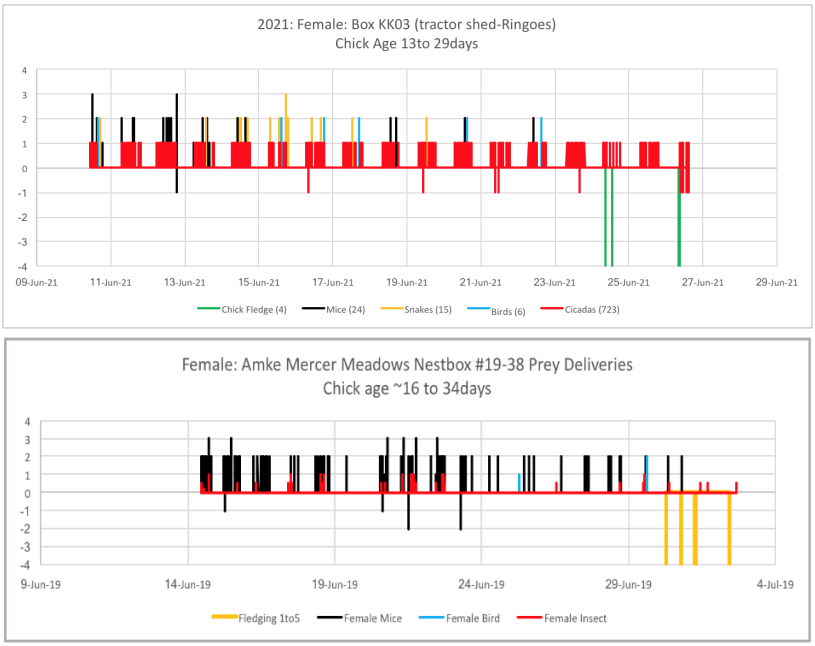

Figure 3. Prey-type deliveries by date at nest boxes: 3a) 2021 (cicada year) and 3b) 2019 (non-cicada year).

2. Excluding 2020, ENSP has captured an average of 44 adults per nesting season between 2012-2021 with an average recapture rate of 39.6%. The oldest bird of the study was recaptured in 2021, having been initially banded as after hatch year (AHY) in June of 2015, this female was at a minimum in her seventh year post-hatching in 2021. Of all individuals recaptured by ENSP, approximately 68% survive beyond their second year post hatching, while only about 31% survive beyond their third year post hatching.

3. ENSP undertook two rounds of geolocators study in 2013-2014 (n=15) and 2015-2016 (n=5). A total of six geolocators were retrieved from live individuals, and of these three wintered in NJ and three migrated to FL for the winter. Motus tags were deployed by Duke Farms and the Port Authority of NY & NJ (PANYNJ) in 2019 and 2020. Five of the seven deployments of PANYNJ were detected moving south, but only one was detected as far as FL, and none of the three deployed by Duke Farms were detected a week after deployment. While this technology has the potential to track long migratory movements, there are currently not enough towers in the network to be reliable.

4. Feathers supplied by ENSP and other banders throughout North America between 2016-2018 were analyzed and used for a genetic modeling of the American kestrel. Currently, there are only two described subspecies of kestrel in North America (*F. s. sparverius and F. s. paulus*), but the work of Ruegg et. al. (2021) suggests that there should be five subspecies throughout the continent.

- **Woodland raptors: Develop revised survey strategies for this guild of raptors, one which will help ENSP assess population trends, and help identify best forest management approaches.**

This job was mainly inactive in 2019-2021. ENSP biologists contributed to the NJDEP Forest Service's NJ Forestry Plan, and recommended barred owl management for forests targeted for Atlantic White Cedar restoration that NJ Forest Service has initiated. Several barred owl nest boxes were installed adjacent to existing cedar swamps to test for occupancy, but were not yet occupied in 2021. Sightings data that were submitted from the public were reviewed for acceptance into the NJ Biotics database.

- **Migrating raptors: Seek data collected by others on important bird migration areas, including Cape May and the raptor banding station (Cape May Raptor Banding Project), and owl banding station (K. Duffy), and add information to the NJ Biotics database for species of conservation concern.**

ENSP compiled data on endangered and threatened status raptors encountered at Cape May in the course of raptor and owl banding, and those data were entered into the Biotics database following database protocols.

Objective 5 – Non-Raptor Land Birds

Prepared by: Sharon Petzinger, Senior Zoologist

Key Findings:

1) Continued to survey known, historic, and potential golden-winged warbler locations in NJ (approx. 150 points) using call-playback point count surveys.
   - A total 127 locations suitable for breeding golden-winged warblers (GWWA) in NJ were surveyed in 2021 by ENSP staff and staff from NJ Audubon. An additional five locations were surveyed in southern NY as part of Cornell's GOWAP.
     - Twenty-four locations were actively managed forest sites, 65 locations were passively managed wetlands, and 38 locations were within powerlines.
     - Eighty-nine of the 127 NJ locations contained forest cover >75% when measured within a 1.5-mile radius from the location: 36 were on powerlines, 12 in actively managed forest sites, and 41 in passively managed wetlands.
       - Ten GWWAs were observed in eleven of the 127 locations surveyed in NJ in 2021 (naïve occupancy = 0.086).
     - Three (27%) locations had GWWAs in 2020 and 2021.
     - Six (55%) locations were recolonized by GWWAs in 2021 after being vacant in 2020.
     - Two (18%) locations were new and had no prior GWWA observations. Both locations were in wetland sites.
     - Eleven (73%) of the previous 15 NJ locations occupied by 14 GWWAs in 2020 were not occupied in 2021.
     - Naïve occupancy of the four GWWAs on powerlines was 0.105, naïve occupancy of the four GWWAs on passively managed wetland sites was 0.065, and naïve occupancy of the two GWWAs on actively managed forest sites was 0.086.
       - When looking at only sites with >75% forest cover, naïve occupancy of GWWAs was as follows: powerlines = 0.111, passively managed wetlands = 0.097, and actively managedforests = 0.167
     - Ninety-three blue-winged warblers (BWWAs) were recorded in 84 of the 127 locations suitable for breeding GWWAs in 2021 (naïve occupancy = 0.661).
       - Sixteen BWWAs were in 12 of the 24 actively managed forest sites (naïve occupancy = 0.50), 44 BWWAs were in 39 of the 41 passively managed wetlands (naïve occupancy = 0.95), and 34 BWWAs were in 34 of the 38 powerline locations (naïve occupancy = 0.89).
     - Eight hybrids were recorded in eight of the 127 locations suitable for breeding GWWAs (naïve occupancy = 0.063).
       - One hybrid was observed in one of the 24 actively managed forest sites (naïve occupancy = 0.042), one hybrid was observed in one of the 41 passively managed wetland sites (naïve occupancy = 0.024), and six hybrids were observed in six of the 38 powerline sites (naïve occupancy = 0.158). Collect data on habitat in surveyed locations, including tree and shrub species, canopy cover and height, proximity of forest edge, as well as the date and type of management where applicable.
     - Habitat data were collected within each of the 135 bird monitoring locations in 2020 and 127 locations in 2021. All GWWAs observed in 2021 were in locations with >75% forest cover (naïve occupancy = 0.112). Sixty-one of the 84 BWWA locations (72.6%) and seven out of the eight hybrids (87.5%) were in locations with >75% forest cover.
       - Based on Chi-squared tests, while GWWAs will occupy upland and wetland sites equally, they tend to occupy sites that contain some amount of saturated ground ($P<0.001$). GWWA occupancy is also dependent upon the amount of tree cover ($P=0.002$), herbaceous cover ($P<0.001$), and shrub cover ($P=0.007$) may also predict GWWA occupancy. GWWAs are more

likely to occupy areas with 5-25% tree cover, 25% herbaceous cover and 25% shrub cover. Elevation is not a significant predictor of occupancy (P=0.184); 51% of GWWAs were observed in sites <1,000 feet in elevation.

2) Track the history of vegetation management on occupied rights-of-way, and provide guidance to managing utility companies to proactively manage and maintain a favorable mosaic of habitats
   - ENSP staff continued to collaborate with NJ Audubon and PSEG to revise and implement management prescriptions for each span on the utility ROW maintained by PSEG that is part of the 1.5-mile stretch containing about half of NJ's GWWA population. Selective herbicide was used outside the breeding season the end of 2019/early 2020 on non-compatible vegetation within some of these spans. Because the herbicide applied reduced the amount of suitable vegetation growing in many of the spans, PSEG planted native vegetation compatible with GWWAs and powerlines in several spans 2021. The cost of these plantings was funded by non-federal monies and used as match for this grant.
     - In 2021, three GWWAs used the GM spans during the breeding season, which is a decrease from the six GWWAs breeding in these spans from 2020. For comparison, no GWWAs were observed breeding in the non-ROW locations that contained known GWWA males in 2012 or 2013 (Fig. 5-1).
     - Overall, although not statistically significant, the declining trend of GWWAs on the 19 GM spans continues to be less than the decline of GWWAs on the 18 non-ROW locations. In 2021, these GM spans contained three of the 10 GWWAs observed in NJ, six were not on ROWs, and one was on a non-GM span along the same transmission line.

3) Color band golden-winged warblers, using target call-playback to lure them into mist nets, to determine the extent of movement and site fidelity in NJ. Create a state Status Assessment and Recovery Plan for golden-winged warblers.
   - ENSP staff mist-netted and color-banded two male GWWAs in May 2021.
   - ENSP staff updated the GWWA status assessment in 2021 with information from new published literature and data from the 2020 and 2021 GWWA monitoring.

4) Seek data collected by others on important bird migration areas, including the Cape May passerine banding station (NJ Audubon), and add information to the NJ Biotics database for species of conservation concern.
   - Data from the 2020 surveys were submitted for entry into the NJ DEP's Biotics database in early 2021 database by mid-February 2022.

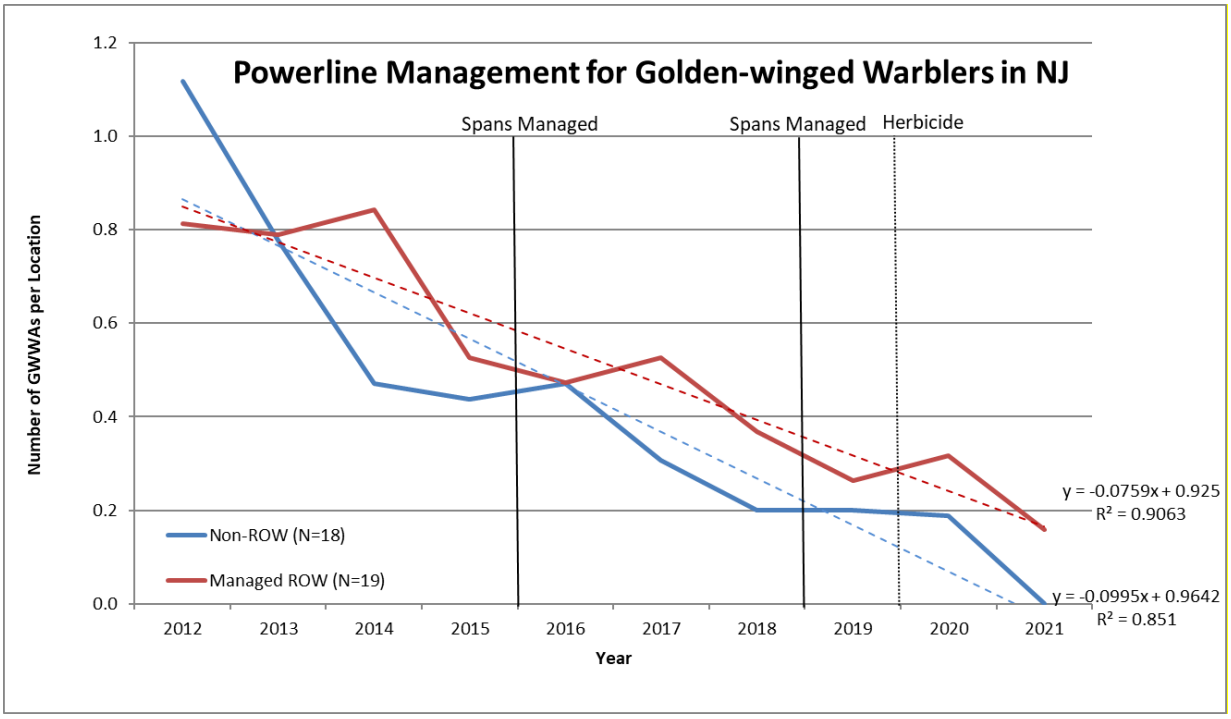

Figure 5-1. Number of golden-winged warblers observed per survey location from 2012 – 2021 (data from ENSP and NJ Audubon). The managed ROW (red) represents the 19 spans chosen for GWWA management, where the span-specific prescriptions were implemented winter of 2015/16 and early 2019, and selective herbicide on non-compatible vegetation was used end of 2019/early 2020. The Non-ROW (blue) represents known GWWA locations in 2012/13 that are not within a powerline. The dotted lines are linear trends.

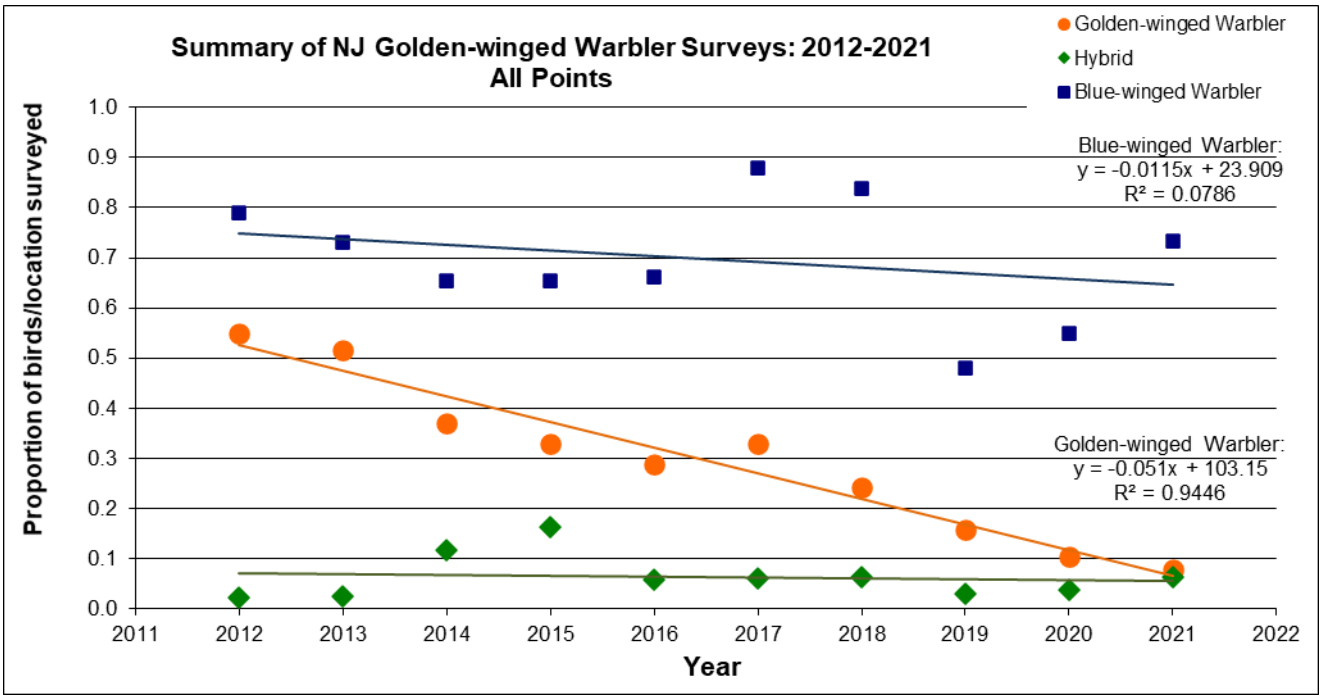

Figure 5-2. Proportion of golden-winged, blue-winged, and hybrid *Vermivora* warblers observed per survey location in suitable habitat during the 2012 (n=60), 2013 (n=60), 2014 (n=65), 2015 (n=76), 2016 (n=83), 2017 (n=67), 2018 (n=62), 2019 (n=102), 2020 (n=135, and 2021 (n=127) surveys.

Conclusions:

- Overall, the proportion of suitable GWWA breeding habitat occupied by at least one GWWA during the breeding season has been decreasing at a rate around 5% per year since 2012 (Fig. 5-2). In 2021 we

observed a net loss of four potential breeding GWWA pairs in five locations, which was a reduction of 28% of the observed populations and 35% of the known locations in 2020.

- Based on repeated *Vermivora* breeding surveys in suitable GWWA habitat, the golden-winged warbler population has declined at a rate of about 6.2 to 6.6% per year since 2012 (Fig. 5-3). If nothing is done to increase GWWA recruitment or productivity in NJ and this rate of decline continues, there is an 88% chance that NJ's breeding population of GWWAs will be extirpated within the next 10 years and 100% chance of extirpation within 20 years (Vortex 10.2.14.0).
- The collaborative work between ENSP, NJ Audubon, and PSEG to maintain certain spans for GWWA while maintaining compliance with federal regulations is successful, even with a continually declining population of GWWAs. In 2021, 40% of NJ's breeding GWWA population was observed on the transmission line maintained by PSEG, and about 30% of the population is breeding in the spans specifically managed for GWWAs. This is lower than the previous year.

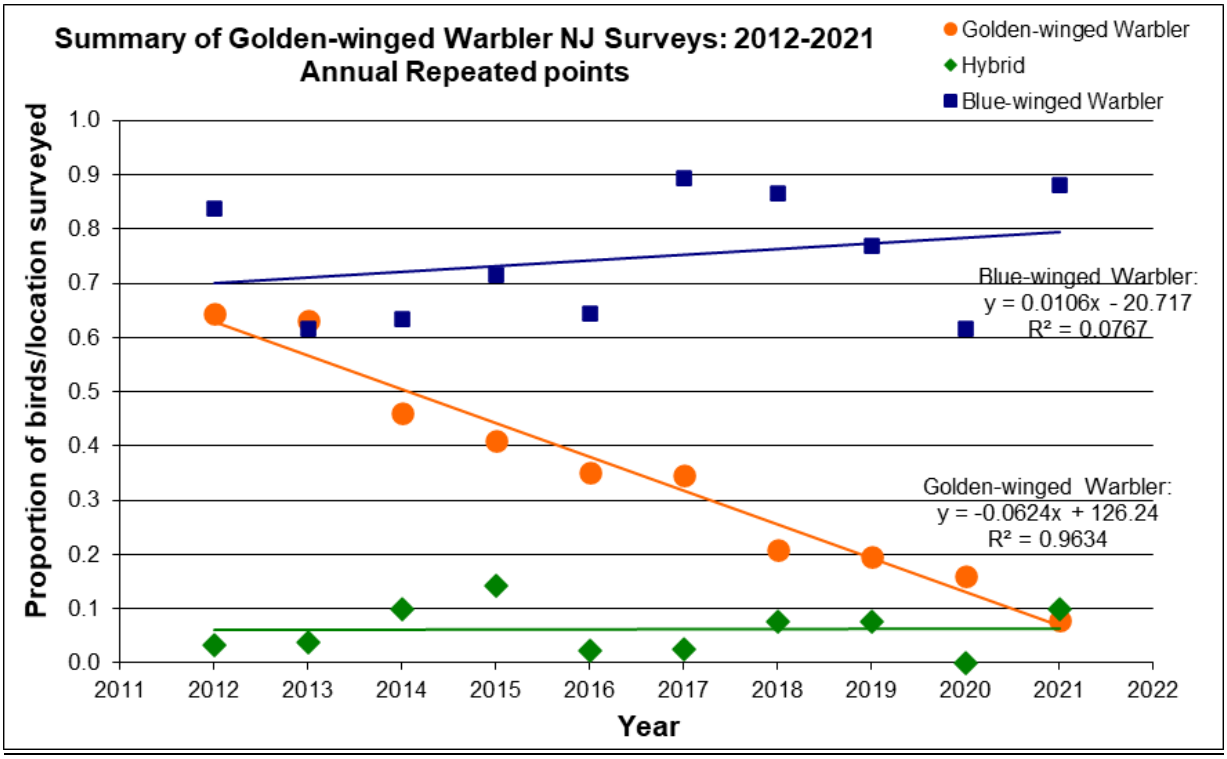

Figure 5-3. Change in golden-winged, blue-winged, and hybrid *Vermivora* warbler population observed in up to 57 NJ locations surveyed at least 7 of the last 10 years in suitable habitat. 2012 (n=45), 2013 (n=46), 2014 (n=50), 2015 (n=56), 2016 (n=57), 2017 (n=55), 2018 (n=53), 2019 (n=56), 2020 (n=56), and 2021 (n=50).

Recommendations:

- Continue to coordinate surveys with NJ Audubon and the Golden-Winged Warbler Atlas Project (GOWAP), specifically targeting areas with >70% forest cover within a 1.5-mile radius.
- Work to create suitable habitat for golden-winged warblers to reduce nest and/or fledgling mortality and increase recruitment. Focus on creating habitat in or near wetlands with > 70% forest cover within a 1.5-mile radius. Create or enhance forests near GWWA breeding habitat to increase post-fledging survival.
  - A 10% reduction on mortality in individuals between 0 and 1 year of age will reduce the probability of extirpation in 10 years from 88% to 69%.
  - A 10% increase in recruitment will reduce the probability of extirpation in 10 years from 88% to 63%
  - A combination of a 10% reduction in juvenile mortality and 10% increase in recruitment will reduce the probability of extirpation in 10 years from 88% to 35% and from 100% to 65% in the next 20 years.
- Retain and improve powerline rights-of-way to retain the breeding GWWAs on those spans.
- Complete the status assessment and draft species recovery plan for golden-winged warblers in NJ.

~ END ~