Lake Superior Common Tern Conservation Final Report

Project Number: 15-306-06D/ 00054248
Contract Number: 105908/ PO 3000089723
NOAA Award Number: NA15NOS4190126

Task Outcomes 1–3:
Attract and Secure Terns, Monitor Terns, Identify Foraging Locations

Annie Bracey[1,2], Gerald Niemi[1], and Francesca Cuthbert[2]

[1]Natural Resources Research Institute, University of Minnesota-Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811
[2]University of Minnesota, Department of Fisheries, Wildlife and Conservation Sciences, 324 Hodson Hall, 1980 Folwell Ave, St. Paul, MN 55108

Final Report Submitted to the Minnesota Department of Natural Resources–Minnesota's Lake Superior Coastal Program on 12/22/2016

This report is NRRI Technical Report number NRRI/TR-2016/39

This report was funded in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration under Award NA15NOS4190126 provided to the Minnesota Department of Natural Resources for Minnesota's Lake Superior Coastal Program.

Introduction

History in the St. Louis River Estuary

The following is an excerpt from a recent report to the Minnesota Pollution Control Agency where we summarized the history of the Common Tern (*Sterna hirundo*) breeding in the St. Louis River Estuary.

> “The number of Common Terns nesting in Minnesota was estimated at 2,000 pairs in the 1930s. At that time in many regions of North America, the species was still recovering from being hunted for the millinery trade in the late 1800s. By the 1970s the number of nesting pairs was again in decline and by 1984 only 880 pairs remained in the state (Pfannmuller 2014). In Minnesota, Common Terns currently nest on four major sites including Mille Lacs Lake, Leech Lake, Lake of the Woods, and the St. Louis River Estuary (Pfannmuller 2014). Common Terns were first documented in the St. Louis River Estuary when a breeding pair was discovered at the Sky Harbor Airport in 1937 (Engstrom 1940, Davis and Niemi 1980, McKearnan 1986). For about 50 years the tern population in this area continued to increase but then experienced a rapid decline in the 1980s (Penning 1993). During an intensive study period by Niemi et al. (1979), Common Terns were found nesting at four sites in the Duluth-Superior Harbor (number of breeding adults 1977-1979): Sky Harbor Airport (14-18), Port Terminal (296-370), Hibbard Power Plant (6-10), and Grassy Point Islands (22-40) (Davis and Niemi 1980). In 1985, 50 pairs of Common Terns attempted to nest on Interstate Island, an 8-acre dredge spoil island situated in the Duluth-Superior Harbor. However, nesting was unsuccessful and terns did not return to the island again until 1989, when the island was cleared of trees to provide suitable nesting habitat for Piping Plovers and Common Terns. Since 1989, Common Terns have successfully colonized the island and continue to nest there; now the only active nesting location in the estuary” (Bracey et al. 2016).

Since its creation, Interstate Island has lost approximately two acres of useable tern nesting habitat, primarily due to wind and water erosion. In 2015, the Minnesota Department of Natural Resources (DNR) added 3,000 cubic yards of clean sand and pebbles to the island to mitigate the effects of erosion and fluctuating water levels, which has caused seasonal flooding of nesting sites. This restoration effort should make the island more suitable for nesting Common Terns, although more restoration work is needed. Interstate Island is a Wildlife Management Area jointly managed by the Minnesota and Wisconsin Departments of Natural Resources (DNR), with the primary objective of providing suitable nesting habitat for colonial waterbirds. Since 1990, this has been the only nesting location of Common Terns in the St. Louis River Estuary with roughly 200 breeding pairs. Interstate Island is also the primary breeding location of Ring-billed Gulls (*Larus delawarensis*) in the area, with an estimated 13,000 breeding pairs. The rapidly increasing population of Ring-billed Gulls has drastically reduced available breeding habitat for Common Terns. This species competes for breeding space with terns, depredates eggs, and preys on tern chicks. In some years the colony has had total nest failure, primarily due to intense predation by gulls.

Current Status in the Great Lakes Region

The Common Tern is listed as threatened or endangered in six U.S. states bordering the Great Lakes, including Minnesota and Wisconsin (Cuthbert et al. 2003). The U.S. Fish and Wildlife Service (USFWS) has designated the Common Tern as a 'Bird of Management Concern' in the Midwest and a 'Bird of Conservation Concern' in the Great Lakes region (Wires et al. 2010). The USFWS Migratory Bird Joint Venture Program listed the Common Tern as a focal species for habitat protection, restoration, and region-wide monitoring in the Upper Mississippi River and Great Lakes Region (Soulliere et al. 2007).

Most large Common Tern colonies in the Great Lakes region require continuous management to sustain colony numbers (Cuthbert et al. 2003, Wires et al. 2010, Morris et al. 2010). Loss and modification of habitat and predation have been identified as the most significant issues facing Common Terns in the Great Lakes (Cuthbert et al. 2003). Suitable habitat is influenced by the number of adequate nesting and roosting locations as well as availability of prey (Cuthbert et al. 2003). Management techniques in the Great Lakes region have included habitat restoration and protection, predator control, and construction of artificial nesting structures (Jones and Kress 2012). Despite these efforts, the number of consistently active breeding colonies has continued to decline. Since the 1970s the number of Lake Superior breeding colonies has decreased from five to two (Cuthbert et al. 2003). Population declines and reduced productivity have been observed at managed, typically artificial nesting sites, which have historically been considered stable (Cuthbert et al. 2003). Because of the additive effects of both natural and man-made stressors, such as fluctuations in prey availability, increasing numbers of predators, and habitat loss; active management is essential, especially in regions where these birds are declining (Rounds et al. 2004).

Since Common Terns colonized Interstate Island in 1989, the Minnesota and Wisconsin DNR have been conducting annual systematic nest counts and banding of hatch-year (HY) birds. Banding of adult birds began in 1998. When possible, they have also documented reasons for nest failure (e.g., predation, weather events). Nesting success for Common Terns in Minnesota has ranged from 0-1.36 fledglings/pair, with most colonies falling below 1.0. Since 1989, the annual reproductive success rate at Interstate Island has averaged 0.84 (1989-2016; F. Strand, pers. comm.). Data from studies on the East Coast of North America suggest that an average of 1.1 young fledged per nesting pair is necessary to sustain a population (Nisbet 1973, DiConstanzo 1980, Cuthbert et al. 2003). Although below the target of 1.1 fledglings/pair, it is higher than the other Minnesota colonies that document fledgling rates (Cuthbert et al. 2003, Pfannmuller 2014).

Worldwide reduced habitat availability and quality are a problem for colonial nesting waterbirds. Habitat loss is the primary factor related to reduced productivity, and with a lack of quality habitat available, terns are forced to nest in marginal habitat, which often leads to reduced nesting success and quality of chicks (Cuthbert et al. 2003). Human development and plant succession in coastal environments have also reduced the number of adequate nesting sites for Common Terns (Parnell et al., 1988).

Recent habitat restoration at Interstate Island provides an opportunity to attract birds to the newly restored area, using artificial social cues. Social attractants such as decoys and audio vocalizations of breeding conspecifics are commonly used to attract birds to new or recently restored breeding sites (Arnold et al. 2011). Common Terns have been shown to readily colonize new and existing sites in response to social attractants. In a review of the world's active seabird restoration projects, Jones and Kress (2012) found high success rates for terns (67%). At Muskeget Island, Massachusetts, Arnold et al. (2011) studied the effectiveness of decoys and playbacks as methods for restoring a Common Tern colony and found sound was the primary driver of nest site selection.

Predation can result in total nest failure and has been known to lead to colony abandonment (Jones and Kress 2012). Predator control is essential to maintaining active colonies and is only effective when control programs occur on an annual basis. Monofilament lines, when placed in parallel rows are perceived as barriers to gulls. It has been suggested that an advantage to using this management technique is that it is successful, long-term, and inexpensive (Parnell et al. 1988). Potential disadvantages include installation and maintenance, lines may break, the possibility of accidents and entanglements, and potential habituation (Parnell et al. 1988). Structures (such as wooden shelters) placed near Common Tern nests have been shown to reduce chick mortality by providing protection against predatory animals (Burness and Morris, 1992). Management techniques that increase available nesting habitat, enhance site condition, and deter predators will benefit nesting terns, by reducing competition with gulls and reducing predation risk (Jones and Kress 2012). Because of the large numbers of Ring-billed Gulls nesting on Interstate Island, the construction of a gull exclosure is essential for minimizing predation pressure. The addition of driftwood, stones, and shelters, is also necessary for providing birds with adequate nesting substrate.

It is also critical that important foraging locations be identified as the City of Duluth is in the process of pinpointing land and habitat conservation priorities, as part of the western Duluth revitalization effort. Use of global positioning system (GPS) technology will allow us to identify local movement with extreme accuracy (within ~10m). Because productivity and site selection are influenced in part by prey availability, identification of foraging areas used on the breeding grounds will help prioritize restoration and protection of sites frequently used during the breeding season. Documenting local movement using GPS tags will provide important information on foraging distances, locations, and frequency which has not previously been documented in such fine-scale spatial resolution.

The objectives of this project were to: 1) determine the effectiveness of social cuing in attracting Common Terns to nest within a specified location within a previously established colony (which has been active for over 25 years), 2) monitor nests within the colony to determine the effectiveness of shelters relative to fledgling rates, and 3) use GPS tags to document local movement within the breeding grounds. For long-term management, identification of best management practices are necessary and best attained through experimental manipulation that addresses management issues (Elphick 1996). Management techniques that include social attraction, use of string grids, and shelters have all been effective in managing Common Terns (Burness and Morris 1992, Arnold et al. 2011). Documenting the effectiveness of these management techniques on Interstate Island will be important for identifying best management practices for maintaining a long-term productive colony. Management of individual colonies is important because regional and global loss begins with local declines (Morris et al. 1992).

Work Completed

Outcome 1: The work done to complete outcome 1 (Attracting and Securing Terns) began with constructing the gull exclosure which we began on 02-May and finished on 05-May, 2016. This task took 3 full days with four people working 8-10hr/day. The decoys and sound system (social attractants) were placed on the island on 05-May, 2016 after the exclosure was completed. Shelters were placed within the tern nesting area once the first young hatched on 10-June, 2016.

Outcome 2: The work done to complete outcome 2 (Monitoring Terns) included placement of cameras on the island to document potential predation events. Cameras were placed on the island on 13-May, 2016. Monitoring nests began on 13-May with the first eggs observed on 16-May. First young hatched were observed on 10-June. All hatch-year birds (HY; a bird hatched during the calendar year in which it was banded [or seen]) were monitored through the month of July to document survival rates.

Outcome 3: The work done to complete outcome 3 (Identify foraging locations) included deploying 10 global positioning system (GPS) tags on adult terns and marking 10 additional birds with auxiliary markers, to determine if attachment of GPS tags effected nesting success. Tags were placed on birds on 30-May, 2016 and retrieved on 11-June, 2016.

Results

Our project met all of the grant's original goals. Using the methods described above, terns appeared to be attracted to the social cuing by nesting in the desired location within the newly constructed gull exclosure. The combination of visual and audio cuing appeared to be important in achieving this outcome. By monitoring HY birds throughout the breeding season, we were able to document nesting success and survival. Fledging rates were higher than average and we observed use of shelters by young birds throughout the breeding season. Cameras placed on the island captured over 10,000 images which will be used in future analyses. We were also able to document movement of adult birds within the breeding grounds using GPS tags. Birds moved primarily along the south shore of Lake Superior. The importance and potential future use of our project deliverables are outlined in the introduction and technical report (Appendix A).

Partnerships

The primary collaborative effort for this project was with the Minnesota and Wisconsin Department of Natural Resources and the University of Minnesota and Natural Resources Research Institute. **Leveraged Dollars:** We received additional support for our project from the US Fish and Wildlife Service ($24,915), the University of Minnesota EVCCA Research and Scholarship Grant ($3,000); Wally Dayton Wildlife Fellowship ($1,900), University of Minnesota Thesis Research Travel Grant ($2,500), Minnesota Ornithologists' Union–Savaloja Grant ($1,376), and the Duluth Superior Area Community Foundation Biodiversity Fund ($5,164).

Conclusions

Adequate management of a state threatened species requires knowledge of the species life history as well as identification of potential threats. Studying behavior and identifying threats requires intensive collection of data over a relatively short period of time and great effort on the part of managers and researchers. There are numerous opportunities for future research that can build upon the work completed in this project, including more detailed analysis of foraging locations documented using geospatial tracking devices.

Photos

All photographs associated with the project can be found in the technical report (Appendix A). All individuals appearing in photographs have signed photo release forms provided by Deb Rose with the MNDNR. This includes A. Bracey, F. Strand, and G. Crozier.

Media Coverage

The following is a list of the media coverage associated with this project in 2016.

- KDAL: Phone interview about research on Interstate Island. Dave Strandberg. Sept 14, 2016.
- U of MN Extension Citizen Science: Driven to Discover Citizen Science Classroom Birding. Sept 2016. https://www.youtube.com/watch?v=2mt021KYE0g
- NRRI News: 'Tern' for the better. June Breneman story. Sept 7, 2016. http://www.nrri.umn.edu/natural-resources-research-institute/news/tern
- Duluth News Tribune: Effort to protect, track nesting terns in harbor turns up surprising results. John Myers story July, 17, 2016. http://www.duluthnewstribune.com/news/4075755-effort-protect-track-nesting-terns-harbor-turns-surprising-results

Results from some of this research were presented at two national conferences by A. Bracey. Funds used for travel to these conferences were covered by internal grants at the University of Minnesota and include the Conservation Sciences Travel Grant and the Thesis Research Travel Grant.

"Conservation and Management of Common Terns (Sterna hirundo) in the North American Great Lakes". Poster presentations at The Waterbird Society, 40th Anniversary Meeting. New Bern, NC, Sept 20-23, 2016 and the North American Ornithological Conference. Washington D.C., August 16-20, 2016.

Acknowledgements

We would like to thank the Minnesota Department of Natural Resources – Minnesota's Lake Superior Coastal Program STAR Grant for providing support for this research which helped purchase supplies necessary for the project, specifically cameras to monitor nesting terns, batteries for the sound system, and GPS tags to document movement within the breeding grounds, as well as travel expenses. We would also like to thank the U.S. Fish and Wildlife Service, Wisconsin Department of Natural Resources, Minnesota Ornithologists' Union, University of Minnesota, Natural Resources Research Institute, the Duluth Superior Area Community Foundation, and the Conservation Biology Graduate Program for support for this project. We are grateful to everyone who volunteered their time to make this project possible including Steve Johnson and Kim Rewinkel at the Natural Resources Research Institute, and Bill Majewski with the St. Louis River Alliance. We also thank individuals who allowed us to use their photographs (photo credits included in the technical report [Appendix A]). I am especially grateful to Fred Strand for his continued dedication to managing the Lake Superior tern colonies, spending 100s of hours each year to ensure these important colonies continue to persist into the future.

Appendix A.

Technical Report for 'Lake Superior Common Tern Conservation' project.

Methods

Study Site

The location of our study was Interstate Island Wildlife Management Area, situated in the Duluth-Superior Harbor (46°44'57.87"N, 92° 6'35.77"W). This island has been identified as a high priority breeding site for Common Terns in the U.S. Great Lakes region, is one of only four longtime active nesting colonies in Minnesota, and has been one of the most consistently productive colonies in the upper Great Lakes region (Cuthbert et al. 2003, Wires et al. 2010, Pfannmuller 2014). We visited the island a total of 12 times from 02-May to 01-Aug, 2016.

Interstate Island Wildlife Management Area in the Duluth-Superior Harbor, Minnesota and Wisconsin (Photo credit: D. Hamilton)

Capture and Handling of Birds

Capture and handling of Common Terns followed protocols approved by federal and state agencies (Bird Banding Lab, Wisconsin DNR and University of Minnesota Animal Care and Use Committees). Adult birds were captured using a box trap made of welded rectangular mesh wire (Burger 1971), which was placed above a nest where a bird was incubating eggs. When a bird returned to its nest to incubate eggs, we collapsed the box trap and immediately retrieved the bird (Silvy 2012). Any adult birds captured that had not been previously fitted with a USFWS stainless steel leg band were given one. Maximum handling time for each adult bird was roughly 15-20 minutes, which includes the time necessary to draw blood from individuals fitted with GPS tags to determine their sex. Because HY birds are not able to fly for several weeks, we are able to capture young birds by hand and place them in a tall cardboard box, to prevent them from escaping while they were handled and to reduce their exposure to heat or cold. Handling time for HY birds was roughly 3 minutes. Field work was only conducted during favorable weather conditions to minimize exposure-related adverse effects on eggs, chicks, and adults.

Capture of adult Common Terns using a box-trap method. (Photo credit: S. Matteson)

Capture and handling of hatch-year Common Terns. (Photo credit: MNDNR)

Task 1: Attracting and Securing Common Terns

Ring-billed Gulls typically arrive and begin nesting 2–4 weeks earlier in the spring than Common Terns. Therefore, we built a gull exclosure prior to the return of Common Terns to ensure adequate space was available. On 02-May, 2016, we began construction of a gull exclosure within the recently restored portion of Interstate Island that we deemed most suitable for nesting terns (i.e., near the center of the island, vegetation free, higher elevation). The perimeter of the exclosure was roughly 61x18m and consisted of wire fencing. Additional wire fencing was then used to subdivide the exclosure into 3–20x18m sections, which was further subdivided into 15–20x4m sections (Fig.1). The sub-sections facilitated ease of capture and handling of HY birds and also provided a spatial reference for the location of nests and placement of shelters. White nylon string was placed parallel to the fencing of the exclosure to deter entry by gulls (e.g., Pochop et al. 1990).

We did not vary the spacing of the string grid within the exclosure to ensure the area within each subdivision was equal. Varying the spacing of the subsections could have biased the number of birds nesting in each unit and potentially confounded the effects of social cuing on nest site selection. Driftwood and additional gravel were placed within the exclosure to provide structure to the site, in the absence of previously existing vegetation. We also placed secondary fencing around the exclosure to buffer the Common Tern nesting area from Ring-billed Gull nests, which were removed within the ~76m buffer zone. Construction of the exclosure was completed on 05-May, 2016 prior to the arrival of Common Terns.

Construction of gull exclosure on Interstate Island 02-05 May, 2016. (Photo credit: A. Bracey)

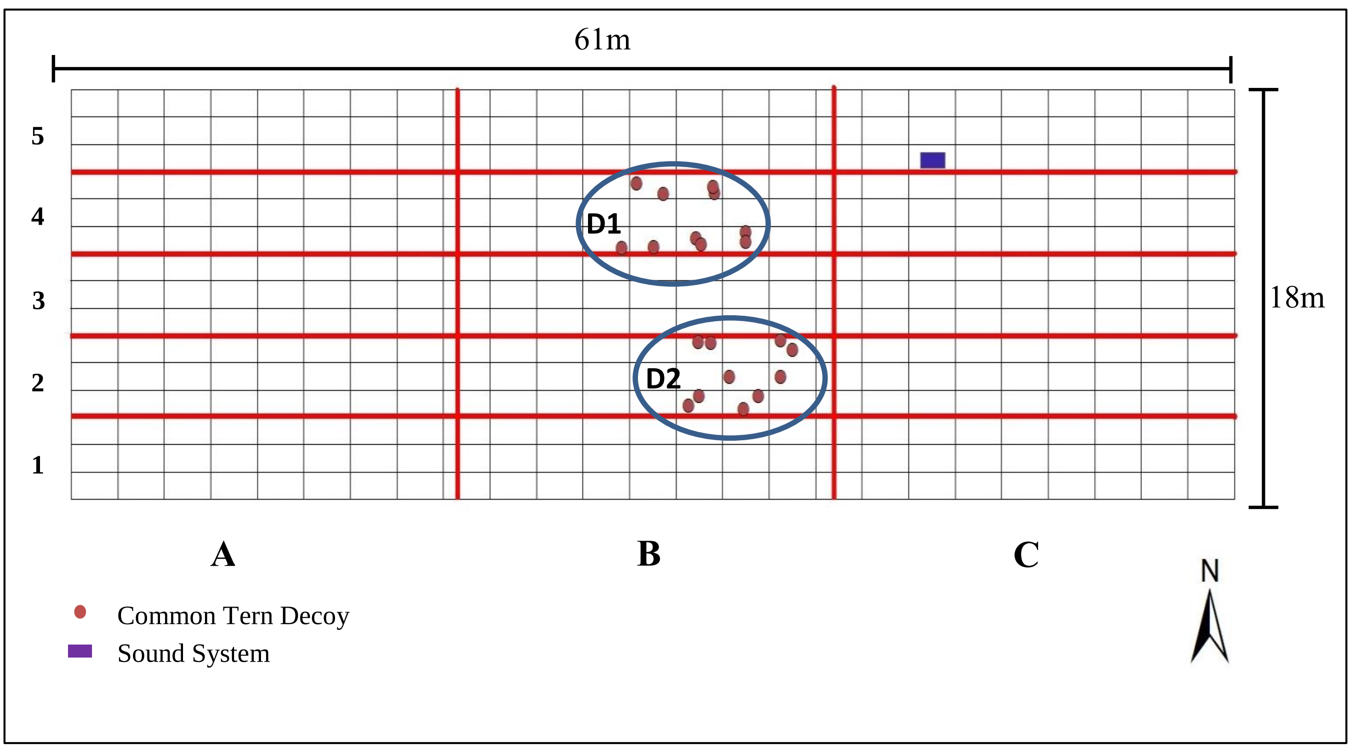

Figure 1. Location of Common Tern decoys and sound system within the gull exclosure/Common Tern nesting area. D1 = location of decoys in section B4 (*n*=10) and D2= location of decoys in section B2 (*n*=10).

 

Driftwood, gravel, and string grid were also placed within the tern nesting area. (Photo credits: A. Bracey & F. Strand)

We used social cuing (tern decoys and audio playbacks) in an attempt to attract terns to the desired nesting location within the gull exclosure. Bill Majewski with the St. Louis River Alliance built a total of 20, 30–38cm hand-carved and painted Common Tern decoys, which were placed within the gull exclosure prior to the return of Common Terns. Decoys were placed in two different locations within the exclosure; 10 decoys were centrally located in section B4, ~17m SW of the sound system and the other 10 decoys were centrally located in section B2, ~32m SW of the sound system (Fig. 1). Because we wanted to attract terns to nest within the gull exclosure, we placed the decoys in the central units, away from the perimeter of the fencing, to minimize proximity of tern nests to gulls.

The sound system used to broadcast Common Tern calls was assembled at the Natural Resources Research Institute (NRRI) in Duluth, MN by machinist Steve Johnson. This device consisted of two components; the sound system used to broadcast calls and the external power source (Fig 2). Vocalizations were played on an MP3 player wired to 4–12 Volt Powersonic batteries and to a car amplifier (Table 1; Fig. 2), which did not require a recharge over the course of the study. We broadcast sound through 1–15 Watt outdoor speaker connected to the portable MP3 player and powered by 2– 12V Duracell batteries (Table 1; Fig. 2). The system broadcast calls of an active breeding colony of Common Terns (*recording from www.xeno-canto.org; XC282450*) which was looped to play in hour intervals beginning at 06:00 and continuing until 20:00 daily from 05-May – 07 June using a programmable timer switch (Table 1; Fig. 2).

Common Tern decoys placed within the tern nesting area on Interstate Island. (Photo credit: A. Bracey)

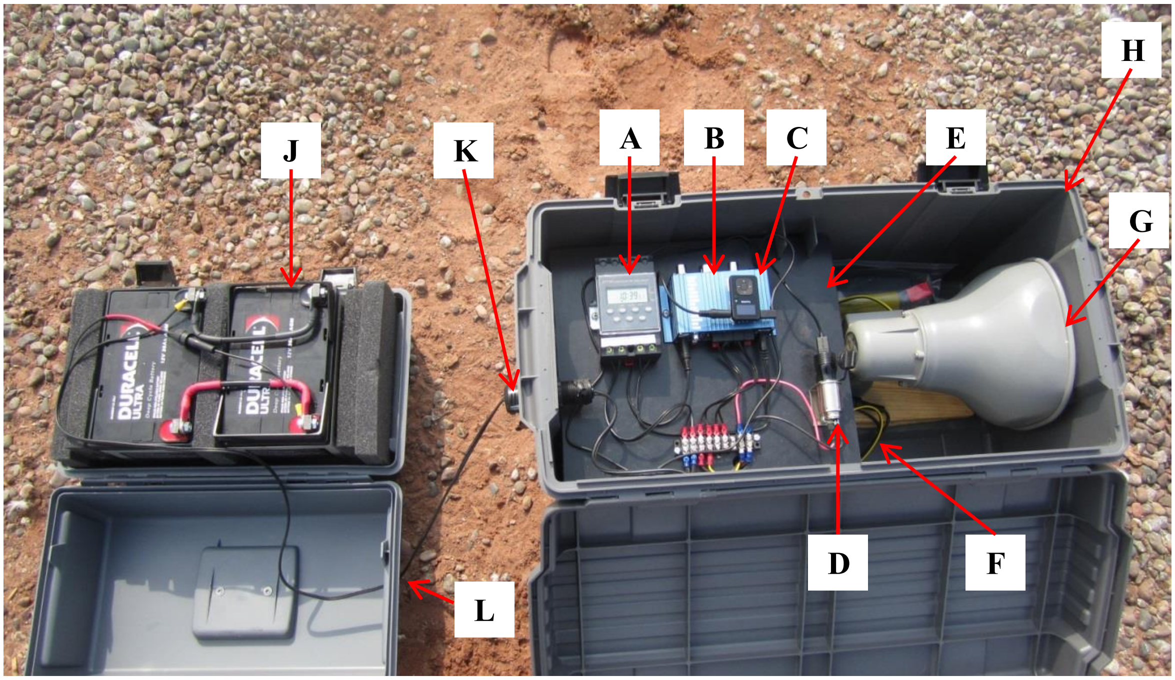

Figure 2. Sound system and external batteries used to attract Common Terns to breed in a specified location within the gull exclosure on Interstate Island.

Table 1. Components of the sound system used to broadcast calls of breeding Common Terns at Interstate Island in an attempt to attract adult birds to desired nesting location within the gull exclosure.

Sound System		
Reference	***Item***	***No. of Items***
A	Programmable Microcomputer Timer Switch (ZYT16G-JW)	1
B	Mini 12V/ 180 Watt Hi-Fi Audio Stereo Digital Car Amplifier (TELI-A6)	1
C	SanDisk Sansa Clip + 4GB MP3 player (SDMX18)	1
D	Car adapter	1
E	Mounting board: black Delrin plastic	1
F*	12 Volt/12 AmpHour Powersonic Battery (PS-12120F2)	4
G	Omni-purpose Atlas Sound loudspeaker 8 OHMS 15 Watts (AP-15TC)	1
H	Plastic tote toolbox for sound system components (11.5’ wide x 24’ long x 14’ high)	1
I**	Insulating foam sealant, Great Stuff (Mfr#: 187273)	1
	External Batteries	
J	Duracell Ultra 12 Volt/35 AmpHour AGM Deep Cycle Marine	2
K	In-line fuse and twist lock plug	2
L	Plastic tote for external batteries (8.5’ wide x 16’ long x 8.5’ high)	1

*Not visible in Figure 2, below mounting board **Not pictured in Figure 2, added around perimeter of loudspeaker

The audio system and external batteries were housed in water-resistant toolboxes to minimize exposure to adverse weather (e.g., rain, high temperatures), sand, and bird feces. The sound system was placed in the NE corner of the gull exclosure with the speaker facing SW (Fig. 1, section C5). Due to the number of nesting Ring-billed Gulls on the island, the sound of the broadcast tern calls was not audible from the set of decoys located farther from the sound system (Fig. 1 , ‘*D2*’), but could be heard from the decoys nearer the sound system (Fig. 1, ‘*D1*’). Once the adult Common Terns returned and began nesting, A-frame shelters constructed of rectangular pieces of ash wood (~ 13x25cm) were placed in the tern nesting area (Burness and Morris 1992), using a semi-randomized design, to determine whether shelters influenced chick survival.

Water-resistant toolboxes used to house the sound system and external batteries which projected vocalizations of breeding Common Terns. A-frame shelters placed within the tern nesting area. (Photo credit: A. Bracey)

Task 2: Monitoring Terns

Nest Monitoring

Using in-person visits, we began monitoring nests on 23-May and continued weekly (1-2 visits/week) through 28-June. Once a female laid an egg, we marked the nest with a wooden garden stake, painted orange, and labeled it with a unique number, which corresponded to the order in which the nest was encountered. For example, a nest labeled 1 would be the first nest of the year, whereas a nest numbered 300 would be the 300th nest of the year. Fates were categorized in the following way: 1) successfully hatched eggs (S), 2) probably successfully hatched eggs (PS), and 3) failed (F). The presence of at least one chick in a nest would confirm a nest was successful. A nest would be designated ‘probably successful’ if there was a high probability that a chick hatched between visits and moved off of the nest. This designation was determined by estimating the number of days an egg had been actively incubated and also on the number of days between visits, as young birds can move off of the nest within 1-2 days. A nest would be considered failed for any of the following reasons: 1) there was a low probability that a chick hatched between visits and the egg(s) were absent, 2) the nest was abandoned, or 3) the egg was non-viable. After the 28-June, new nests would continue to be marked to document nesting events but the fate of the nests would not be followed after this date because of the low probability a chick would hatch and survive to fledge. In 2016, there were nine encounter histories for HY birds between 17-June and 27-July. To determine whether shelters increased HY survival, we will analyze the mark-recapture data for these HY birds.

Common Tern eggs and a nest marked to document nesting success of each breeding pair. (Photo credit: MNDNR)

Banding

In addition to monitoring nests, we also banded adult and HY birds with USFWS stainless steel leg bands. Methods for capturing and handling birds can be found above (‘*Capture and Handling of Birds*’). We captured adult birds when they were actively incubating eggs (late-May – early-June). Each year approximately 20-30% of adult birds are recaptured. We banded unbanded adults and documented annual survival from previously banded individuals. For HY birds, we capture all individuals observed and also fit them with USFWS bands. Once a HY bird has been banded, we document the fate of the bird (dead or alive) and if alive, estimate its age during subsequent visits. Colony productivity was measured by the number of chicks fledged (i.e., ≥15 days at last capture) at the end of the breeding season. We did not continue to monitor the survival of HY birds past 27-July because by this date most of the young birds had reached fledgling age and little to no additional information would have been gathered past this date.

Hatch-year Common Terns banded at Interstate Island. (Photo credits: C. Henderson, MNDNR)

Cameras

In addition to in-person visits, we also collected ~10 weeks of camera footage, at fixed 1-min intervals, 24hrs/day, in an attempt to document predation events at the breeding colony. Two cameras (Bushnell Trophy Cam HD *model 119676*) were placed within the breeding area on 23-May and removed on 01-August, 2016.

Images captured on Interstate Island from Bushnell Trophy cameras. (Photos taken by Bushnell cameras)

Task 3: Identifying Foraging Locations

To identify local-scale movement patterns, we attached archival global positioning system (GPS) tags (*Lotek: PinPoint-50 version V4.16*) to 10 adult Common Terns. To document potential negative impacts of GPS tags on individuals, we marked 10 control birds with auxiliary markers (i.e., alpha-numeric plastic field-readable (PFR) color bands). Birds with GPS tags were also fitted with auxiliary markers to easily identify individuals. We used black bands with the K numeric series (0-100). The band series was chosen by Jeff Spendelow, with the U.S. Geological Survey, who coordinates auxiliary marking of terns internationally. Due to the extensive banding records at Interstate Island, only previously banded adults of a known age group (4-11yr) were included in the GPS study (specified by BBL) for both GPS and control groups.

To deploy GPS tags, adult birds were first captured on a nest using a box trap (Silvy 2012). An auxiliary color band was placed on the leg opposite the USFWS stainless steel leg band. A GPS tag was then fitted to the bird using a pre-constructed leg-loop harness (Rappole and Tipon 1991, Mallory and Gilbert 2008; Fig. 3A & 3B). The total weight of each attached tag (GPS unit + harness + auxiliary marker) was ~3.5-4.0 grams, below 3% of the birds' body weight, a requirement of permitting. Units were deployed on 30-May and retrieved on 11-June, 2016. These same capture and handling methods were used for control birds with the exception of fitting them with a GPS tag. During weekly visits, we monitored individuals fitted with GPS tags to ensure the attachment was not negatively impacting nesting behavior. We also marked the nests of the GPS tagged birds and those of the 10 control birds, to document whether nesting success was effected by the attachment of GPS tags.

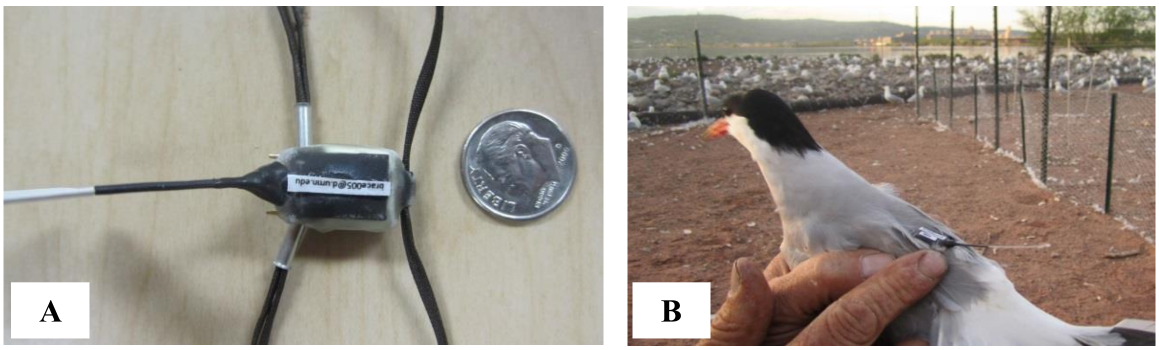

Figure 3. A. Global positioning system (GPS) tag and harness pre-constructed to be fit using a leg-loop attachment method. **B.** Adult bird fit with a GPS tag in the field on 30-May, 2016.

Upon removal of the GPS tags, units were taken back to NRRI where data were downloaded using the PinPoint Host Software provided by Lotek Wireless Inc. Because GPS locations can be downloaded as geographic coordinates there is no analysis subjectivity (Hallworth and Marra 2015). Once data were downloaded from each device, the geographic coordinates were uploaded into ArcMap 10.2.2 and shapefiles created. For each location estimate recorded (latitude and longitude), GMT and local date/time, dilution of precision (DOP), and number of satellites were also recorded. DOP is an indicator of the quality of the GPS position, with low DOP values indicating a higher probability of accuracy. Units were scheduled to record individual (discrete) daily fixes every 30 minutes from 06:00 to 22:00. When tags are switched to take a fix, they have to download a map of the sky which takes 10s of seconds. If the receiver does not have an adequate view of the sky (e.g., covered by feathers) it will continue to try to take a fix for up to 70 seconds, if no fix is achieved it will shut down until the next scheduled fix to conserve battery life (PinPoint User Manual 2015). Therefore, because of variation in battery life and number of fixes obtained, not all tags will acquire the same number of fixes even though they were given the same schedule. We will provide a map of the locations of individuals fitted with GPS tags as well as a GIS database of these locations with FGDC metadata.

Results

Task 1: Attracting and Securing Common Terns

The Common Tern decoys and sound system were set up on 05-May, 2016 prior to the return of Common Terns to the breeding colony. Our next visit to the island was on 13-May, 2016. Upon arrival we observed approximately12 individuals making scrapes or resting near the decoys closest to the sound system (Fig. 1, '*D1*') and another group of approximately eight individuals were making scrapes near the sound system itself. We did not observe any terns interacting with the decoys located further from the sound system (Fig. 1, '*D2*').

Common Terns nesting among decoys in cell B4 in tern nesting area on Interstate Island (Photo Credit: F. Strand)

Task 2: Monitoring Terns

Nest Monitoring and Banding

Nest failure, especially when occurring early in the breeding season, often leads to renesting attempts by breeding pairs; therefore counting nests throughout the breeding season will likely include counts of renesting individuals. Because of the frequency of visits to the island, we were confident that we could accurately determine the date of peak nesting activity. In 2016, the number of Common Tern nests increased to a peak in early June and then declined. The 'peak nest count' was 162 nests on 7-June. The first chicks hatched on 10-June. We did not count chicks found dead prior to banding, therefore, we report the total number of chicks banded, fledged, found dead, or of unknown fate, as well as the number of shelters and nests in each cell within the tern nesting area (Table 2). The number of young fledged (*n* =200) per peak nest count (*n* =162) was 1.23 fledglings per nesting pair, which is an index of annual productivity and above the 27 year average of 0.84 (F. Strand, pers. comm.).

Over the course of the field season (23-May to 01-Aug, 2016), we handled a total of 85 adult birds, of which 10 individuals were previously unbanded, meaning they likely originated from a colony outside of Lake Superior. These 10 adults were banded for future monitoring. We also banded a total of 321 HY birds, of which, 200 survived to fledgling age, 68 were found dead, and the fate of 53 birds remain unknown (i.e., they may have fledged and we did not re-encounter the bird or they were predated).

Table 2. Total number of shelters, nests, and eggs monitored within the tern nesting area on Interstate Island in 2016. Within each cell we documented the number of HY birds banded, fledged, found dead, or of unknown fate throughout the nest monitoring period.

Cells	No. of Shelters	No. of Nests	No. of eggs	Total Banded	Shelters/ HY bird	Fledged	Dead	Unknown
A1	0	0	0	NA	0	NA	NA	NA
A2	20	12	31	7	2.86	6	0	1
A3	0	24	55	32	0	22	5	5
A4	0	36	79	33	0	15	7	11
A5	16	5	11	5	3.20	2	0	3
B1	0	0	0	NA	0	NA	NA	NA
B2	0	2	5	9	0	5	2	2
B3	13	27	68	47	0.28	33	9	5
B4	28	73	187	115	0.24	70	31	14
B5	0	18	39	14	0	4	3	7
C1	0	0	0	NA	0	NA	NA	NA
C2	0	0	0	NA	0	NA	NA	NA
C3	0	0	0	NA	0	NA	NA	NA
C4	11	35	93	54	0.20	38	11	5
C5	0	3	8	5	0	5	0	0
Total	**88**	**235**	**576**	**321**		**200**	**68**	**53**

Shelters placed within the tern nesting area and use of shelters by chicks. (Photo Credits: MNDNR, K. Rewinkel)

Cameras

From 23-May to 01-Aug 2016, we captured ~80,000 images total for both cameras placed on Interstate Island. These images will allow us to document nesting behavior, including feeding behavior, as well as any predation events which will be useful for future research on colony productivity.

Images from tern nesting area, documenting feeding by adult birds as well as entry by other species, including Canada Goose and Ring-billed Gull. (Photos taken by Bushnell cameras)

Task 3: Identifying Foraging Locations

Of the 10 GPS tags that were deployed on 30-May and retrieved on 11-June, 2016, we were able to retrieve data from 9 units. One unit malfunctioned completely and we were not able to obtain any data. The other units that recorded less than 50 fixes (*n*=2) also likely malfunctioned. Variability in the number of fixes obtained from the remaining tags was likely due to obstructions from the sky that did not allow for a fix to be recorded and not a malfunctioning unit. After downloading data, we sent GPS tags back to Lotek to identify the reason for tag failure and were told it was due to water ingress in the units. They will be replacing all tags for potential future use.

We removed data with obvious outliers (e.g., a point location in St. Paul, between two points in Duluth), of which there were only 3 locations removed. A total of 1,043 locations were estimated during the 12 day period for nine Common Terns. The number of fixes obtained per unit varied from 11-294 with an average of 115.9. The average number of satellites acquired per fix was 6.3, with a range of 3 to 11. The average DOP was 2.6, with a range of 0.8 to 87.5 and a mode of 1.2. DOP values ≤5 are considered accurate and anything >20 poor (Milbert 2008). Local activity data from the GPS tags revealed movement up to 35km from the breeding colony on Interstate Island, primarily along the coastal waters on the south shore of Lake Superior. One bird also moved within the St. Louis River Estuary, but the majority of recorded movements away from the breeding site were along the south shore of Lake Superior.

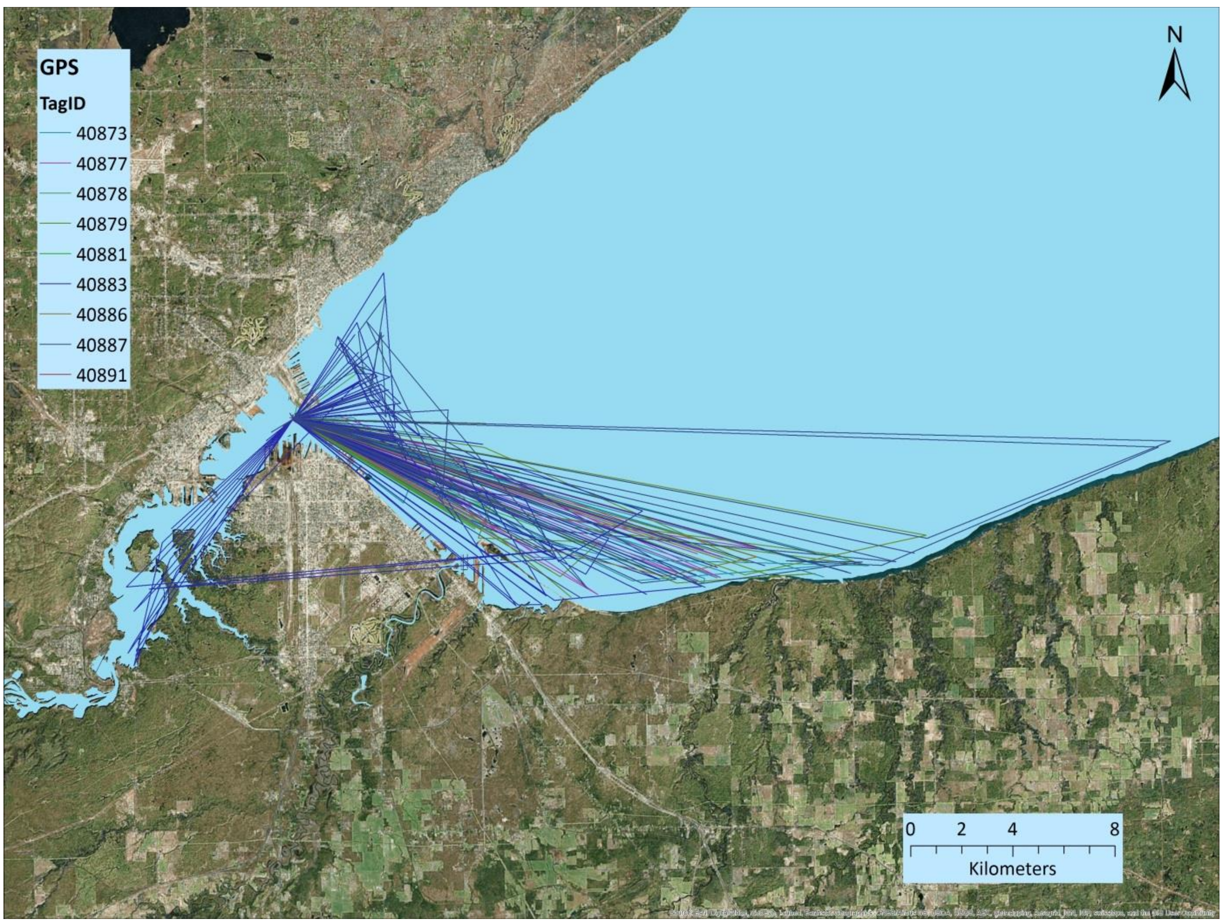

Figure 4. Composite locations of (*n*=9) adult Common Terns breeding on Interstate Island in the Duluth-Superior Harbor. TagID represents the unique identification of each individual bird's path.

We monitored individuals fitted with GPS tags during all subsequent visits to document any potential negative effects associated with harness attachment. Once fitted with a tag and released all birds flew off and returned to their nests within minutes. Based on nest monitoring of GPS and auxiliary marked adult birds, there were no differences in nesting success between the two groups (Table 3). Of the 10 GPS tagged birds, eight nests successfully hatched young, one nest 'probably successfully hatched young', and one nest failed, potentially due to abandonment. For the 10 control birds, six nests successfully hatched young, two nests 'probably successfully hatched young', and two nests failed. Reasons for nest failure are unknown but appear to be due to nest abandonment.

Table 3. Fate of nests of GPS tagged birds (*n* =10) and control birds (*n* =10). Each bird is identified by band number, auxiliary band number, and GPS number (if applicable). Nests were monitored using nest numbers, and the fate of each nest was monitored weekly. The possible fates for each nest were: 1) successfully hatched eggs (**S**), 2) probably successfully hatched eggs (**PS**), and 3) failed (**F**). For each individual, the number of eggs present during each visit is provided below each date visited. Nests with one or more chicks are listed under the date as '**y**' = young. In nests with young and eggs, eggs are labeled '**e**'. If the nest was believed or known to be abandoned it was designated '**A?** or **A**'.

Band Number	Auxiliary Number	GPS Number	Nest Number	Date							Fate
				5/23	5/27	6/3	6/7	6/17	6/21	6/28	
1252-20277	K13	40883	3	1	1	3	2	3	2y		S
1252-17138	K14	40891	64		2	1	1A?	1	0		F
1252-20446	K15	40879	65		1	2	2	1y			S
1252-20081	K12	40887	66		1	3	3	3	1y1e		S
1252-20225	K08	40873	68		2	3	3	1	1		PS
1252-17057	K06	40877	81		1	3	3	2	1y1e		S
1252-20079	K16	40878	89		3	3	3	3y			S
1252-20441	K07	40886	95		2	2	1	1y			S
1252-20710	K09	40888	102		2	3	3	1y2e	1		S
1302-01789	K11	40881	106		1	3	3	3	1y1e		S
1252-20281	K37	Control	50	1	3	3	3	1y			S
1252-20625	K54	Control	55		1	3	3	3	2y		S
1252-20001	K32	Control	63		1	2	2	2	2y		S
1252-20463	K40	Control	98		3	3	3	2y1e	1y		S
1252-20656	K30	Control	109			3	3	3	3	0	PS
1252-20072	K33	Control	111			1	2	2	A		F
1252-20253	K38	Control	134			3	3	3	2y1e	0	S
1252-20075	K36	Control	147			3	3	3	0		PS
1252-17112	K35	Control	162				2	3	3	1y2e	S
1252-17883	K34	Control	163				3	3	3	A	F

Common Terns fitted with GPS tags returned to normal breeding activities within minutes of release. (Photo credit: K. Rewinkel)

Discussion

Task 1: Attracting and Securing Common Terns

Social attraction is commonly used in seabird restoration projects to establish or restore a colony in a given location. Arnold et al. (2011) found that terns responded to decoys only when coupled with vocalizations of conspecifics. In a review of active seabird restoration projects, Jones and Kress (2012) found that projects were successful when using decoys or vocalizations independently, but that success rates increased when projects included both techniques. In our study, birds only nested near decoys that were within range of the sound system. Although the nesting area within the gull exclosure appeared to be uniform throughout (e.g., same sediment type, same sized sections), there may have been other reasons why the terns did not chose to nest near the decoys located out of range of the sound system. However, our goal was to attract the terns to nest centrally within the exclosure which was successfully achieved. We estimate 90% of first arrivals were attracted to the presence of the 'decoy + sound system'.

Task 2: Monitoring Terns

In a synthesis of state and federal conservation plans for the Common Tern, Pfannmuller (2014) provides guidelines for continual and effective conservation planning for Minnesota colonies. One of the goals is that colonies produce at least 1.1 young per breeding pair for the state to maintain its current population. Although long-term averages are more useful for determining colony stability, the high fledgling rates for 2016 indicate conditions were favorable and fledgling rates high.

Continual monitoring, which includes banding of adult and HY birds, nest monitoring, and maintenance of the gull exclosure is critical to maintaining this colony, determining colony stability, and measuring productivity over time. Maintenance and continual collection of these data are invaluable to natural resource managers for conserving this species at risk in the Great Lakes Region.

To determine whether shelters increase HY survival, we will need to collect an additional year of data. We will then analyze the mark-recapture data for HY birds using the package RMark (Laake 2013) in R version 3.3.2. We will use the multi-state ‘live-dead’ encounter model and define groups based on location within the nesting area and number of shelters as the single covariate. We will set capture probability to vary with time, given older birds are more difficult to recapture due to their ability to fly, and survival probability set to be equal among visits.

Although predation events are often difficult to observe and to quantify, documented observations of predation can be incorporated into models of nesting success. Using the methods of Etterson and Stanley (2008), future work will include estimating predation rates from camera traps as well as predation events documented in the historical data. I will also build a project in Zooniverse, an online, peer-reviewed, crowd-sourcing tool designed to analyze large sources of data using volunteer effort (www.zooniverse.org). The project will be designed to categorize behaviors captured by cameras.

Task 3: Identifying Foraging Locations

By using tracking technology to identify local-scale movement patterns of breeding Common Terns nesting in the SLRE we have identified distances traveled and direction of movement from the breeding site. Information gained from these GPS tags can be used in future analyses. For example summarizing duration of trips, length of stay between trips, as well as identifying characteristics of the surrounding landscape, including water quality that may be associated with observed movement patterns. We could also sample prey fish within the estuary and along the south shore of Lake Superior to compare prey availability and quality (e.g., contaminant analysis).

Conclusions

The Common Tern colony in the SLRE needs continual management to sustain colony numbers and to insure successful reproduction. Compared with the late 1970s, the Common Tern now only nests at one highly vulnerable site in the SLRE. To sustain this colony it is imperative that these birds have suitable nesting habitat where predation risk is low and food supplies are adequate. A better understanding of the natural history and ecology of this species is essential to providing an accurate assessment of the condition and stability of this site and to aid in conservation and management of this species in the Great Lakes Region and elsewhere. The legal status of the Common Tern requires that future development does not adversely impact this species. Given its status in the region (threatened in Minnesota and endangered in Wisconsin), continued monitoring and research at this highly important breeding location is necessary to minimize risk of local extirpation.

This report was funded in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration under Award NA15NOS4190126 provided to the Minnesota Department of Natural Resources for Minnesota's Lake Superior Coastal Program.

References

Arnold, J, I Nisbet, and R Veit. 2011. Assessing aural and visual cueing as tools for seabird management. Journal of Wildlife Management 75: 495–500.

Bracey, A, J Chatterton, and G Niemi. 2016. St. Louis River AOC R2R Support Projects: Ecological Monitoring and Assessment of Bird Use. NRRI Technical Report, University of Minnesota, Duluth, MN.

Burger, J. 1971. A method for marsh-trapping breeding Franklin's Gulls. Bird Banding 2:123–124.

Burness, GP, and RD Morris.1992. Shelters decrease gull predation on chicks at a Common Tern colony. Journal of Field Ornithology 63: 186–189.

Courtney, PA, and H Blokpoel.1980. Behavior of Common Terns nesting near Ring-billed Gulls. Canadian Field-Naturalist 94:336-338.

Courtney, PA, and H Blokpoel. 1983. Distribution and numbers of Common Terns on the Lower Great Lakes during 1900-1980: A review. Colonial Waterbirds 6:107-120.

Cuthbert, FJ, LR Wires, and K Timmerman. 2003. Status assessment and conservation recommendations for the Common Tern (*Sterna hirundo*) in the Great Lakes region. U.S. Department of the Interior, Fish and Wildlife Service. Ft. Snelling, MN.

Davis, TE, and GJ Niemi. 1980. Larid breeding populations in the western tip of Lake Superior. The Loon 52:3-14.

DiConstanzo, J. 1980. Population dynamics of a Common Tern colony. Journal of Field Ornithology 51:229–243.

Elphick, CS. 1996. Experimental approaches to shorebird habitat management. International Wader Studies 9: 20-28.

Engstrom, H. 1940. 1939 Minnesota nesting records. Flicker 12:12.

Jones, H, and S Kress. 2012. A review of the world's active seabird restoration projects. Journal of Wildlife Management 76: 2–9.

Hallworth, M, and PP Marra. 2015. Miniaturized GPS tags identify non-breeding territories of a small breeding migratory songbird. Scientific Reports 5, article number 11069.

Laake, JL. 2013. RMark: An R interface for analysis of capture-recapture data with MARK. AFSC Processed Rep 2013-01, 25 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Mallory, ML, and CD Gilbert. 2008. Leg-loop harness design for attaching external transmitters to seabirds. Marine Ornithology 36:183–188.

McKearnan, JE, and SJ Maxson. 1986. Status and breeding success of Common Terns in Minnesota. (M.S. Thesis, University of Minnesota, St. Paul, Minnesota. 53 pp.)

Milbert, D. 2008. Dilution of precision revisited. Navigation: Journal of the Institute of Navigation 55:1 67-81.

Morris, RD, DV Weseloh, FJ Cuthbert, C Pekarik, LR Wires, and L Harper. 2010. Distribution and abundance of nesting common and caspian terns on the North American Great Lakes, 1976 to 1999. Journal of Great Lakes Research 36:44-56.

Niemi, G, T Davis, and P Hofslund. 1979. Distribution and relationships of habitats and birds in the St. Louis River Estuary. Report to U.S. Fish and Wildlife Service, St. Paul, MN by Department of Biology and Lake Superior Basin Studies Center, University of Minnesota Duluth. 99 pp.

Nisbet, ICT. 1973. Courtship feeding, egg size and breeding success in Common Terns. Nature 241:141–142.

Parnell, J, D Ainley, H Blokpoel, B Cain, T Custer, J Dusi, S Kress, J Kushlan, W Southern, L Stenzel, and B Thompson. 1988. Colonial Waterbird Management in North America. Colonial Waterbirds 11:129-169.

Penning, WL. 1993. The Common Tern (*Sterna Hirundo*) in Western Lake Superior: history, management, and population modeling (M.S. Dissertation, University of Minnesota, St. Paul, MN).

Pfannmuller, LA. 2014. Common Tern Minnesota conservation plan. Blueprint for Minnesota Bird Conservation. Audubon Minnesota: http://mn.audubon.org/sites/default/files/documents/common_tern_minnesota_conservation_plan_10-16-2014_0.pdf.

PinPoint User Manual. 2015. PinPoint Host Software for the PinPoint GPS Tag. User manual Revision 04. Lotek Wireless Inc. 2015.

Pochop, PA, RJ Johnson, DA Aguero, and KM Eskridge. 1990. The status of lines in bird damage control–A review. Proceedings of the Fourteenth Vertebrate Pest Conference. Paper 70.

Rappole, JH, and AR Tipon. 1991. New harness design for attachment of radio transmitters to small passerines. Journal of Field Ornithology 62:335–337.

Rounds, R, R Erwin, and J Porter. 2004. Nest-site selection and hatching success of waterbirds in coastal Virginia: some results of habitat manipulation. Journal of Field Ornithology 75:317-329.

Silvy, NJ, editor. 2012. The Wildlife Techniques Manual. 7th Edition, Volume 1. Johns Hopkins University Press, Baltimore, Maryland, USA.

Soulliere, GJ, BA Potter, DJ Holm, DA Granfors, MJ Monfils, SJ Lewis, and WE Thogmartin. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterbird Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

Wires, LR, and FJ Cuthbert. 2001. Prioritization of waterbird colony sites for conservation in the US Great Lakes. Final Report to USFWS.

Wires, LR, SJ Lewis, GJ Soulliere, SW Matteson, DV Weselooh, RP Russell, and FJ Cuthbert. 2010. Upper Mississippi Valley/Great Lakes waterbird conservation plan. A plan associated with the Waterbird Conservation for the Americas Initiative. Final Report submitted to the U.S. Fish and Wildlife Service, Fort Snelling, MN.