Section 6 Federal Aid to Endangered Species
E-1-37
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Endangered & Threatened Wildlife Conservation

Final Report, Project Year
September 1, 2014 – August 31, 2015

NJ Department of Environmental Protection

DIVISION OF FISH AND WILDLIFE
ENDANGERED AND NONGAME SPECIES PROGRAM
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NEW JERSEY DIVISION OF
Fish and Wildlife

Conserve Wildlife
New Jersey Division of Fish & Wildlife
Endangered & Nongame Species Program

PERFORMANCE REPORT

STATE: New Jersey

PROJECT NUMBER: E-1-37

PROJECT TYPE: Research and/or Management

PROJECT TITLE: Endangered and Threatened Wildlife Conservation

STUDY NUMBER AND TITLE: IV - Vertebrate Wildlife Conservation

JOB NUMBER AND TITLE: 2-B Piping Plover Population Survey

PERIOD COVERED: September 1, 2014 to August 31, 2015

PREPARED BY: Christina Davis and Todd Pover

JOB OBJECTIVE: To determine statewide and site specific piping plover populations, nesting success, and productivity.

SUMMARY: The New Jersey Division of Fish and Wildlife (NJDFW)-Endangered and Nongame Species Program (ENSP) monitored just over half (10 sites or 53%) of the state's 19 active piping plover nesting sites. NJDFW-monitored sites accounted for only 16% of the state's total nesting pairs (108). NJDFW regularly monitored 10 additional sites and several others less regularly, although no nests were found at those sites. Other sites in the state were monitored by cooperators including the National Park Service (Gateway National Recreation Area-Sandy Hook Unit); The Wetlands Institute (Stone Harbor Point); Cape May National Wildlife Refuge (Two-Mile Beach and Coast Guard LSU); the U.S. Coast Guard (Coast Guard LSU and Cape May Training Center); The Nature Conservancy (Cape May Migratory Bird Refuge), and the Conserve Wildlife Foundation of New Jersey (Holgate and Little Beach Units of the Edwin B. Forsythe National Wildlife Refuge, as well as various sites throughout the state in conjunction with ENSP). NJDFW worked closely with those cooperators to implement standardized monitoring and data collection protocols. The cooperators provided data on population and reproductive success from their sites to NJDFW so that we could compile and analyze nesting data for the entire state. A statewide cooperators meeting was held prior to the breeding season to review recent statewide trends, ongoing research, changes to data protocols, predator management initiatives, and other relevant management needs.

A total of 108 pairs of piping plovers nested in New Jersey in 2015, a 17% increase from 2014, (92 pairs, the lowest level recorded since federal listing in 1986). Despite the robust increase in statewide abundance this year, pair totals remained below the long-term state average since federal listing (118 pairs) and remained notably low over the past decade. Sandy Hook continued to account for the greatest share of pairs in the state; its 53 pairs represent nearly half (49%) of the statewide total and established a new record for pairs for the site. The region consisting of

Holgate, Little Beach (both part of Edwin B. Forsythe NWR), and North Brigantine Natural Area accounted for 43 pairs (40% of the state total). Of particular note, Holgate alone accounted for 24 pairs (22% of the statewide total), double the number of pairs at the site in 2014 (12) and the most of any single site in the state. The number of pairs nesting in Cape May County continued its steep drop, falling to 8 pairs in 2015 from 43 pairs in 2004, or 7% of the statewide total in 2015 compared to nearly a third (32%) of the pairs in 2004.

The number of active nesting sites statewide dropped slightly in 2015 to 19 sites (versus 21 in 2014). It was well below the peak number of sites recorded in the state (30 sites in 2004 and 2005) and was the lowest tally since federal listing.

Statewide pair nest success (pairs that hatch at least one chick) was high in 2015 at 79%, above the average for the years since federal listing (68%).

Statewide productivity remained near record statewide levels for the second year in a row (1.29 fledglings/pair in 2015 and 1.36 in 2014), well above the statewide average since federal listing (0.99 fledglings/pair) and above the range-wide level (1.245 fledglings/pair) believed necessary to maintain a stationary population (USFWS 1996).

SIGNIFICANT DEVIATIONS: None.

RECOMMENDATIONS: Continue intensive monitoring of populations and reproductive success.

BACKGROUND

The piping plover (*Charadrius melodus)* was listed as endangered by the New Jersey Department of Environmental Protection in 1979. In January 1986, the U.S. Fish and Wildlife Service (USFWS) included the piping plover on the Federal Endangered Species list and classified the Atlantic coast population as "Threatened". ENSP has directed local and statewide assessment of population trends since 1976. Statewide surveys were conducted in 1980 and 1984-2015, with limited surveys in 1976 and 1983.

PROCEDURES

Starting in March, NJDFW began visiting coastal beaches to assess the suitability of nesting habitat. Nesting activity was then monitored at all identified nesting sites (with emphasis on areas where nesting had occurred in recent years) following nesting survey guidelines published in the Atlantic Coast Piping Plover Recovery Plan (USFWS, 1996). Starting in mid-April, NJDFW visited nesting areas at least 3 times a week, and typically more frequently, to search for active nests and pairs on territories. Once located, nests, and then broods, were checked 3 to 5 times a week to monitor breeding progress and outcome. Cooperators throughout the state followed a similar protocol, although the Monmouth County sites (outside Sandy Hook), Holgate, Little Beach, and Stone Harbor Point, were monitored near daily in 2015. In addition to regular monitoring, a statewide, date-restricted count was conducted between June 1 and 9. All sites where piping plovers had nested the past 10 years (if suitable habitat still existed), as well as

any newly created habitat that could potentially support nesting plovers were checked using methodology established by the USFWS (1996) for the Atlantic coast breeding population. NJDFW-ENSP adjusted the date-restricted count to include pairs discovered after the survey window that, based on nesting phrenology, were present during the survey period. Additionally, because NJDFW-ENSP surveyed individual sites more than once during the census period, identification of pairs at NJDFW surveyed sites was based on breeding and territorial behavior noted during the entire survey period (rather than from one specific visit).

FINDINGS

One hundred-eight (108) pairs of piping plovers nested in New Jersey in 2015, a 17% increase from 2014 (92). Despite the increase, the current number of nesting pairs remains below the long-term average since federal listing (118 pairs) and significantly below the peak count of 144 pairs in 2003. Furthermore, the statewide population trend remains flat to slightly declining over the period since federal listing, once you factor in an initial population "bump" due to an increase in survey intensity immediately following listing (Figure 1).

The total number of adults recorded for the entire nesting season (218) was somewhat higher than during the date-restricted survey conducted June 1-9 (205). Likewise, the number of pairs tallied during the entire nesting season (108) was higher than the pairs recorded during the date-restricted census (95). This is consistent with the pattern in New Jersey whereby the date-restricted pair counts are well below the final season count, as well as the total adults to a lesser degree, although in 2014 the two counts were more similar.

Northern Monmouth County, as a region, continued to account for the largest percentage of pairs in the state, just over half of the statewide population (55 pairs or 51% of the statewide total). Most of those pairs nested at Sandy Hook (53 pairs or 49% of the statewide total). The region comprised of Holgate, Little Beach, and North Brigantine Natural Area also accounted for a significant proportion of the statewide population (43 pairs or 40% of the statewide total). Cape May County, the southernmost region of the state, consisting of Ocean City to Cape May Point, continued its long-term downward trend, hosting just 8 pairs in 2015, compared to 11 pairs in 2014 and 43 pairs in 2004 at its peak.

Looking at the individual sites, there was little change in pairs in 2015 versus 2014, with the exception of Holgate, which doubled its tally to 24 pairs. No pairs nested at Strathmere in 2015 for the first time in several years due to severe beach erosion. Combined with the recent loss of pairs nesting at Corson's Inlet State Park, this is the first year since federal listing that no pairs nested in the Corson's Inlet complex. Likewise, no pairs nested at the South Cape May Meadows in 2015, the first time this occurred since federal listing, as well.

Pairs nested at 19 sites statewide, down from 21 sites in 2014, and well below the peak count of 30 sites recorded in both 2004 and 2005. It was the lowest total since federal listing. NJDFW monitored 10 of the active nesting sites (52% of the sites statewide), accounting for 17 nesting pairs (16% of the nesting pairs statewide). NJDFW typically monitors about half of the state's active sites (i.e., sites where nests are located), but the total number of active pairs monitored at NJDFW sites dropped again in 2015, continuing a precipitous downward trend, down from a

peak of 70 pairs in 2003. NJDFW also regularly monitored 10 other potential breeding sites with historic nesting records and/or highly suitable habitat, as well as several other sites on a less frequent basis; however none of those sites yielded nests.

Statewide pair-nest success (the percentage of pairs that successfully hatch at least one nest) was high this year (79%), above the average for the period since federal listing (68%). Pair nest success in the Northern Monmouth County region (55 pairs) was especially high (93%). Of sites with a significant number of pairs, pair-nest success was also strong at Holgate (83% for 24 pairs). However, it was notably low (36%) at Little Beach (14 pairs). Looking at just NJDFW-monitored sites, pair-nest success was notably higher than last year (65% versus 47% in 2014), but about average for NJDFW-monitored sites for the period since federal listing (66%).

The statewide fledgling rate, which includes data collected and provided by all the state cooperators, was 1.29 fledglings per pair, down slightly from 2014 (1.36 fledglings/pair), but still one of the highest statewide levels since federal listing (Figure 1). Although still below the 1.50 fledglings per pair federal recovery goal, it was above the 1.245 fledglings per pair range-wide threshold for population maintenance established in the USFWS Recovery Plan for the Atlantic Coast population of piping plovers (USFWS, 1996). Furthermore, it was well above the long-term statewide average since federal listing (0.99 fledglings/pair). Productivity at NJDFW-monitored sites nearly doubled in 2015 (1.41 fledglings/pair for 17 pairs) compared to 2014 (0.74 fledglings/pair for 19 pairs), and, atypically, ran higher than the statewide average.

Productivity varied considerably by individual site and region. The Northern Monmouth County region fledged 1.22 chicks per pair (55 pairs), down from last year (1.43 fledglings/pair), but still a robust result. Likewise, Sandy Hook's productivity fell in 2015 (1.19 fledglings/pair for 53 pairs vs. 1.40 fledglings/pair for 47 pairs), but this was still a relatively strong productivity. Within Sandy Hook, the northern sites (Coast Guard to Gunnisons) fared notably better than the southern sites (Critical Zone to Fee) with comparative productivity of 1.31 fledgling per pair versus 0.94 fledglings per pair, respectively. The Holgate, Little Beach, and North Brigantine Natural Area region nearly reached the federal recovery goal with a rate of 1.49 fledglings per pair (43 pairs). Holgate fledged 1.54 chicks per pair (24 pairs), down from the extremely high result in 2014 (2.33 chicks per pair - 12 pairs), but this fledgling output was still a major driver for the high statewide productivity this year. The combined Edwin B. Forsythe NWR sites of Holgate and Little Beach produced 1.37 fledglings per pair (38 pairs). Although only five pairs nested at North Brigantine Natural Area, it recorded a particularly high rate of 2.40 fledglings per pair. Cape May County recorded very low productivity in 2015 (0.13 fledglings/pair for 8 pairs), consistent with the recent trend in that region.

DISCUSSION AND CONCLUSIONS

New Jersey's statewide piping plover breeding population stood at 108 pairs in 2015, a sharp reversal of the 92 pairs recorded in 2014 when the state reached a historic low since federal listing. However, even with this increase, the population trend remains largely flat since federal listing and has been consistently below average for the past decade or so.

The state recorded its second consecutive year of strong productivity, well above the long term average in New Jersey and above the levels believed necessary to maintain a range-wide stationary population. Last year's robust productivity likely helped spur the population growth seen in the state this year, as productivity and abundance are typically fairly closely correlated in New Jersey, thus one would expect the population to continue to grow or at least not lose ground next year, as well. While these are positive results, any chance for long-term recovery still rests with sustained higher than average productivity, which has proved difficult to achieve in New Jersey.

A few other trends that raise concerns are the distribution and number of active sites within the state. The state tallied its lowest level of active sites since federal listing. Furthermore, breeding pairs were further concentrated to just a few sites, with Sandy Hook accounting for nearly half the population, and Edwin B. Forsythe National Wildlife Refuge (Holgate and Little Beach) another 35%, so combined those sites hosted nearly 85% of the statewide population. While productivity at these federal sites, where piping plovers can be afforded more stringent protection against human recreational activities and the associated disturbance, needs to be maximized in order for our state to have its best chance at moving towards recovery, those sites alone are not likely to allow us to fully achieve this. Even those sites will have periodic down years, their habitat suitability may degrade over time, and as densities at those sites increases, productivity may drop, thus other breeding sites need to be available and perform more successfully as well.

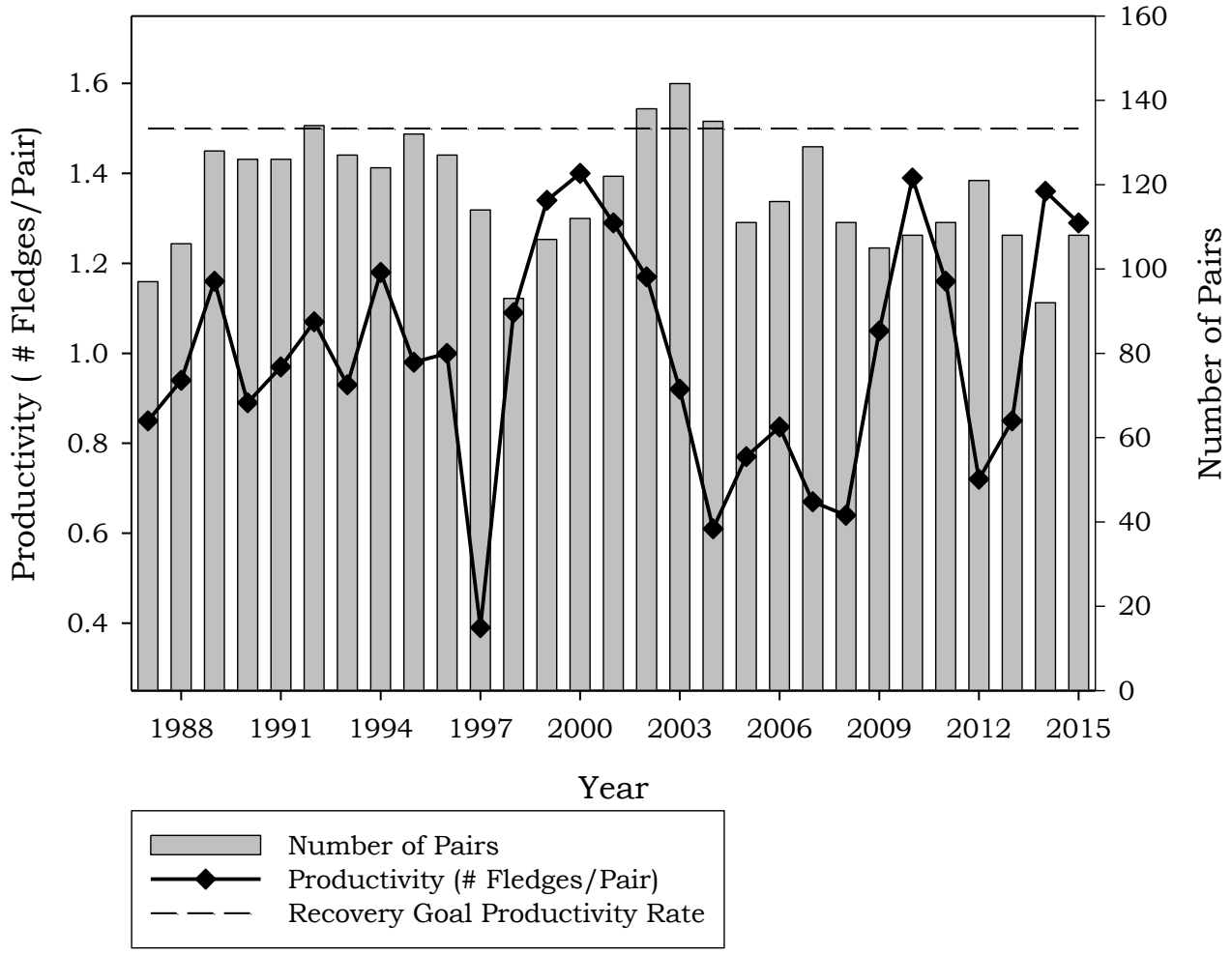
Pairs at municipal sites continue to drop, especially in Cape May County, once a stronghold in the state. This is not necessarily surprising given the higher level of recreational disturbance and predator activity that typically occurs at municipal sites, but nonetheless those sites have played an integral role in some years in our state due to the limited habitat availability overall. Of particular concern, no pairs nested at Cape May Point State Park, Corson's Inlet State Park, or Strathmere Natural Area in 2015; those state-owned and managed sites have historically provided important suitable nesting habitat where disturbance can be mitigated more than at the municipal sites. Another state site, North Brigantine Natural Area saw a small increase in pairs and a big jump in productivity in 2015, a positive trend, although that site is still performing well below capacity. The state sites, in particular, need to play a bigger role, both in terms of the number of pairs present and reproductive success, to augment the federal sites, if statewide recovery is to be achieved.

FAIRS ACTIVITY CODES: 1450, 1460.

LITERATURE CITED

U.S. Fish & Wildlife Service. 1996. Piping Plover *(Charadrius melodus)*, Atlantic Coast Population, Revised Recovery Plan. Hadley, MA. 258 pp.

Figure 1. New Jersey piping plover population: 1987-2015.



PERFORMANCE REPORT

STATE: New Jersey

PROJECT NUMBER: E-1-37

PROJECT TYPE: Research and/or Management

PROJECT TITLE: Endangered and Threatened Wildlife Conservation

STUDY NUMBER AND TITLE: IV - Vertebrate Wildlife Conservation

JOB NUMBER AND TITLE: 2-C Piping Plover Threat Assessment and Management

PERIOD COVERED: September 1, 2014 to August 31, 2015

PREPARED BY: Christina Davis and Todd Pover

JOB OBJECTIVES: To determine the nature and level of threats to piping plover populations and reproductive success and to reduce threats through management.

SUMMARY: The New Jersey Division of Fish and Wildlife (NJDFW)-Endangered and Nongame Species Program (ENSP) tracked the nest outcome and causes of nest failure, as well as brood loss (where possible), for 17 pairs of piping plovers nesting at 10 active breeding sites. This accounted for about 16% of the state's nesting population at just over half (52%) of the active nesting sites.

NJDFW staff was able to determine nest outcome for all of the known nests (28) at the sites we monitored. Just over half (54%) of the nests failed and a little under half (46%) hatched. NJDFW was able to determine the cause of failure for 80% of the failed nests. Predation was the leading cause of nest failure at NJDFW-monitored sites, accounting for just over half (53%) of the failed nests. Abandonment of the nest (eggs remained intact) was the cause of failure for 20% of the failed nests. One nest failed due to flooding (7% nest failures). Human disturbance was not a direct factor in any nest failures. The cause of nest failure could not be determined for 20% of the failed nests. Despite greater effort this year to determine causes of chick loss, those factors remained difficult to determine, thus no definitive assessment could be made. However, chick loss was lower than average with a relatively high fledge success rate.

Fencing and signage were erected at all NJDFW-monitored nesting sites to minimize human disturbance. As chicks hatched, foraging areas were posted with signage alerting beachgoers that chicks were present, in order to limit disturbance, and, where possible, totally restrict human access into preferred foraging areas (i.e., Barnegat Light, North Brigantine Natural Area, Malibu WMA, and Stone Harbor Point). Nesting areas were patrolled on a regular basis, most intensively on weekends and holidays.

All NJDFW-monitored sites where active breeding occurred were managed to reduce predation of nests. Predator exclosures were used on a selective basis on nearly half (46%) of the nests, up from 2014 (35%) when their use was drastically scaled back over concerns of adult mortality associated with their use. Nest hatch success was significantly higher for the exclosed nests, as expected (85% vs. 13% for unexclosed nests). Furthermore, nearly all the fledged chicks at NJDFW-monitored sites originated from exclosed nests (23 of the 24 fledglings or 96%). Abandonment was less of a factor in nest failure at NJDFW-monitored sites in 2015, just 3 (11%) of the total nesting attempts failed due to abandonment. Nonetheless, abandoned nests still garnered close scrutiny as this has been a problematic issue recently in New Jersey. Research looking at the effectiveness of exclosures in New Jersey (and range-wide) entered a two-year field assessment phase in 2015; results of that are still not available although it is expected to provide us with a more directed assessment of the conditions when it might be best to use exclosures.

NJDFW continued its work with the U.S. Fish and Wildlife Service (USFWS)-New Jersey Field Office (NJFO) to assist municipalities and other landowners in developing comprehensive management plans for the protection of federally and state-listed beach dependent species, in particular piping plovers. Revisions for some of the older existing plans began this year and planning for the development of a number of new plans was begun, as well. NJDFW continues to have the lead role in on-the-ground implementation of those plans as part of its routine management activities.

SIGNIFICANT DEVIATIONS: None.

RECOMMENDATIONS: Maintain current monitoring frequency to ascertain causes of nest failure and brood loss. Continue use of predator exclosures (and electric fence) where they are likely to reduce predation without leading to adult mortality. Continue to monitor the effectiveness of predator exclosures, especially as it relates to the rate of nest abandonment and possible adult mortality. Increase the use of targeted mammalian predator removal measures where needed. Continue to assess the methods and effectiveness of crow management, in order to increase breeding success at impacted sites. Continue to closely coordinate management efforts with municipalities, as well as county, state, and federal landowners. Continue working with the USFWS-NJFO to develop, revise, and implement beach management plans. Explore opportunities for habitat enhancement to increase reproductive success and ultimately breeding pairs, and implement such restoration, where funding allows.

BACKGROUND: NJDFW has actively managed nesting piping plovers in the state for 30 years using the basic techniques described in "Procedures" below. Funding provided through the B. T. Nautilus oil spill natural resource damage settlement from 1995-2000 and the M.T. Anitra oil spill settlement from 2006-2011, as well as ongoing funding provided by the U.S. Army Corps of Engineers and/or the NJDEP Office of Engineering and Construction has resulted in increased monitoring and management intensity throughout the state since 1995. An intern project initiated with Monmouth University in 2001 has provided students to assist NJDFW with stewardship and management programs in the Monmouth County region. Through a partnership with the Conserve Wildlife Foundation of New Jersey, in part through funding provided by the National

Fish and Wildlife Foundation since 2007 and other funding sources, monitoring and stewardship was increased at sites all along the coast, especially within Hereford Inlet.

PROCEDURES:

Nest/brood checks: Through regular (3-5 times/week) monitoring, NJDFW attempted to examine the relationship between adverse factors and nest outcome (i.e. nest success and fledging rates). Observers attempted to determine the cause of all nest failures (destruction and abandonment), including evidence of predator activity, weather factors and human disturbance. Brood monitoring included assessing factors that might be involved in chick loss, but rarely resulted in direct observations of chick mortality.

Field management techniques: Specific methods NJDFW applied to protect nesting piping plovers and increase breeding success vary from site to site, although certain basic measures are used at most locations. Signs and fencing, most commonly string-and-post "symbolic" fencing, restrict public access to nesting areas. Site managers erect fencing either prior to the nesting season in areas with a well-established nesting history ("pre-fencing") or as nesting activity is discovered. NJDFW staff regularly patrols all major sites on weekends and holidays to monitor human and predator activities, to help reduce human disturbance and to perform on-site education and outreach. Predator exclosures are the primary field technique used to reduce nest predation by large avian and mammalian predators. Exclosures are constructed and erected as outlined in the USFWS recovery plan (USFWS, 1996). Due to the higher rate of nest abandonment associated with predator exclosures and the elevated risk of human vandalism and predator harassment at "identified" nests, as a general practice NJDFW historically used exclosures on a selective basis, only at sites with a recent history of nest losses due to predation or where managers have observed ongoing predator activity. In the past decade or so, predator activity has been identified at nearly all active nesting sites, and as a result NJDFW started using predator exclosures more routinely at most sites (vs. a more selective approach). However, because of persistently higher rates of nest abandonment with exclosed nests and more recent concerns over the potential of adult mortality in association with exclosure use, NJDFW scaled back exclosure use in 2014 and 2015. Other management techniques used on a more limited basis include: the use of electric fence where exclosures alone are not an effective means of deterring mammalian predation; erection of fenced and/or posted "feeding corridors" to protect foraging areas at beaches with high levels of human activity and/or where human activity is not already seasonally restricted; implementation of seasonal public ORV closures (i.e., North Brigantine Natural Area, Corson's Inlet State Park); "nest raising", where sand mounds are created to raise the elevation of eggs (exclosed nests only) to mitigate minor flooding. In addition, although not funded through this or any other federal grant, NJDFW conducted targeted predator removal at some sites with acute predator problems. Intensity of predator removal was increased in 2015 in Southern New Jersey through a cooperative effort with the USFWS-NJFO and other partners.

Long-term and field-support management: NJDFW, in conjunction with USFWS-NJFO, has developed or is developing comprehensive management agreements with municipalities and other landowners as a means to minimize the detrimental effects of their activities (e.g., beach maintenance, vehicle use, etc.) on nesting success. During the nesting season, NJDFW issued regular management updates or emails - communications to municipalities and other appropriate

agencies outlining current nesting activity and applicable management restrictions. NJDFW also met directly with individuals or departments (including public works, beach patrol, administrative staff, law enforcement, etc.) within municipalities or other agencies to review management issues. More generalized public outreach has included the distribution of informational brochures, placement of interpretive signs at nesting sites, informal on-site contact with the pubic, formal group presentations, and informational booths at local civic events and festivals.

FINDINGS

NJDFW monitored nest outcomes and cause of nest failure, as well as brood loss, where possible, at 10 sites, just over half (53%) of the active piping plover nesting sites in the state. Data were collected for 17 nesting pairs, representing 16% of the state's pairs.

NJDFW was able to determine nest outcome for all (100%) of the known nesting attempts at the sites it monitored. Of the 28 known nesting attempts, 15 (54%) failed and 13 (46%) hatched. NJDFW determined the likely cause of 80% (12) of the failed nests (15). Predation was the leading cause of nest failure at NJDFW-monitored sites, accounting for 8 nests (29% of nesting attempts, 53% of failures). Of the 8 nests lost to predators, five (63%) were believed to be destroyed by avian species and 3 (37%) by mammalian species. Abandonment (3 nests) was the next highest cause of nest failure (11% of nesting attempts, 20% of failures). Flooding was the cause of failure for 1 of the NJDFW-monitored nests (4% of nesting attempts, 7% of failures). The cause of failure could not be determined for 3 failed nests.

The degree of the causes of nest failure at NJDFW-monitored sites varied over the past five years, as is typical. Predation was the leading cause of nest failure again in 2015, the third year in a row; however, it decreased proportionally compared to the past two years and especially compared to last year. Flooding has been a very minor factor in nest failure over the past three years, after being, by far, the leading cause in 2011 and 2012. Nest abandonment rates have varied over the past five years, but was at one of its lower levels in 2015, especially for exclosed nests. Human disturbance has not been the direct cause of any known nest failures over the past five years.

Causes of brood loss were difficult to determine, as is always the case. However, given the high fledgling rate this year and a high ratio of chicks fledged to those that actually hatched, brood loss was relatively low this year at NJDFW-monitored sites, as was the case last year as well.

NJDFW employed predator exclosures on about half (13 or 46%) of the 28 nests it managed in 2015, up slightly from last year (35%), but still lower than average. Just over half (15 or 54%) of the nests were not exclosed. The vast majority (13 or 87%) of the unexclosed nests failed, about two-thirds (62%) due to predation. As expected, the hatch success rate of the exclosed nests (85%) was higher than the rate for unexclosed nests (13%). Furthermore, nearly all of the fledged chicks at NJDFW-managed sites were produced from exclosed nests (23 of the 24 or 96% of the total fledgling). Abandonment was much less of a factor in nest failure at NJDFW-monitored sites in 2015, just 3 (11%) of the total nesting attempts failed due to abandonment, and just 2 (7%) of those were associated with exclosures.

DISCUSSION AND CONCLUSIONS:

Productivity for New Jersey's breeding piping plovers was well above average for the second year in a row; near record productivity in 2014 led to a statewide population increase this year and another increase is likely next year, if long-term trends hold (Davis, Pover, 2015). However, even with this increase in breeding pairs, the statewide population remains below long-term averages and no sustained recovery has occurred in the state since federal listing. NJDFW has long maintained, including in a similar report last year (Davis, Pover, 2014), that a more intensive directed predator removal program, which has proved effective in other states and regions, is necessary to achieve sustained population growth for piping plovers in New Jersey. In addition, it would benefit other state-listed species, such as least tern and black skimmer.

NJDFW, in partnership with USFWS-NJFO, mounted a more elevated predator control initiative in the late winter and spring of 2015 to address these concerns. Although directly correlating this effort to breeding success is always difficult in light of other confounding factors, NJDFW believes it played a significant role in the higher than average pair hatch success rate and fledgling rate recorded this year.

NJDFW will continue to address all factors adversely impacting piping plover reproductive success within the state, through a comprehensive management strategy, however, strong emphasis will be placed on mitigating the impacts of predators. Predator exclosures will be an important component, but NJDFW will continue to be highly selective about their use, as they are not uniformly effective at all sites and concerns still exist about potential adult mortality. NJDFW will continue to actively partner and cooperate with other agencies and universities researching the relative merits and drawbacks of predator exclosures, with the hopes that detailed assessments of their use will aid management decisions in the near future.

Even with improved decision making tools to better inform the safest and most effective deployment of predator exclosures, if left unchecked, high abundance of predators (the underlying cause of low reproductive success) will remain a significant threat. As a result, NJDFW strongly supports continued, targeted predator control at all active nesting sites and at some highly suitable unoccupied sites, both immediately prior to the breeding season and as needed during the breeding period. This management is necessary to improve reproductive success and increase the breeding population. It is highly unlikely piping plover recovery will be achieved in New Jersey without an intensive long-term commitment to reducing localized predators.

FAIRS ACTIVITY CODES: 1450, 1460.

LITERATURE CITED

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U.S. Fish & Wildlife Service, 1996. Piping Plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, MA. 258 pp.

PERFORMANCE REPORT

STATE: New Jersey PROJECT NO.: E-1-37

PROJECT TITLE: Endangered & Threatened Wildlife Conservation

STUDY TITLE: IV. Vertebrate Wildlife Conservation

JOB NUMBER AND TITLE: 10A. Red Knot Conservation on Delaware Bay

PERIOD COVERED: September 1, 2014 to August 31, 2015

PREPARED BY: Amanda Dey, Principal Zoologist

OBJECTIVE 1: Protect critical habitats and resources on the Delaware Bay stopover for migratory shorebirds: continue regional collaboration with state and federal agencies to recover horseshoe crab and shorebird populations, reduce anthropogenic disturbance to shorebirds enhance/create coastal habitat and impoundments for crab spawning/shorebird foraging and roosting.

OBJECTIVE 2: Assess recovery of red knot and other shorebird species: monitor mass gain and adult survival through resightings of marked individuals; monitor stopover population size through baywide aerial survey and mark-and-resighting methods. ***(Covered in grant NJ T-1-7 report 2014-2015.)***

OBJECTIVE 3: Assess recovery of the horseshoe crab egg resource: monitor horseshoe crab egg densities on Delaware Bay beaches. (***Not funded here in 2015.)***

SUMMARY: In 2015, NJ continued seasonal restricted access (i.e., beach closures) on Delaware Bay (13 sites) and the Atlantic coast (1 site) to protect shorebird foraging and roosting areas from disturbance during the May migration stopover. Beach closures, staffed by Shorebird Steward Volunteers and backed by NJDFW Conservation Officers, have played a critical role in aiding a larger proportion of red knots to gain adequate weight (≥180 grams) prior to Arctic breeding. While horseshoe crabs and crab egg resources remained low, the protection of a large number of widely distributed foraging beaches allows birds to spread out, reducing interspecific and gull competition, risk from aerial predators, and allows more birds to take advantage of limited resources over a larger area. Together with slightly improved egg resources and recent spawning beach restoration, the proportion of red knots achieving adequate weight has been >50% in three of the last four years and reached 77% in 2015. Improvement in the number of birds reaching 180g is hopeful but should be tempered by the fact that the red knot stopover population is 27% of its former size (>94,000 in 1989; 25,596 in 2015), the horseshoe crab population has shown no significant trend (up or down) despite 14 years of harvest management.

SIGNIFICANT DEVIATIONS: Section 6 funding was insufficient to include the 2015 horseshoe crab egg survey.

RECOMMENDATIONS: The volunteer Shorebird Steward program, with conservation officer support, is one of our most effective conservation actions which, we believe, has helped stabilize the red knot stopover population. Continued funding would help expand protection efforts and community engagement.

The horseshoe crab egg survey is critical to assessing foraging conditions on Delaware Bay. The addition of egg cluster survey has provided the potential to link deep egg clusters (an index of spawning activity) to surface eggs (index of foraging conditions). In absence of egg density data, it is impossible to assess conditions that affect red knots weight gains on the bay.

The Atlantic Coast Benthic Trawl Survey should be fully funded so that it will continue to provide accurate population estimates, which underpin setting of horseshoe crab harvest quotas, including female crabs.

COSTS: $20,000 (15,000 Federal, $5,000 state/in-kind)

BACKGROUND: NJ Endangered and Nongame Species Program has carried out intensive shorebirds studies on Delaware Bay since 1997, when unregulated harvests of horseshoe crabs peaked and the Delaware Bay states (NJ and DE) began to quantify the impact of crab harvests on shorebird migrants.

The work centers on capture and individually marking shorebirds (survival and population estimation using mark-and-resightings methods), measuring weight gain through the stopover period (assess number of birds reaching adequate departure weight), aerial survey (trend in shorebird abundance and distribution), and egg density survey (assess foraging conditions for red knots and other shorebird migrants). This work, and the work of others in Canada and South America, led to the red knot status assessment in 2007, and helped underpin the red knot listing proposal.

Now with 19 years of data, the metrics above are useful to assess recovery of red knots and horseshoe crab egg resources in Delaware Bay.

Over the 12 years of the Shorebird Steward volunteer program, the incidence of disturbance has been greatly reduced, shorebirds optimize foraging free from human disturbance, and the program enjoys overwhelming community support.

PROCEDURES

Seasonal Beach Closures:

- Seasonal closures have been in place since 2003. All or part of 13 bayshore beaches and one Atlantic coast site were closed from May 7 to June 7 annually. A map of these locations was provided on the NJDFW website: http://www.njfishandwildlife.com/ensp/beachclozmap.htm
- Public viewing areas were present at each site; three viewing areas were established in the southern, middle and northern Delaware Bay (at Norbury's Landing, Reeds Beach, and Fortescue) for up-close public viewing of shorebirds and horseshoe crabs.

- Shorebird Steward volunteers staffed all closed beaches; they educated the public on the importance of beach habitat for crabs and shorebirds and prevention of disturbance to foraging shorebirds.
- Conservation officers assisted with closure efforts. Weekend shifts of two officers, on two shifts per day, covered Cape May and Cumberland counties when visitation and recreational use is greatest. Officers educated the public and assisted Stewards in dealing with disturbance problems. *Annual cost for officer support was $10,000 from non-federal funds provided by the NJ Natural Lands Trust.*

FINDINGS

- Seventeen Shorebird Stewards worked a combined 534 hours at seven Delaware Bayshore sites during May. They spoke with beach-goers and provided brochures to those interested, and helped to maintain beaches free from disturbance.
- We suggest that temporary beach closures staffed by volunteers during the peak of shorebird migration have helped create the result of a greater proportion of red knots reaching adequate take-off weight.
- The proportion of red knots achieving adequate weight reached 77% in 2015 and has been >50% in three of the last four years. We estimate that 80% of the red knot stopover population must consistently reach 180 grams to support recovery.

DISCUSSION AND CONCLUSIONS

- Delaware Bay is a critical stopover for Arctic-nesting shorebirds because it is the last stopover before Arctic breeding. Fat reserves from Delaware Bay help birds survive and successfully reproduce in years when Arctic conditions are favorable.
- Continued seasonal beach closures, and other collaborative methods, to help protect shorebirds from disturbance is a critical conservation job that should take place equally on both sides of Delaware Bay, and on Atlantic Coast stopovers and wintering areas Massachusetts to Florida. Beach protection would benefit both migrant and post-breeding/wintering beach-nesting shorebirds.
- While it appears declines of red knots and horseshoe crabs may have been stemmed, their populations are now at a much lower level than historic numbers. This leaves red knots and other declining shorebirds vulnerable to any perturbation in Delaware Bay or elsewhere in the flyway.

FAIRS ACTIVITY CODES:

PERFORMANCE REPORT

STATE: New Jersey **PROJECT NO:** E-1-37

PROJECT TITLE: Endangered and Threatened Wildlife Conservation

STUDY TITLE: Vertebrate Wildlife Conservation **STUDY NUMBER:** V

JOB TITLE: Bog Turtle Habitat Assessment & Survey and Habitat Restoration

PERIOD COVERED: September 1, 2014 - August 30, 2015 **JOB NUMBER:** 14A

PREPARED BY: Brian Zarate, Senior Zoologist

OBJECTIVE: To monitor and conserve populations of the federally threatened and state endangered bog turtle *(Glyptemys muhlenbergii)* on public and private lands.

SUMMARY: Funds for this project period were used to develop small contracts to complete population monitoring surveys at priority sites April – June 2015. Population monitoring protocols have been developed by state, federal, and private partners over a multi-year period, with piloting of the protocols beginning in 2014 and extending into this project year. Five vendors conducted the surveys in eight bog turtle wetlands. State scientific collecting permit conditions allow permittees to submit data on permitted work by January 31 of the next year, so at this time we cannot report all the findings because of the delayed reporting deadline under state permits.

No habitat restoration was completed using Section 6 funding during this period.

Other bog turtle work not identified here was conducted under federal aid grant NJ T-1-7.

SIGNIFICANT DEVIATIONS: None.

RECOMMENDATIONS: Developing small contracts with qualified bog turtle surveyors to perform the protocol-specific population monitoring surveys has been a good use of this funding and can be expanded to potentially also include the habitat monitoring component as well.

COST: $11,111 ($10,000 federal, and $1,111 state)

BACKGROUND

Develop and use a standardized bog turtle survey protocol is identified in the USFWS Northern Population Recovery Plan (2001) as a Recovery Task and while a Phase II protocol has been developed and implemented to determine presence or absence of bog turtles in a wetland, the new population monitoring protocols are intended to be used to monitor trends over time. As data is collected by the northern states it will be input into a newly developed regional database

maintained by USFWS – Region 5. Meta-analyses by federal partners and privileged-users with the pooled dataset will assist in improving the population monitoring protocols over time.

Due to limited staff resources at the state, and federal, levels, implementing the population monitoring protocols in-house are difficult due to the number of surveyors needed per monitoring event.

PROCEDURES

Protocols for conducting bog turtle population monitoring surveys were followed based on the peer-developed document Regional Population Monitoring Protocol for the Bog Turtle (March 2015). This monitoring program is designed to evaluate the impact of habitat management activities and guide future conservation and management decisions, to assist with the recovery of the bog turtle across the northeastern range.

Monitoring Goals:
1. Establish a regional, standardized and robust sampling framework to assess population status and long term population trends of the bog turtle in the northeastern US.
2. Use the monitoring information to evaluate the population status and progress towards the recovery goals.

Sampling Objectives:
1. Quantify and track trends in regional estimates for detection, occupancy and abundance of bog turtle populations across the northeast every 5-10 years.
2. Quantify and track trends in site-specific population size and structure at a subset of sites in each of the three major Recovery Units, Hudson/Housatonic, Delaware, Outer Coastal Plain, and Susquehanna/Potomac Recovery Units, every 5-10 years.
3. Evaluate the effects of population management actions.

FINDINGS

Six of the eight surveys completed under contract were in Sussex County and the remaining two were in Hunterdon County. Communication with contractors indicates all eight surveys were completed on-time and within constraints of the protocols. State scientific collecting permit conditions allow permittees to submit data on permitted work by January 31 of the following year, so at this time we cannot report on the findings because they have yet to be submitted to our program.

Data collected as a result of the contract surveys will be input into the regional database and available for review at that time and/or upon receipt of original datasheets or reports.

DISCUSSION AND CONCLUSIONS

In order to fulfill our obligations within the region to implement both population and habitat monitoring protocols we plan on continuing to use these funds to increase our number of sites monitored beyond SWG and/or Comp SWG funding.

Language will be added to future scopes of work for contracts that reports must be filed with ENSP by August 31 of the survey year in order to be available for this report.

The ENSP will file an addendum report by 28 February 2016 that includes the 2015 survey data.

FAIRS ACTIVITY CODE:

LITERATURE CITED

U.S. Fish and Wildlife Service (USFWS). 2001. Bog Turtle (*Clemmys muhlenbergii*), Northern population recovery plan. USFWS, Hadley, Massachusetts.

APPENDIX

Regional Population Monitoring Protocol for the Bog Turtle (March 2015).

Regional Population Monitoring Protocol for the Bog Turtle

(02 March 2015)

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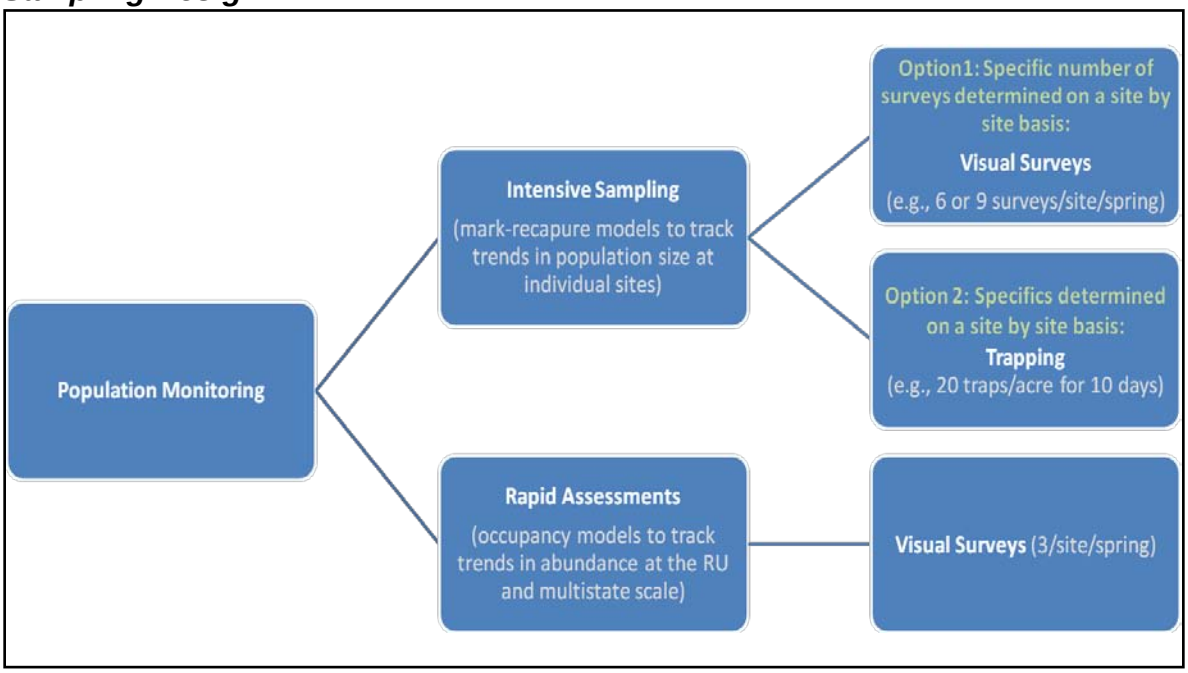
Basic Protocol

Survey Season

RU	*Visual/Tactile Surveys*	*Trapping Surveys*	*Nesting Surveys*	*Radio Telemetry*
SQ/PO, OCP, DE, HU/HO	15 April–15 June	1 May – 15 June 1 Sept – 15 Oct	1 June – 15 June	Year round
PP/LP	25 April–25 June	15 May–15 Sept	5 June–20 June	Year round

Sampling Design



Monitoring Site Selection

- Survey locations will be centered about Core Habitat.
    - Areas with appropriate vegetation, hydrology and soils for bog turtles.
- Monitoring sites will be separated by ≥3 km (one per PAS or metapopulation).
- Sites selected should be diverse, spanning the types of habitat and landscape conditions that exist.
- ≥20 Rapid Assessment (RA) sites will be selected in each of the three major RUs (PO/SQ, HH/HU, and DE) and at least one in the PP/LP and OCP RUs.
- ≥2 Intensively Sampled (IS) sites will be selected in each of the RUs (a subset of the RA sites).
- Sites will be stratified by the level of habitat management.
    - 1/3 sites with no management
    - 1/3 sites with light management (1/2 or less of the site impacted)
    - 1/3 sites with heavy management (most of the site impacted)
- Sites selected should recent turtle observations, within the past 30 yrs.
- Sampling areas will range in size from ¼ –7.5 acres.

Rapid Assessments

Survey Timing and Schedule

- Each site will be surveyed every 5–10 years.
- Annual sampling should be stratified by RU so that sites are surveyed throughout the range each week of the survey window to avoid clustering in time and space.

- 3 visual/tactile surveys will be completed within a single season.
- Sites should not be resampled within 7 days time, when possible.
- Survey time of day will be between 8 AM and 8 PM.
- Survey weather conditions should be: temperature between 65^{o}–85^{o} F and not during heavy rains if surveyor visibility is hindered.

Basic Protocol and Pre-season Planning

- State agency project leads will determine surveyors qualified to lead monitoring surveys.
- Where possible alternate surveyors for the three surveys at an individual site to minimize a surveyor effect at a given site.
- One or more lead surveyors will be present to supervise during all surveys.

Field Methods

- Perform visual/tactile surveys, spending approximately 2 person hrs/acre actively searching for turtles.
- Calculate search time based on survey area and number of surveyors (refer to the effort hour chart in the Monitoring Instructions document).
- Search the entire survey area during the allotted time; however the lead surveyor should use best professional judgment to spend more time in areas with the best habitat (e.g. open canopy, mucky soils).
- Briskly walk throughout the survey area looking for turtles that are on the surface. After the entire area has been walked through surveyors can use tactile/probing methods to search the best habitat until the predetermined survey time is up. Surveyors should search under dead vegetation, in puddles, mud and tunnels particularly near tussock sedge and around the roots of shrubs.
- Keep track of each surveyors search time spent actively looking for turtles (because sometimes people stop once an animal is found). Record the survey start end times. Each time you stop the survey for any reason (e.g. process turtles, talk to someone), record the stop time and then record the time when you resume the survey again. You will need to calculate the number of minutes NOT spent actively searching to estimate effort hours.

Intensive Sampling

- Intensive Sampling will occur at a minimum of 2 sites in each RU.
- Intensive Sampling will be performed at a subset of the RA sites, so that the IS survey data can help to inform the RA results.
- Intensive sampling may include visual/tactile surveys or trapping and may be supplemented with nest surveys or radio-telemetry.

Visual/tactile surveys

- Same survey window and methodology as RA surveys but with additional replication.

- Number of surveys required will be assessed on a site by site basis, but will typically be 6-9 surveys within 2-years time in each 5- year round of sampling.

Trapping

- Survey Window: *1 May – 15 June* and *1 Sept – 15 Oct*
  - Except the PP/LP area which is *15 May–15 Sept*
- Trap density and the number of trap nights required will be determined on a site by site basis, based on capture rates from previous studies at the site.
- Distritbute traps throughout the sampling area (the same area where you performed visual/tactile surveys).
- Use Fahey or eel pot-type trap designs with wings. Traps should be ≥4" in height.
- Use 3 drift fences set up perpendicular to the water flow.
- Follow the USFWS Phase 3 survey protocol for detailed instructions on trap labeling and placement.

Nest Surveys

- Survey Window: *1 June – 15 June*
- Search along transects spaced 8 m apart in a grid patter across the open canopy Core Habitat.
- Detailed methodology yet to be developed.

Telemetry

- Obtain locations on radio-tagged turtles at least 2 times each week throughout the active season and once every 4-6 weeks through the inactive season.
- Consider more intensive effort during the nesting season.
  - Re-locate female turtles every day or two
  - Use thread spool to track fine scale movements
- Consider evaluating home ranges before and after habitat management.
- Consider using Mark-resight models to estimate population size.

Turtle Processing Guidelines

- Prior to surveys all lead surveyors should coordinate with their state project lead to acquire appropriate permits and to determine if turtles will be marked and if so how (notching scheme, numbers to use and exact methods).
- Complete a *Bog Turtle Capture Form (or an equivalent capture form)* for each turtle found.
- Turtles found on or near the survey site before/after the actual survey period should be processed, but please note this on the *Capture Form*. Also, collect GPS location information for deceased turtles (shells, DOR).
- GPS coordinates (lat, long) for turtle locations should be labeled with the monitoring site number, turtle number and gender initial, and the date (e.g. **25-861M-06012014**). Record all coordinates as **WGS84 decimal degrees**.

Exclude M/F or the second dash (never the first) if your GPS unit has a 15 character limit.

- Process all turtles including taking measurements and photographs (carapace, plastron, and neck patch if possible); unless you're sure the turtle was captured during a previous survey in the same year.
- When a turtle has an irregular number of marginal scutes (e.g., 11 or 13) on one or both sides of the carapace, make sure that you note the appropriate turtle ID. Prior to the field season check with your state project lead to determine the appropriate way to determine the turtle ID in these cases.
- Coordinate with your the state project lead to determine if data should be collected on other species observed (e.g., wood turtles or other state-listed species).
- Coordinate with the state project lead prior to surveys to determine what to do if you find sick or injured turtles. The USFWS Health Bulletin guidelines should be followed for injured or sick bog turtles.
- If transmitters are used, transmitters and affixing material (e.g. epoxy) combined should not exceed 7% of the body weight of the turtle.

Survey Steps for Rapid Assessment (Visual/Tactile) Surveys

Presurvey

1) Contact landowners for permission to survey the site.
2) State project leads create a list of qualified surveyors and determine which sites each surveyor will sample.
3) Provide a training session to lead surveyors.
4) Create and print a site map with ortho imagery background and delineated Core Habitat area (and the Survey area boundary if different from the Core Habitat).
5) Disinfect waders/footwear, turtle processing equipment

Survey

6) The lead surveyor(s) should define/show the survey area boundaries to all surveyors.
7) Record site info, date and start time, surveyor's names, and weather conditions at the beginning of the survey.
8) Briskly walk the survey area looking for turtles on the surface.
9) Perform a more thorough search of the best habitat within the Core Habitat, probing in the mud, searching in puddles, along the edge of tussock sedge, and under dead vegetation.
10) Record stop time, surveyor's names, weather conditions at the end of the survey period.
11) Process Turtles (may occur during the survey, but keep track of the time surveyors are not actively searching to deduct this time before calculating the effort hours).
12) The transcriber should put their initials at the top of the data sheet(s).
13) Have a second person review the data sheet(s) for completeness and initial the top of the form.

Population Monitoring Instructions

A. Site Identifiers, Date and Start Time, and Surveyors

1. ***Monitoring Site ID*** is the two digit RU initials–two digit state initials–two digit monitoring site ID/code (e.g. for a site in the Delaware RU in Pennsylvania, first site may be DE-PA-01).
   Site Name is the nickname for the Core Habitat.
   Town is the town where the Core Habitat is located (can be multiple towns).

2. ***Core Habitat Area (ac)*** is the number of acres the Core Habitat area includes.
   Survey Area is the number of acres of the survey area if smaller than the Core Habitat.

3. ***Survey Date*** is the date the survey took place.
   Required Survey Time is the amount of time the survey should take given the number of surveyors and the size of the survey area (2 person hrs/acre). See Table 1 on the last page of this document.

4. ***Site visit Number*** is to identify whether the survey is the first, second, or third survey of the season at a given site.

5. ***Lead Surveyor(s)*** is the surveyor or surveyors that are leading the survey and have been identified by the State Project Lead as a "lead surveyor" for this project.
   Assistant Surveyor(s) are all other surveyors regardless of level of experience.

B. Environmental Factors and Number of Surveyors

6. ***Start Conditions:***
   Start Time is the time you start actively searching for turtles.
   Rain is the amount of precipitation at the start of the survey period. Categories include n=no rain; l=light rain; i=intermittent rain; and h=heavy rain.
   Air Temp is the air temperature in the shade at the beginning of the survey period. Temperature can be recorded in C or °F.
   Wind Speed is the wind speed at the beginning of the survey time period. Use the percentage categories in the Beaufort Wind Scale (on the data sheet) for a description of the wind condition categories.
   Cloud Cover is the amount of cloud cover at the beginning of the survey period. Use the following cloud cover categories: c=clear; p=partly cloudy; or o=overcast.
   Num of Surveyors is the number of both lead and assistant surveys actively searching for turtles at the beginning of the survey.

7. ***End Conditions***

   End Time is the time you stop actively searching for turtles.

   Rain is the amount of precipitation at the end of the survey period. Categories include n=no rain; l=light rain; i=intermittent rain; and h=heavy rain.

   Air Temp is the air temperature in the shade at the end of the survey period. Temperature can be recorded in C or °F.

   Wind is the wind speed at the end of the survey time period. Use the percentage categories in the Beaufort Wind Scale (on the data sheet) for a description of the wind condition categories.

   Cloud Cover is the amount of cloud cover at the end of the survey period. Use the following cloud cover categories: c=clear; p=partly cloudy; or o=overcast.

   Num of Surveyors is the number of both lead and assistant surveys actively searching for turtles at the end of the survey.

8. ***Stopped Searching (min)*** the number of minutes your survey team was not actively searching for turtles, between the survey start and end time recorded. For example if you all stopped to look at and photograph the first turtle captured.

9. ***Effort Hrs*** is the person hours (number of surveyors/search time) spent actively searching divided by the number of acres searched (survey area).

10. ***Other Turtle Species Observed*** is where you record the name of any turtle species found other than the bog turtle, such as spotted or wood turtles.

11. ***Herpetofauna Species Observed*** is where you record a list of the names of other herpetofauna found during the survey.

12. ***# Live Bog Turtles Captured*** is the number of individual bog turtles you captured during the survey period.

13. ***Signs of Bog Turtles (y/n)*** is where you note yes if you observed any tracks, shells or other signs that bog turtles may be present at the site.

14. ***Comments*** on any other important information, such as new beaver impoundment within your survey area, other alterations to the habitat, etc.

Equipment List

- GPS unit
- Camera
- Calipers
- Scale
- Clip board
- Pens/pencils
- Site map that identifies the survey area/Core Habitat
- Data sheets (turtle survey form, turtle capture forms)
- Instructions document
- Watch/Clock
- Turtle notching numbers (if marking turtles)
- Turtle notching schematic (if marking turtles)
- Waders
- Disinfectant, brush, rinse water, and containers/sprayer

Primary Sources

- How to develop survey protocols: a handbook (USFWS 2013).
- Demography and population genetics of the bog turtle (*Glyptemys muhlenbergii*): implications for regional conservation planning in New York State (Shoemaker 2011)
- Guidelines for bog turtle surveys (Phase 2 and 3 Turtle Surveys; USFWS 2006)
- A role of trapping in detection of a small bog turtle (*Glyptemys muhlenbergii*) population. (Somers and Mansfield-Jones 2008)
- Monitoring of bog turtle colonies at sites in immediate proximity to development in Southeastern Pennsylvania (PFBC 2008)
- Massachusetts eastern box turtle monitoring protocol (Erb and Willey 2010)
- Coordinated monitoring strategy for wood turtles (*Glyptemys insculpta*) in the Northeastern United States (Jones et al. 2013)
- Coordinated regional monitoring strategy for Blanding's turtle in the Northeastern United States (Jones et al. 2012)
- Revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*) (USFWS 2011)

Table 1. Survey time chart to calculate 2 person hours/acre of effort given the number of surveyors and the size of the area to be surveyed.

Survey Time by Site Size and Number of Surveyors

Size of Site in Acres	Number of Surveyors																			
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***
0.25	30	15	10	8	6	5	4	4	3	3	3	3	2	2	2	2	2	2	2	2
0.5	60	30	20	15	12	10	9	8	7	6	5	5	5	4	4	4	4	3	3	3
0.75	90	45	30	23	18	15	13	11	10	9	8	8	7	6	6	6	5	5	5	5
1	120	60	40	30	24	20	17	15	13	12	11	10	9	9	8	8	7	7	6	6
1.25	150	75	50	38	30	25	21	19	17	15	14	13	12	11	10	9	9	8	8	8
1.5	180	90	60	45	36	30	26	23	20	18	16	15	14	13	12	11	11	10	9	9
1.75	210	105	70	53	42	35	30	26	23	21	19	18	16	15	14	13	12	12	11	11
2	240	120	80	60	48	40	34	30	27	24	22	20	18	17	16	15	14	13	13	12
2.25	270	135	90	68	54	45	39	34	30	27	25	23	21	19	18	17	16	15	14	14
2.5	300	150	100	75	60	50	43	38	33	30	27	25	23	21	20	19	18	17	16	15
2.75	330	165	110	83	66	55	47	41	37	33	30	28	25	24	22	21	19	18	17	17
3	360	180	120	90	72	60	51	45	40	36	33	30	28	26	24	23	21	20	19	18
3.25	390	195	130	98	78	65	56	49	43	39	35	33	30	28	26	24	23	22	21	20
3.5	420	210	140	105	84	70	60	53	47	42	38	35	32	30	28	26	25	23	22	21
3.75	450	225	150	113	90	75	64	56	50	45	41	38	35	32	30	28	26	25	24	23
4	480	240	160	120	96	80	69	60	53	48	44	40	37	34	32	30	28	27	25	24
4.25	510	255	170	128	102	85	73	64	57	51	46	43	39	36	34	32	30	28	27	26
4.5	540	270	180	135	108	90	77	68	60	54	49	45	42	39	36	34	32	30	28	27
4.75	570	285	190	143	114	95	81	71	63	57	52	48	44	41	38	36	34	32	30	29
5	600	300	200	150	120	100	86	75	67	60	55	50	46	43	40	38	35	33	32	30
5.25	630	315	210	158	126	105	90	79	70	63	57	53	48	45	42	39	37	35	33	32
5.5	660	330	220	165	132	110	94	83	73	66	60	55	51	47	44	41	39	37	35	33
5.75	690	345	230	173	138	115	99	86	77	69	63	58	53	49	46	43	41	38	36	35
6	720	360	240	180	144	120	103	90	80	72	65	60	55	51	48	45	42	40	38	36
6.25	750	375	250	188	150	125	107	94	83	75	68	63	58	54	50	47	44	42	39	38
6.5	780	390	260	195	156	130	111	98	87	78	71	65	60	56	52	49	46	43	41	39
6.75	810	405	270	203	162	135	116	101	90	81	74	68	62	58	54	51	48	45	43	41
7	840	420	280	210	168	140	120	105	93	84	76	70	65	60	56	53	49	47	44	42
7.25	870	435	290	218	174	145	124	109	97	87	79	73	67	62	58	54	51	48	46	44
7.5	900	450	300	225	180	150	129	113	100	90	82	75	69	64	60	56	53	50	47	45

Grayed cells represent surveys outside the recommended effort hours/acre