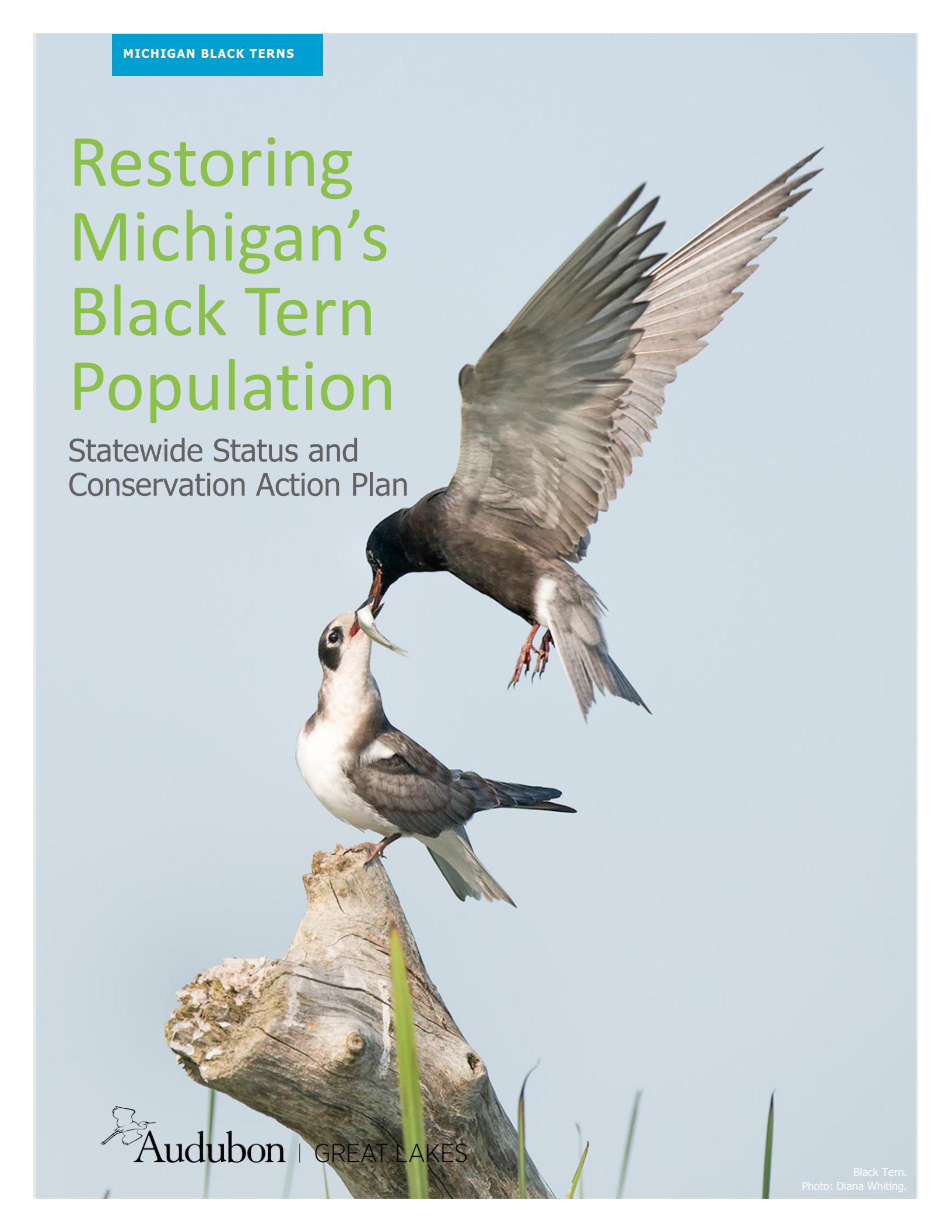
MICHIGAN BLACK TERNS

Restoring Michigan's Black Tern Population

Statewide Status and Conservation Action Plan



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Black Tern.
Photo: Diana Whiting.

Contents

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Executive Summary

The North American Black Tern (*Chlidonias niger*), a migratory bird species that breeds in freshwater marshes, is rapidly declining across the Great Lakes region and throughout its breeding range in the Midwest, underscoring an urgent need for conservation action. This Conservation Action Plan synthesizes findings from Audubon Great Lakes' statewide monitoring program which gathered data from 92 wetlands across the state of Michigan from 2021 to 2024 and outlines strategies to restore and protect critical wetland habitats for the species' recovery. We identified five priority focal breeding sites—Wigwam Bay State Wildlife Area, Portage Marsh State Wildlife Area, Munuscong Bay State Wildlife Management Area, Tawas Lake, and Shiawassee National Wildlife Refuge—that represent essential breeding habitats in need of targeted conservation efforts.

Despite focal sites offering critical nesting opportunities, threats such as habitat degradation, predation, and fluctuating water levels continue to jeopardize Black Tern populations. Recommended actions to conserve Black Terns include targeted removal of invasive species such as hybrid cattail (*Typha x glauca*) and *Phragmites australis*, improving the interspersion of open water and emergent vegetation, and exploring the use of water-level manipulation to enhance availability of floating mats for nesting. Expanding data collection efforts, such as tracking fledgling success (e.g., number of eggs or chicks that survive to fledging) and identifying predation impacts, is also vital for understanding the challenges Black Terns are faced with. Additionally, collaboration with local stakeholders and communities is needed to promote habitat stewardship and minimize human disturbance.

Through habitat restoration, adaptive management, and community partnerships, Audubon Great Lakes and partners plan to ensure the preservation of this iconic marsh bird and the wetland ecosystems it inhabits, fostering long-term ecological resilience in Michigan and across the Great Lakes region.

Introduction

The North American Black Tern is a migratory bird species that is rapidly disappearing from Great Lakes coastal wetlands and throughout its breeding range in the Midwest and now requires urgent conservation action. This status report and Conservation Action Plan aims to share recent findings from Audubon Great Lakes' statewide monitoring program in Michigan during 2021-24 and recommended actions to restore and protect critical wetland habitats to support the recovery and sustainability of Black Tern populations. By implementing targeted conservation strategies at critical colony locations while engaging partners and monitoring progress, we strive to restore thriving Black Tern colonies across the state of Michigan and the Great Lakes region.

The Black Tern is listed as a species of concern, threatened or endangered in most of the Great Lakes states and the only Great Lakes-bordering province where it resides, which includes Illinois, Indiana, Ohio, Michigan, New York, Wisconsin, and Ontario. Black Tern population trends documented by the North American Breeding Bird Survey (BBS) indicate a long-term decline in Black Terns of 3.1% annually for the Eastern U.S. and Canada since 1966, and up to 99% loss of Michigan's Black Tern population between 1966 and 2019 (Sauer et al., 2020). Although BBS trend estimates may be imprecise for Black Terns, these data represent the only information available on their status and trends at a broad geographic extent. Recent, regional-scale findings from analysis of Great Lakes Marsh Monitoring Program (GLMMP) data further suggested that the Black Tern was the marsh bird species with the most significant downward trend during 1996 – 2013 in the Southern Great Lakes (Tozer, 2016). Because of these observed declines, Black Tern was identified as a focal species in the USFWS Midwest Coastal Program Strategic Plan and as a State Threatened species in Michigan.

In order to ensure a future for Black Terns in Michigan, Audubon and partners prioritized the following goals in 2021-24: 1) Direct habitat management for Black Terns at active breeding locations through systematic monitoring, threat identification and action planning; 2) Strategically guide restoration and enhancement at wetlands historically important for Black Terns; 3) Develop an inventory of Black Tern nesting sites across Michigan to better understand population status at breeding colonies and opportunities for habitat enhancement.

The purpose of this report is to summarize the resulting threats and actions that were identified and outline specific next steps for Black Tern conservation in Michigan, with a focus on five priority sites. In addition, we will share the results of a statewide inventory, as the first project to do so since the Michigan Breeding Bird Atlas, which was last completed in 2008.

Project Scope

Focal Sites

Focal sites were identified as priority Black Tern breeding areas in coastal Michigan with known colonies and with habitat conservation information needs. These sites included Munuscong State Wildlife Management Area (Chippewa County), Portage Marsh State Wildlife Area (Delta County), Tawas Lake (Iosco County), Shiawassee National Wildlife Refuge (Saginaw County), and Wigwam Bay State Wildlife Area (Arenac County). The list of focal sites excluded one of the largest known colonies in Michigan, St. Clair Flats State Wildlife Area, since this area has already been the focus of intensive research and monitoring. Monitoring continued at St. Clair Flats in 2021-24, led by project partners, Detroit Bird Alliance and Michigan Department of Natural Resources, however, the results of that monitoring are not captured in this report.

Statewide Monitoring

Ninety-three wetland sites were initially selected for monitoring for Black Terns across the state of Michigan. Eighty-two of these sites were monitored by Audubon and partners, identified by using the best available data for Black Tern occurrences (including but not limited to eBird, Michigan Breeding Bird Atlas, Great Lakes Colonial Waterbird Survey, and knowledge from local experts; eBird, 2024; Chartier et al., 2013; Cuthbert & Wires, 2013). The remaining 11 sites were identified as potential breeding areas for Black Terns but were not visited by volunteers or partners partly due to lack of volunteer availability or accessibility. We determined the status of 10 of the remaining 11 sites using eBird data. One site did not have any eBird data (Canadian Lakes).

Partners

In 2021-24, Audubon Great Lakes coordinated with the following partners on this research and resulting Conservation Action Plan:

- Common Coast Research & Conservation (CCRC), a non-profit research organization based in Michigan. CCRC was responsible for leading Black Tern monitoring and scouting in Delta and Schoolcraft Counties and deploying cameras. CCRC also lead habitat enhancements at priority focal site, Portage Marsh.
- Detroit Bird Alliance, a chapter of the National Audubon Society. Detroit Bird Alliance was responsible for leading Black Tern monitoring at St. Clair Flats, deploying nest platforms and cameras.
- Lake Superior State University (LSSU) Biology Department, a local university based in Sault Ste. Marie, Michigan. LSSU was responsible for leading Black Tern monitoring, deploying cameras, and scouting in Chippewa, Mackinac and Luce Counties.
- Michigan Department of Natural Resources (Michigan DNR) is a state agency and land owner/manager. Michigan DNR provided access to state-owned properties and contributed to the coordination of monitoring at Munuscong SWMA and Wigwam Bay SWA.
- U.S. Fish and Wildlife Service (USFWS) is a federal agency and landowner/manager. USFWS provided access to Shiawassee National Wildlife Refuge and relevant site information while conducting monitoring.
- Saginaw Chippewa Indian Tribe. The Saginaw Chippewa Indian Tribe provided insight into the habitat and wild rice (Manoomin, *Zizania palustris*) management at Tawas Lake.
- Sault St. Marie Tribe of Chippewa Indians (Sault Tribe). The Sault Tribe was responsible for leading Black Tern monitoring and deploying cameras at Munuscong SWMA.

- CISMAs: Lake to Lake, Three Shores, and Saginaw Bay Cooperative Invasive Species Management Area (CISMA) all contributed to this project by alerting the team of Black Tern presence while conducting invasive species management at wetlands within the project focal areas.

Methods

BLACK TERN MONITORING

Of the 93 historic Black Tern breeding sites, volunteers and/or partners visited 82 wetlands throughout the state to 1) continue monitoring at sites with known breeding activity, 2) confirm breeding activity at sites with recent records of activity, and 3) confirm breeding activity at sites with little to no recent records of Black Tern presence/absence (e.g., local monitoring or eBird sightings). The remaining 11 sites that could not be visited by volunteers and/or partners due to limited capacity were evaluated with supplementary data (e.g., eBird). A total of 92 out of the 93 historic breeding sites were evaluated either by monitoring or eBird records. Coastal sites were prioritized for scouting over inland sites, with coastal being defined as 15 miles from a Great Lakes coast. Priority coastal sites included Wigwam Bay State Wildlife Area, Portage Marsh SWA, Munuscong SWMA, Tawas Lake, and Shiawassee NWR. In addition to priority coastal sites, volunteer monitors conducted scouting, colony monitoring and habitat assessment at 31 sites across interior Lower Michigan. In Upper Michigan, scouting was led by CCRC in Delta and Schoolcraft Counties at 29 sites and LSSU in Chippewa, Luce, and Mackinac Counties at 15 sites.

Five priority coastal sites included additional nest monitoring to varying levels of frequency and detail. Wigwam Bay State Wildlife Area included the most frequent monitoring data from 2018 to 2023, where nests were either monitored with nest cameras or checked every 1-2 weeks during the breeding season, and as many nests as possible were documented throughout the colony. Portage Marsh SWA included a thorough nest count and camera monitoring of either most or all nests throughout the colony in 2022 and 2023, and full nest count and monitoring in 2024. Tawas Lake, and Shiawassee NWR included opportunistic camera monitoring in 2023, and Munuscong SWMA in 2022 and 2023, but did not include nest counts throughout the colony.

Beginning in 2021 and for all surveys, a timed area search was used to look and listen for Black Terns. Area searches were conducted either from the shoreline or within the wetland area by boat (boat access permitting). Black Terns are diurnal, medium-sized birds that forage while in flight and vocalize frequently during the breeding season, which made them relatively easy to detect compared to other marsh birds.

If Black Terns were found while conducting an area search and the area was accessible by boat, a flush count was also done. During a flush count, surveyors carefully explore the nesting site via boat, causing adults to flush or fly up above emergent vegetation to better determine the total approximate number of adult breeding pairs. If access allowed, the surveyor also documented number of nests, nest contents (eggs, chicks), water depth, and nest substrate (what nests were built on). If time allowed for repeat visits, at least one additional visit was made near the end of the summer season at active sites to reaffirm population size and determine if fledglings were present and nesting was successful. Nest cameras were deployed depending on accessibility and timing.

At all survey locations, if a site was particularly large and contained multiple sub-groupings of nesting terns, we asked monitors to make note of these distinct areas and perform a shoreline and/or flush count for each one if possible. This allows for a more thorough understanding of the entire colony and whether distinct sub-groupings experience different factors influencing breeding use and nesting success (e.g., threats, habitat changes). These sub-groupings of nesting terns are hereafter referred to as sub-colonies.

HABITAT ASSESSMENT

CCRC, LSSU, and volunteer monitors performed a rapid assessment of habitat characteristics using an adapted version of Integrated Waterbird Management and Monitoring Program protocol for vegetation at all wetland sites where intensive Black Tern monitoring and scouting occurred (Loges et al. 2021). Habitat surveys occurred once a year during the peak growing season at all wetland sites that were scouted and monitored.

Focal Site Results and Recommendations

Wigwam Bay State Wildlife Area (SWA)

WIGWAM BAY RESULTS & ANALYSIS

Wigwam Bay State Wildlife Area is a 3,137-acre impounded wetland unit managed by the Michigan DNR located in Arenac County, MI, on the northern coastline of Lake Huron's Saginaw Bay. Black Tern monitoring was conducted by Audubon Great Lakes staff and contracted technicians between 2018 and 2023, which included shoreline and flush counts (adults and fledglings if possible), nest documentation (GPS coordinates, egg count, estimated incubation start date) and monitoring of nest outcome (nest checks or cameras) every 1-2 weeks. Habitat surveys were also conducted once a year during the peak growing season. Peak breeding adult counts occurred in 2019 (n = 114), and peak fledglings were observed in 2018 (20-28 fledglings). More detailed information on population trends from 2018 to 2020 can be found in Audubon's Restoring Wigwam Bay for Breeding Marsh Birds Report (2021).

Wigwam Bay Population Statistics by Year (2018-2023)

Between 2018 and 2020, breeding adult counts ranged from 74 to 114 adults, and peaked in 2019. Fledgling counts ranged from 9 to 28 and peaked in 2018.

In 2021, there were 66 adults and 18 fledglings recorded. Nest and fledgling success data were particularly detailed in 2021 as the result of a Black Tern population demographics and tagging study (add reference). 56 total nests were monitored with a nest success rate of 7-31%. Of the monitored nests, 30 nests with eggs failed, 1 nest with chicks failed, 5 nests hatched, 2 nests fledged, 1 nest failed without knowledge of whether it hatched, and 1 nest status was unknown. Raccoons were captured on camera predating nests with eggs. It should be noted that while only 2 nests had confirmed fledged, there were at least 11 fledglings from nests that were not monitored. Either disturbance from more intensive monitoring negatively impacted chick survival, chicks moved away from original monitored nests as they are highly mobile, or nests which were highly successful were in locations that were missed by monitors early on in the season.

In 2022, there were 41 total breeding adults and 8-12 fledglings. A total of 32 nests were monitored with a nest success rate between 21-42%. Of the monitored nests, 18 failed, 1 nest with chicks failed, 3 hatched, 3 fledged, and 1 nest status was unknown.

In 2023, there were 22 total breeding adults and 0 known fledglings. A total of 10 nests were monitored with a nest success rate of 20-90%. 1 nest failed, 2 hatched, and 7 were unknown. Due to the severe decline in adult and nest numbers and concerns with monitoring disturbance, most nests were monitored entirely with cameras. Unfortunately, these cameras were hit by a severe storm that the new battery holder design was not waterproof enough to withstand, so minimal data were collected. One owl was observed on camera and chicks at this nest were not seen after this event and therefore were possibly predated.

Table 1. Known head count and nest success ranges at Wigwam Bay. A nest is considered successful if at least one chick hatched.

YEAR	ADULT COUNT	KNOWN FLEDGE COUNT	NEST SUCCESS RANGE
2018	74-76	20-28	51-84%
2019	114	9-11*	24-56%
2020	76-84	12-13*	35-68%
2021	66	18	7-31%
2022	41	8-12	21-42%
2023	22	0	20-90%

*Count is possibly or likely an underestimate

Figure 1. Nesting substrate types at Wigwam Bay State Wildlife Area. These include tussock-dominated areas (A) with tussock-mound nests (B) and water lily–dominated areas (C) with floating lily-muck mat nests (D). Photos: David Fuller.

Wigwam Bay Nesting Substrate

The largest known breeding location, up until 2022, was primarily dominated by sedge tussock and waterlily (Figure 1A). This area was referred to as the Sedge sub-colony. Nests in the Sedge sub-colony were typically built beside tussock grass on floating mounds (Figure 1B), and occasionally on lily muck mats created by floating root masses. In all other sub-colonies, nesting substrate entirely consisted of floating lily muck mats (Figure 1C & D). At Wigwam Bay, we have documented approximately 4 sub-colonies, which we refer to as Sedge, North, East, and Southeast sub-colonies.

Wigwam Bay Habitat Summary by Year (2021-2023)

2021: The Sedge sub-colony of the impoundment was dominated by waterlily, cattail, grasses and grasslike sedges with very little interspersion of open water. Unvegetated areas consisted of mostly mudflats. Some pickerelweed, purple loosestrife, and woody shrubs were also present. The North, East, and Southeast sub-colonies of the impoundment were all dominated by waterlily. The North and Southeast sub-colonies had an interspersion of about 40% open water and 60% emergent vegetation while the East sub-colony only had about 20% open water and 80% emergent vegetation. The East sub-colony also had some cattail presence, and the Southeast sub-colony had slight presence of pickerel weed, cattail, and grasses and grasslike sedges.

2022: The Sedge sub-colony of the impoundment was again dominated by waterlily, grasses and grasslike sedges but this time only with slight presence of cattail. The amount of open water slightly increased from 2021 but was still 60% emergent vegetation and 20% scrub/shrub. The unvegetated areas also still had a large area of exposed mudflats with about 50% mud and 50% water deeper than 10 inches. Other vegetation that was present included purple loosestrife, water willow, fern, and pickerel weed. The North and East sub-colonies of the impoundment were both dominated by waterlily with slight presence of cattail, though, the East sub-colony had very little emergent vegetation relative to open water while the North sub-colony had 60% emergent vegetation and 40% open water. The South sub-colony was dominated by cattail and water lily with slight presence of pickerelweed. Half of the area was covered by emergent vegetation and scrub/shrub and the other half was mostly open water with some mud flats.

2023: The Sedge sub-colony of the impoundment, much like 2022, was dominated by waterlily and grasses and grasslike sedges with slight presence of cattail and pickerelweed. The sub-colony was nearly 100% emergent vegetation with very little open water interspersed. Both the East and the Southeast sub-colonies were dominated by water lily and cattail with slight pickerel weed presence. The Southeast sub-colony had an interspersion of 50% open water and 50% emergent vegetation while the East had approximately 25% open water to 75% emergent vegetation. The northern portion of the East colony was dominated by water lily with only slight presence of cattail and had interspersion of 25% open water and 75% emergent vegetation. The North sub-colony was dominated by water lily which, made up 90% of the area with the remainder being open water. The western portion of the North colony was dominated by both water lily and cattail and had an interspersion of 50% open water and 50% emergent vegetation.

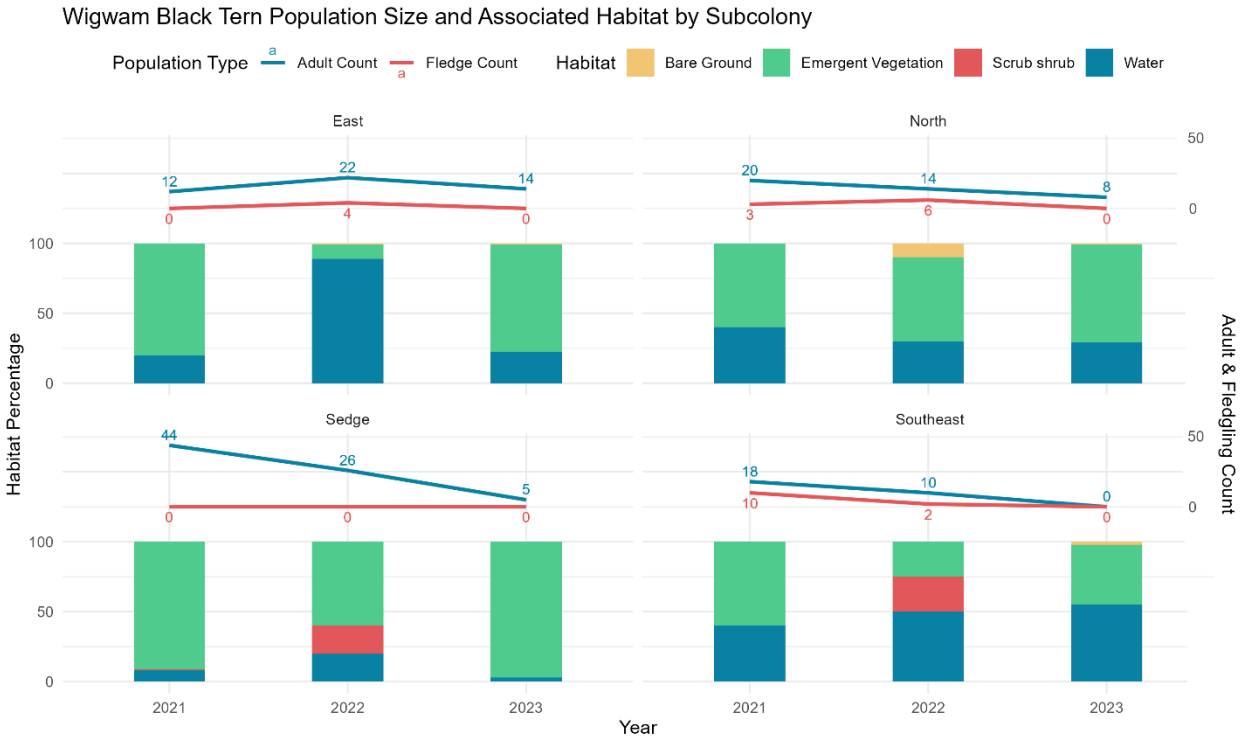

Figure 2. Wigwam Black Tern population size and associated habitat percentages by sub-colony. Note that the habitat data collected focused on areas where terns were nesting within the sub-colony area rather than the same area over time. If terns were not nesting in the sub-colony in a given year (e.g., Southeast, 2023) habitat was assessed where terns colonized the previous year.

Map of Wigwam State Wildlife Area

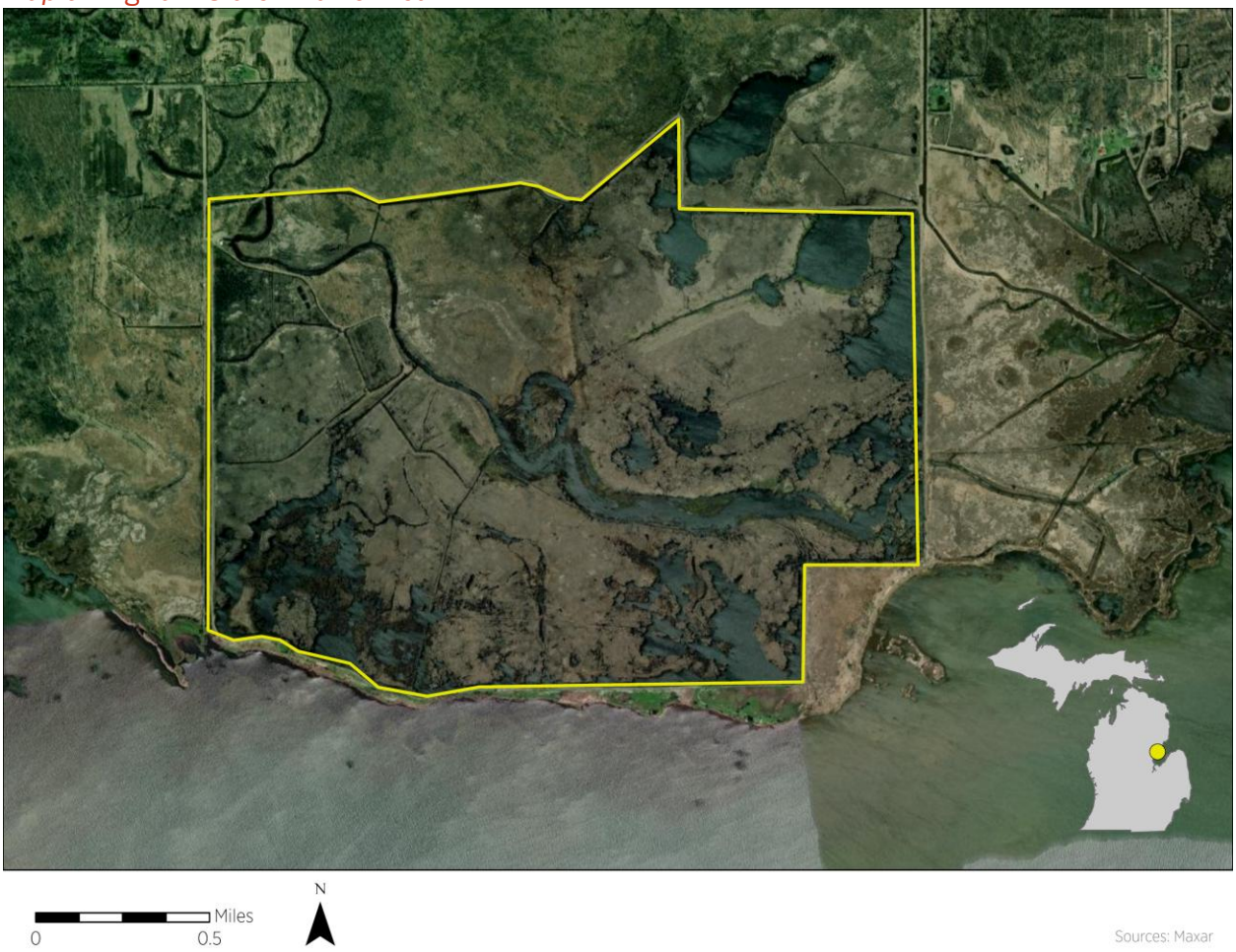

Figure 3. A map highlighting the diked unit of Wigwam State Wildlife Area where Black Terns were monitored between the years of 2018 and 2023.

Wigwam Bay Threats

Disturbance: Disturbance is extremely minimal at Wigwam Bay State Wildlife Area. However, it should be noted that human disturbance caused by monitoring efforts that require entry into the marsh in close proximity to nesting colonies, particularly after chicks hatch, could have detrimental consequences to chick survival. We implemented and highly recommend setting up cameras on nests as early in the season as possible and before nests hatch, monitoring remotely throughout the season. Flush counts should be as brief as possible, ideally under 10 minutes, and only target adults (e.g., avoiding proximity to nests which may result in chicks fleeing).

Habitat Availability: The Sedge sub-colony generally appeared to provide high-quality habitat and nesting opportunities. However, most Black Terns left the Sedge sub-colony starting in 2022, which we suspected was a result of rampant racoon predation. Habitat change was ruled out as a potential culprit, as nesting availability did not change in the Sedge sub-colony by any significant way across 6 years of monitoring. Unfortunately, in 2023, there were comparatively fewer nesting opportunities in other areas (Southeast, East, and North sub-colonies), due to an apparent lack of lily muck mats.

Predators: Raccoon predation on eggs was recorded in every year between 2019-2022 (Figure 4A & B). Mink were also captured predating eggs in 2022 (Figure 4C). Owls were documented in 2021 and 2023, likely hunting chicks (they investigated, but did not predate eggs,

Figure 4D). It's likely that raccoon predation was extensive, especially in the Sedge/South Sedge region, given that large numbers of nests failed around the same time as raccoons were detected on camera in the same sub-colony.

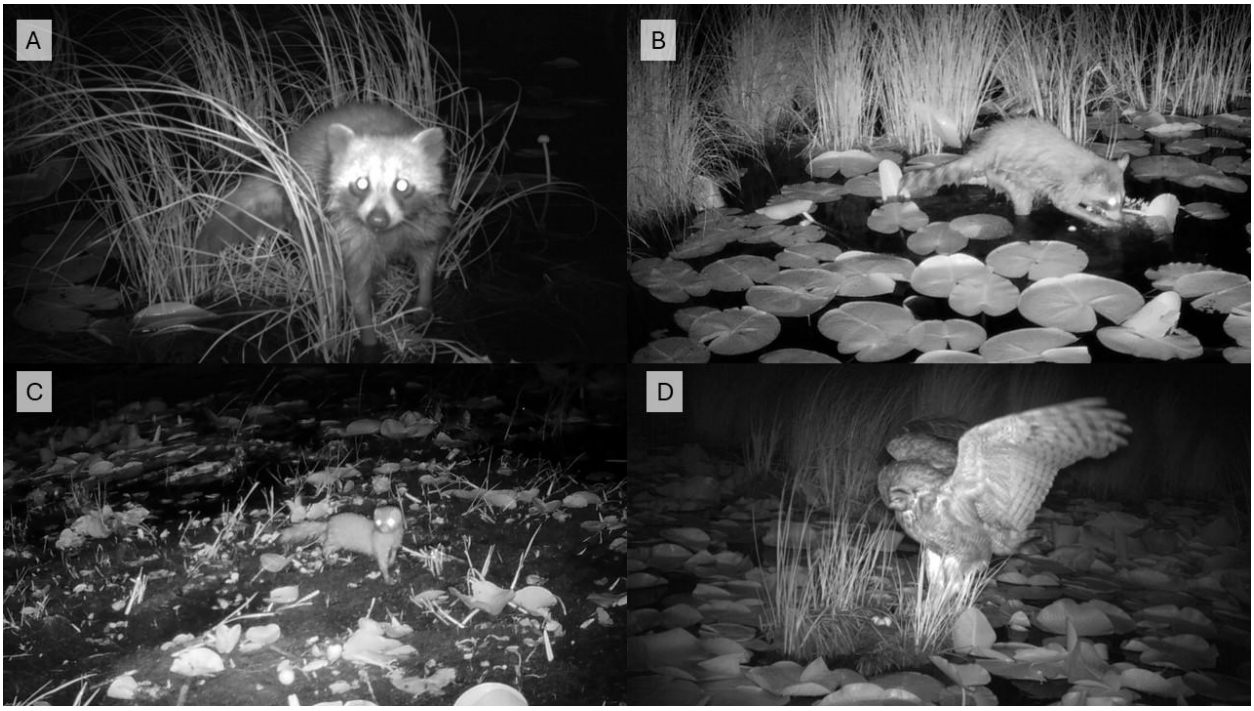

Figure 4. Examples of predators captured on camera at Wigwam Bay State Wildlife Area, including raccoons (A & B), mink (C), and great-horned owl (D).

Weather: Nests in the Sedge sub-colony appeared relatively stable based on camera evidence during storms, likely because of their height above the water. However, we observed some nests on lily muck mats either flooded or disappeared after major storm events in other parts of the colony (Southeast, East, North sub-colonies). In one case, a nest was found saturated but still incubating. We suspect that flooded lily muck mats may have still been anchored to the bottom, preventing them from floating to the surface during heavy rainstorms. We were unable to confirm further nest flooding on cameras.

Wigwam Bay Data Gaps

Disturbance: It is likely that monitoring efforts involving human entry into the marsh causes disturbance, however, the extent of the effects on chick survival remains unknown and therefore a cautionary approach should be taken if monitoring continues.

Predators: We do not know the exact extent of racoon predation (where, approximately how many raccoons are predating tern nests, how many nests can be taken in one night). Similarly, we have same questions for mink and owls. There were also sightings of river otters in 2018, though they have not yet been captured on nest cameras.

Weather: We do not know how severely weather impacts nests and what types of nests are more susceptible, though we suspect nests in the Sedge sub-colony are better protected than elsewhere due to their often more stable tussock-mound substrate that rests higher above water level than lily muck mats (Figure 1B & D).

WIGWAM BAY OBJECTIVES AND ACTIONS

Disturbance: While the extent of human disturbance impact on chicks is unknown, utilizing nest cameras for monitoring and avoiding human presence in the marsh is recommended to avoid any possible detrimental disturbance, especially around hatch period when chicks are highly mobile and vulnerable.

Habitat, Predators, and Weather: As of 2023, little nesting habitat existed outside of the Sedge sub-colony and this sub-colony experienced significant predation, presumably rendering it unsuitable for nesting. While the Sedge sub-colony otherwise provided optimal nesting habitat, the creation of nesting habitat elsewhere in the Wildlife Area may have offered opportunities to evade the heavy predation that occurred in the Sedge sub-colony. Suitable tussock sedge habitat in other regions of the Wildlife Area was limited due to dense stands of invasive hybrid cattail and *Phragmites*. We recommend management of the cattails and *Phragmites* in a way that will increase interspersion of open water relative to emergent vegetation while allowing for establishment of more diverse vegetation, including tussock sedge, that will improve nesting habitat for Black Terns.

We recommend using a cookie cutter as a method for mechanically cutting dense cattail stands to improve habitat structure. While some of the cut vegetation can be left in the marsh to serve as temporary floating material, we recognize that long-term nesting habitat requires more stable, naturally occurring floating root-muck mounds. To promote the formation of these mounds, some of the cut and floating material should be strategically retained in shallow areas where natural accumulation and decomposition can occur, while excess vegetation should be removed to ensure open water areas persist and allow for the establishment of other native vegetation. To further support natural nesting substrate formation, management should be paired with periodic water level manipulations (where feasible) to encourage sediment deposition and the development of floating organic mats.

Application of herbicide could also be considered to treat the stands of *Phragmites* in the late summer to early fall when the plants are actively moving nutrients to their roots to increase efficacy (Great Lakes Phragmites Collaborative, 2024). Treated vegetation should be flattened, cut, or removed via prescribed burn, if water levels allow. When treating invasive vegetation adjacent to high-quality tussock sedge areas, we recommend hand wicking or using backpack sprayers and avoiding broadcasted herbicide application methods as to minimize impact on native vegetation and herbicide drift.

A management method that we recommend exploring further for Wigwam Bay SWA is the opportunity to manipulate water levels within the impoundment. The impoundment currently has passive water drainage but no ability to add water to the unit. We recommend conducting a feasibility study to better understand the hydrology and bathymetry of the unit and the potential to add water into the system, or drawdown the unit lower than water level in Saginaw Bay, via pumps or other water control structures. If deemed feasible, the added water level management would offer an additional and cost-effective method of invasive vegetation control by means of increasing water levels to drown out the invasive species and then dewatering to allow native vegetation to establish (Kaminski et al., 2018; Sojda and Solberg, 1993). Lower rates of raccoon predation were observed in the North sub-colony which may be due to its higher water levels making it more difficult for raccoons to reach the nests. The ability to manipulate water conditions may be used as an option to further dissuade raccoons.

By implementing the habitat management strategies outlined above, we expect to achieve the following outcomes: greater diversity of native vegetation, more available habitat and floating mats for nesting Black Terns, and improved resilience to storm events.

Manmade nesting platforms are another management strategy to be considered. Platforms may offer additional nesting opportunities and increased protection from predation and storm events (see "Other recommendations" below).

Portage Marsh State Wildlife Area (SWA)

PORTAGE MARSH RESULTS & ANALYSIS

Portage Marsh SWA is a 600-acre coastal wetland located in Delta County along the Upper Peninsula's Lake Michigan shoreline. The area is managed by the Michigan DNR and the breeding Black Tern colony is located within Portage Bay, on the northern margin of the bay's long, narrow peninsula. CCRC conducted Black Tern monitoring between

2019 and 2024, which included shoreline and flush counts (adults and fledglings if possible), nest documentation (GPS coordinates), and monitoring of nest outcome (nest checks or cameras). Habitat surveys were conducted in 2021 and 2022 during the peak growing season.

Portage Marsh Population Statistics by Year (2020-2023)

Breeding Black Terns were absent from Portage Marsh SWA prior to 2019 with non-breeding individuals reported only in 2010 and 2012. In 2020 there were 8 breeding adults and 10 breeding adults in 2021, with a minimum of 4-6 fledged terns in both 2020 and 2021. Sixteen nests were documented in 2022, 11 of which were monitored with cameras. There were relatively high failure rates due to abandonment after storm, seiche, and wind activity and two instances of predation, one of which was caused by mink, the other unknown. Of the 11 nests, 1 chick fledged, 2 failed due to abandonment, 2 to predation, 5 to storms, and 1 by an unknown cause. In 2023, there were 10-14 breeding adults and only one chick fledged out of 6 total nests. CCRC deployed 12 artificial platforms, though none were used by terns. In 2024, a maximum of 8 breeding adults and 2 nests were reported. Both nests failed likely from storm activity in June.

Portage Marsh Nesting Substrate

Nesting substrate primarily consisted of bulrush and cattail mats (Figure 5).

Figure 5. Example of a late-season bulrush-substrate nest with black tern chick at Ogontz Bay, exhibiting a similar nesting habitat to Portage Marsh. Photo: Joe Kaplan.

Portage Marsh Habitat Summary by Year (2021-2022)

2021: The habitat where Black Terns are nesting outside of the impoundment at Portage Marsh SWA was 60 percent covered by emergent vegetation with the dominant species being cattail. There was slight shrub presence, and the remainder was open water estimated to be greater than 10 inches deep.

2022: Cattails were again the dominant emergent vegetation species and existed in islands outside of the lagoon. Within the cattails were limited mats of bulrush debris that the Black Terns were using for nesting.

Map of Portage Marsh State Wildlife Area

Figure 6. Map of the area at Portage Marsh State Wildlife Area where Black Terns were surveyed for.

Portage Marsh Threats

Disturbance: In general, Portage Marsh SWA does not have frequent human activity, though airboats are occasionally used during high-water years. Airboats are noted to cause a considerable level of disturbance, as most birds appear to take flight when these are being used in the area. The presence of boats from carp bow-hunting activity at night may cause disturbance as well if use-area overlaps with nesting areas during the breeding season.

Habitat Availability: Inadequate nesting substrate and greatly fluctuating water levels are the primary limitations to the Portage Marsh SWA breeding colony. A large portion of the marsh is dominated by a dense cattail monoculture without standing water, leaving Black Terns to primarily use cattail islands to the east, closer to areas of open water. There has been a growing deficit of bulrush mat, likely due to a combination of factors: high-water years causing flooding and washing away the beds, leading to dieback and unvegetated mudflats, as well as adjacent landowners spraying or manually removing the bulrush. Cattail mats are also limited due to a lack of snow and ice formation during winter, which helps to shear off cattail stems at the ice layer, creating layers of floating dead vegetation that can be used for nesting (as observed in 2019-2020). Finally, renesting of Black Terns may be limited in Portage Marsh SWA because limited mats are overtaken by fast growing cattail in July and August creating dense mats that may serve to limit nesting success. This obstruction is not an issue during early nesting initiation (May and June). Floating mats utilized early for nesting are largely inundated and broken up by July.

Predators: While predator pressure does not appear to be the greatest threat to breeding Black Terns in the area, mink predation has been documented by cameras on multiple occasions.

Weather: Storms and/or seiche events appear to heavily impact nesting success at Portage Marsh SWA, depending on the severity and frequency of that year. For example, in 2023, storms accounted for 45% of nest losses. We consider stochastic weather events during early breeding (June) to be an important factor for determining nesting success.

Portage Marsh Data Gaps

Habitat Availability: We do not currently know if there are any impacts on habitat availability as a result of invasive Eurasian water milfoil presence in the area. Additionally, Mute Swans are present and may displace nesting terns, but their impact of habitat-use and nesting success at Portage Marsh SWA is unknown and there has only been one pair of Mute Swans noted in the area of the nesting Black Terns since 2023.

PORTAGE MARSH OBJECTIVES AND ACTIONS

Disturbance: During times when airboats were causing disturbance, it was noted that Michigan DNR Law Enforcement was successful in preventing the airboats from returning. We recommend continued communication between local land managers and Michigan DNR Law Enforcement to monitor the area and intercept any additional airboat usage should it occur. Educational postings at recreational access points in the area to inform the public of the impacts certain recreational activities may have on Black Terns and other wildlife and why certain activities may be prohibited should also be considered to prevent airboats and other highly disruptive activities from occurring before law enforcement needs to get involved.

Habitat, Predation, and Weather: Due to the recent warm winters and lack of ice formation in the marsh, it has not been possible to manage the dense monocultures of cattails by means of shearing the cattails from the ice. This method would also create material for floating nesting mats. However, because of the lack of ability to take advantage of this natural process, we recommend treating the cattails via other means such as dredging to create potholes and channels, cutting below the water line in mid-summer, and herbicide application in early fall.

We recommend prioritizing the establishment of bulrush mats as a key strategy for enhancing nesting habitat conditions within the Black Tern breeding area (Figure 6). While dredging and cattail removal can serve as methods for creating planting sites, the primary goal should be to replace dense cattail monocultures with a more diverse emergent plant community. Dredging in select areas, such as the interior of the unit, is one method that can help improve interspersion of open water and emergent vegetation, benefiting Black Terns and other secretive marsh birds (Johnson and Poiani, 2016). Additionally, dredged material can be used to construct barrier islands off Portage Point, increasing resilience to storm and seiche events (O'Brien and Zedler, 2020). These islands, along with areas where cattails have been cleared, should be prioritized for bulrush plantings to promote greater habitat diversity and stability.

Increasing the available habitat through the recommended methods above may help mitigate predation, benefiting not only Black Terns but also other wetland wildlife. A lack of sufficient suitable habitat may be increasing susceptibility of Black Terns to predators and heightening competition for resources with other wildlife. By increasing available habitat, we may be able to decrease competition pressures and further camouflage Black Tern nests from predators.

Testing the usage of nesting platforms may also be considered to offer additional nesting opportunities, predator deterrence, and resilience to storm and seiche events (see "Other recommendations" below).

Munuscong State Wildlife Management Area (SWMA)

MUNUSCONG RESULTS

Munuscong State Wildlife Management Area is a habitat-diverse 14,200-acre region in Chippewa County along the Upper Peninsula's St. Mary's River shoreline managed by the Michigan DNR. The region is also an area of cultural significance to the Sault Ste. Marie Tribe of Chippewa Indians. The Sault Tribe Wildlife Program has been involved in collaborative invasive species management since 2011 and began restoration efforts of wild rice (Manoomin) in 2018 with plans to expand these efforts throughout the 1836 Treaty Ceded Territory (Sault Ste. Marie Tribe of Chippewa Indians, 2024). The Black Tern colony has primarily been located within the breached diked unit (in 2021 during high water levels) and has since moved outside the diked unit making two larger sub-colonies in the greater coastal

wetland referred to hereafter as Munuscong Bay North and South sub-colonies. Black Tern monitoring was conducted by the Sault Tribe between 2021 and 2023, which included shoreline and flush counts (adults only), opportunistic nest documentation (GPS coordinates), and camera monitoring of said nests.

Munuscong Population Statistics by Year (2020-2023)

In 2021, there were 24 breeding adults observed within the Diked Unit sub-colony, though other information on fledgling counts and nesting success was unknown. In 2022, the overall count increased to 93 breeding adults in Munuscong South sub-colony. Six nests were monitored by cameras, but these did not collect conclusive data. Fledgling and nest success information was similarly unknown. In 2023, the overall count increased to 99 breeding adults in the Munuscong South sub-colony, along with an additional 73 adults in Munuscong Bay North sub-colony. Six nests were monitored with cameras, 3 of which hatched chicks, one of which may have fledged. The final status of the other 3 nests was unknown.

Munuscong Nesting Substrate

Black Terns primarily used edges of narrow-leaf cattail monocultures where mats of vegetation accumulated for nesting. These areas were often adjacent to areas of open water. While bulrush was present, bulrush mats did not form in Munuscong Bay and did not provide Black Terns with suitable nesting substrate.

Munuscong Habitat Summary by Year (2021-2023)

2021: In 2022, three sub-units totaling an area of 10 acres within the Munuscong South sub-colony were surveyed for vegetation. On average, the three units were dominated by cattail with some presence of either smartweed and arrowhead, water willow and water lily, or grasses and grasslike sedges. Open water averaged at 32% of the area, and emergent vegetation at 65%.

2022: The Munuscong South sub-colony was dominated by cattail and consisted of 40% open water and 58% emergent vegetation.

2023: The Munuscong South sub-colony was dominated by cattails and consisted of 50% open water and 45% emergent vegetation. While two more Black Tern sub-colonies were identified in 2023 (Munuscong North sub-colony), vegetation surveys were not conducted in these areas.

Map of Munuscong State Wildlife Management Area

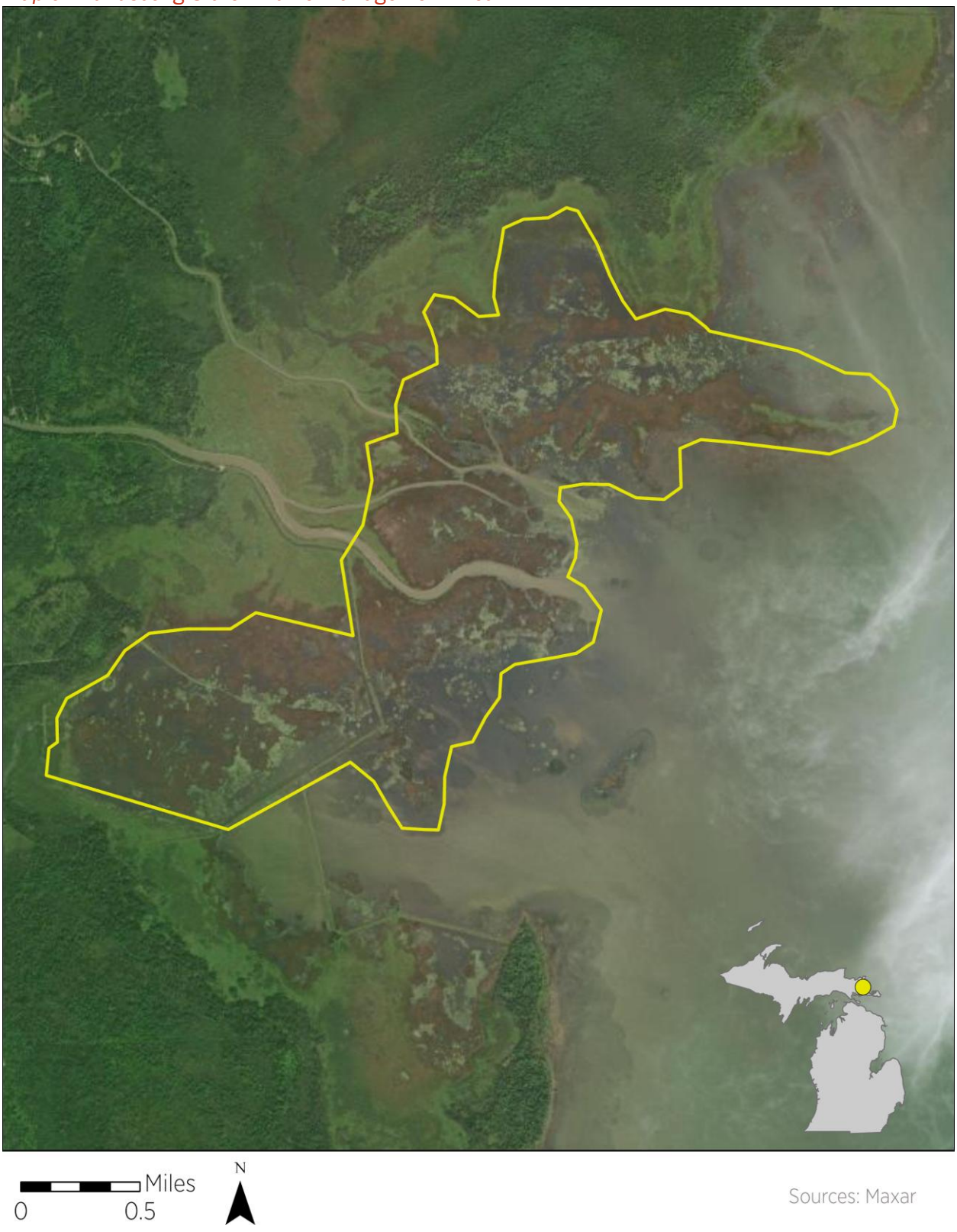

Figure 7. Map of the portion of Munuscong State Wildlife Management Area where Black Terns have been documented breeding and monitored.

Munuscong Threats

Disturbance: Heavy boat traffic was present in Munuscong SWMA but was not frequently reported near nesting areas. Muskrats were observed stepping on nests but did not seem to cause any issues.

Habitat Availability: Hemi-marsh is a type of marsh that is roughly equal parts open water and emergent vegetation that provides diverse habitat structure for wildlife. In general, hemi-marsh was readily available at Munuscong SWMA, though in the future, nesting could become limited if cattail stands become increasingly dense and open water is lost. Additionally, there was a lack of bulrush, which is a preferred nesting substrate for Black Terns.

Predators: Potential predators in the area were primarily birds of prey and northern pike, both of which may target pre-fledged chicks.

Weather: High winds break apart nesting mats fairly often, which may be due to the relatively more exposed nature of nesting areas on the coastline (e.g., Munuscong North sub-colony) as opposed to nests within the Munuscong South sub-colony.

Munuscong Data Gaps

Fledgling Success: Overall nesting success and fledgling output here was unknown.

Predators and Weather: Due to the lack of or limited data from in-person and/or camera monitoring, we were not able to identify relative impacts of threats such as predators and weather events (e.g., wind, waves, water fluctuations) on nesting success and if either were a limiting factor to the population.

MUNUSCONG OBJECTIVES AND ACTIONS

Habitat and Weather: We recommend monitoring the existing stands of cattail. If hemi-marsh conditions become degraded, consider herbicide treatment in late summer to early fall, or mechanical control in mid to late summer, or a combination of those means. Herbicide should be avoided in favor of mechanical control where concerns exist about its use or where wild rice is present.

We recommend the consideration of wave energy attenuation features such as barrier islands and vegetation shoals outside of the impounded area. These features, which can be planted with bulrush and other native emergent vegetation, can help to reestablish bulrush habitat to provide additional nesting opportunities for Black Terns, while offering increased protection and resilience to high winds experienced in the bay which can break apart nesting mats (O'Brien and Zedler, 2020).

Disturbance, Predators, Other, and Data Gaps: Unfortunately, camera monitoring data was limited due to technical issues (e.g., short lifespan of camera batteries due to high frequency timelapse settings of 30s). Six cameras were deployed in 2022 and 2023, however, no conclusive data was collected in 2022 due to cameras shutting off too early. Cameras collected more data in 2023, but only 3 out of 6 nests captured nesting events (e.g., hatching, failure). To better understand the extent of impact from disturbance, predators, and weather events, we recommend more extensive monitoring using nest cameras and extra care taken to prevent technical issues (e.g., using less battery-intensive settings such as lower timelapse frequency, deploying cellular cameras that can remotely communicate battery status). The cameras should be deployed early in the breeding season prior to hatching. Extensive monitoring could give us a better understanding of the primary driving forces on the Munuscong SWMA Black Tern colony and if there are other management efforts that should be prioritized.

Manmade nesting platforms may offer increased resilience to potential predation and weather events that break Black Tern nesting mats apart. We recommend the consideration of testing different platform designs (see "Other recommendations" below).

Tawas Lake

TAWAS LAKE RESULTS

Tawas Lake is a shallow (max depth = 5-ft), 1,600-acre lake in Iosco County, just north of Saginaw Bay and roughly 1-mile inland from the Lake Huron shoreline. Much of the area is managed by the Saginaw Chippewa Indian Tribe of

Michigan, and is home to the state's largest intact wild rice bed (Manoomin) (Thompson 2020). Black Tern colony is primarily located throughout the central northeast portion of the lake where the wild rice beds are present. Black Tern monitoring was conducted by Audubon Great Lakes volunteers and monitoring technicians in 2023, which included shoreline and flush counts (adults and fledglings when possible), opportunistic nest documentation (GPS coordinates) and camera monitoring of said nests. Habitat surveys were also conducted in 2023 during the peak growing season.

Tawas Lake 2023 Population Statistics

In 2023, there were between 116 and 138 breeding adults, with 18 to 20 fledglings. Fledgling count was likely an underestimate given the census was taken later in the season (late July) and could have been as many as 68. The maximum estimated count was 138 adults observed on June 24th. Some satellite sub-colonies were found with 6-12 adults, but the largest congregation of adults consisted of anywhere between 80 and 100 adults. This largest sub-colony also had approximately 25 nesting Forster's Terns and 5 Caspian Terns in the same area (breeding activity was unknown). On July 29th, 48 adults were observed along with a rough estimate of 18-20 fledglings. It's likely that many of the adults and fledglings were already moving south at this time. Local eBird counts found 86 adults on Tawas Point on July 20th, with many immature Black Terns present. 33 Black Terns were observed on Tawas Point on July 26th, apparently most of which were juveniles. Another eBird observation from that date counted 5 adults with 10 juveniles. Assuming the fledglings sighted on Tawas Point originated from Tawas Lake, the ratio of adults to successful fledglings could have been 1:1.

Tawas Lake Nesting Substrate

Black Terns appeared to predominantly use nesting substrate consisting of mud and root mats, surrounded by wild rice (Figure 8).

Figure 8. Wild rice dominant habitat used by Black Terns at Tawas Lake (left) and nest atop shallow wild rice bed and surface root-mats (right).

Tawas Lake 2023 Habitat Summary

Tawas Lake is a 1,600-acre natural lake, relatively shallow with an average depth of 5-ft. In 2023, the northeastern portion of the lake was dominated by extensive cultivated wild rice hemi-marsh that was largely inaccessible by most boats. The wild rice appeared to create a deep layer of root mass and muck of varying depths (1-4-ft), which Black Terns were using for nesting. Other vegetation included waterlily and pickerelweed. Thick cattail was only dominant along the shoreline. It was noted after discussions with residents that these cattail stands were preventing boat

access from most of the southern residential shoreline. Therefore, boaters were limited to using the boat launch on the far southern end. The northern side of the lake is entirely forested with no public access.

Habitat data collected via Survey123 confirmed that all sub-colonies were dominated by wild rice with some presence of pickerelweed, waterlily, or rushes. Most of the area had little open water relative to emergent vegetation with open water ranging from 4-20% and emergent vegetation cover ranging from 80-96%.

Map of Tawas Lake

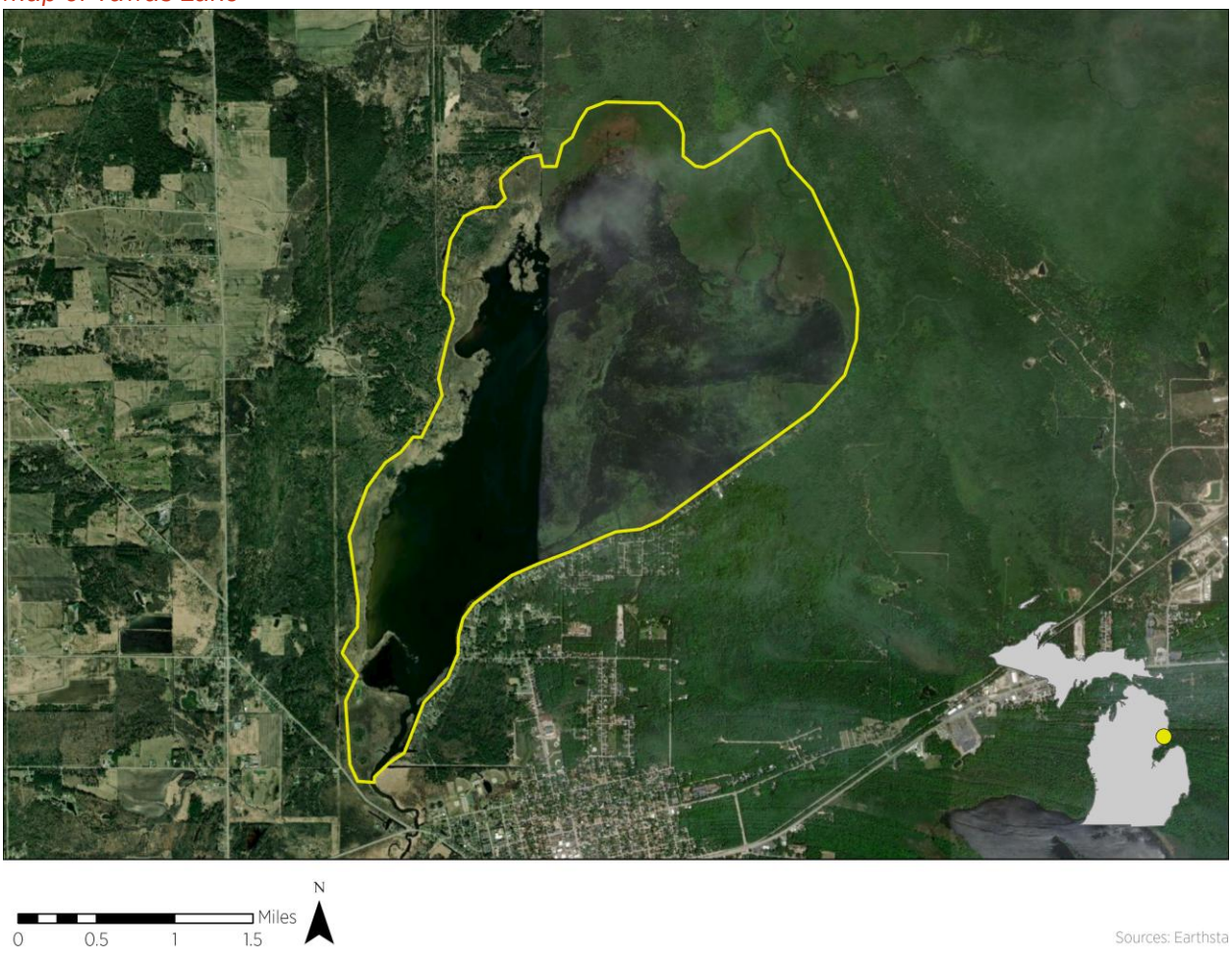

Figure 9. Map showing the boundaries of Tawas Lake where Black Terns were surveyed for.

Tawas Lake Threats

Disturbance: Disturbance at Tawas Lake appeared to be very low. No boats were observed near the nesting areas on either visit in June and July, likely because it was extremely shallow with dense vegetation. Around three fishing boats and a couple of kayaks entered the lake on June 24th but were nowhere near the sub-colonies. For comparison, the nearby Lake Huron shoreline was busy with boaters and beach-recreationists.

Habitat Availability: Nesting habitat here appeared to be extensive and high-quality based on initial observations. Some neighboring residents have expressed concerns about lake accessibility due to emergent vegetation that may impact their support of lake and wild rice management. Establishing positive relationships and communications will be needed to alleviate these concerns. Tuttle Marsh, just north of Tawas Lake appeared to periodically support nesting Black Terns as well, but there was little to no available nesting substrate or breeding activity in 2023. Consistent high population counts reported on eBird indicate that the nearby Tawas Point State Park and Lake Huron may provide important staging and foraging areas as well (Sullivan et al. 2009).

Predators: Large fish were spooked on the surface, though the species was unknown. One large fish was observed splashing the water where a Black Tern was aggressively diving. This was not near any nest and observed from a distance. Local fisherman noted that they have caught very large dogfish in the lake and gar were also spotted from kayaks. It seemed unlikely that chicks were at high risk of fish predation due to the dense submergent vegetation and shallow water surrounding nesting areas. There were also several egrets, some of which were dive-bombed by Black Terns, but it was unknown whether they were predating nests. It did not appear likely that a raccoon could attempt to swim to the nesting areas from the shoreline, outside of one small 2-nest sub-colony that was shoreline adjacent.

Tawas Lake Data Gaps

Colony Size: Given the size of Tawas Lake (1,600 acres) and that volunteers and technicians were limited to kayaks for transportation, we were not certain that it was surveyed in its entirety. Adult Black Terns were also present at the nearby Tuttle Marsh 2021-2023, either sighted by volunteers or eBird users. However, breeding status is unknown and Tuttle Marsh did not appear to have an active breeding colony in 2023. It is possible that Black Terns use the area for foraging or inconsistently use the area for nesting.

Fledgling Output: We estimated fledgling success, however, census timing would have ideally included at least one additional count earlier in the breeding season during peak fledging. This occurs roughly between late June through early July, though this timing can depend on when Black Terns begin nesting at a site and how successful their first clutches are. The observation point at Tawas Point could be a more reliable point for estimating the Black Tern population of the area, but only given the assumption that birds observed there originated from Tawas Lake.

Predators and Weather: We did not confirm evidence of what predators had access to eggs or chicks, or what level of pressure they had on nesting success. We also did not confirm to what extent and severity weather (e.g., wind, waves, water fluctuations) impacted nesting success.

TAWAS LAKE OBJECTIVES AND ACTIONS

Habitat: Wild rice (Manoomin) has appeared to be highly beneficial for the Black Terns at Tawas Lake. Because of this, collaboration with the Saginaw Chippewa Indian Tribe and other stakeholders of Tawas Lake to maintain and protect wild rice beds on the lake is critical. We recommend engagement with the Tawas Lake Association to educate stakeholders on the importance of wild rice. Stakeholders have expressed a concern for lack of recreational access to the lake. While the specific cause of these concerns is unclear, it may be a result of thick cattail blocking access along the lake's shoreline, and/or the large extent of restored wild rice on the shallow, marsh-dominated, northeastern portion of the lake limiting overall recreational usability. We recommend collaboration between the Tawas Lake Association, Michigan DNR, the Saginaw Chippewa Indian Tribe, and other local conservation organizations to treat invasive vegetation that may be impeding recreational access. Invasive vegetation management and improved recreational access should allow for wild rice and the Black Terns to thrive while offering recreational opportunities on the lake that are distant from the nesting locations.

Disturbance, Predators, Other, and Data Gaps: While there are several potential factors that could influence the Black Tern colony at Tawas Lake, their specific effects and extent remain unknown. We recommend continued monitoring of the colony including thorough head counts of adults and fledglings throughout the breeding season. For areas of the lake that are less accessible, we recommend deploying nest cameras early in the breeding season prior to hatching, to avoid increased disturbance. Nest camera data will help us better understand any potential disturbance, such as that from human recreation on the lake, and any predators that may be significantly impacting nesting success. It will also help us better understand the full extent of the colony and potentially reveal additional details about habitat usage and threats. In turn, new knowledge will help to better inform management and community engagement needs at Tawas Lake.

Shiawassee National Wildlife Refuge (NWR)

SHIAWASSEE RESULTS

The Shiawassee NWR is a 9,501-acre wetlands complex in Saginaw County roughly 24 miles south of Saginaw Bay, where the Tittabawassee, Shiawassee, and Crass Rivers merge in the lower peninsula to form the Saginaw River. The area is managed by the U.S. Fish and Wildlife Service and is predominantly (75%) marshes, wetlands, and

bottomland-hardwood forest. Volunteers and technicians located small sub-colonies throughout the diked wetlands units, and suspect that Black Terns occupied a portion of the river delta as well (Figure 11). Black Tern monitoring was conducted by Audubon Great Lakes volunteers in 2022 and a combination of volunteers and technicians in 2023, which included shoreline and flush counts (adults and fledglings if possible), opportunistic nest documentation (GPS coordinates) and camera monitoring of said nests. Habitat surveys were conducted in 2022 and supplemented with photo points in 2023.

Shiawassee Population Statistics by Year (2020-2023)

In 2022, 6-17 breeding adults were observed in the Shiawassee NWR diked units. 6-8 adults were observed on June 15th, and 2-3 on June 17th. Another 6 adults were observed on July 11th, far from the area surveyed on June 15th, but close to the shoreline count on June 17th. Dive-bombing behavior was observed, indicating likely nesting activity, but no nests were located or monitored. In 2023, 18 to 20 breeding adults were observed. The maximum adult count was taken on June 19th. 10 adults were flushed in one sub-colony with suspected nesting activity. Otherwise, no nesting activity was observable from the road. Only 1 juvenile was spotted, and general behavior seemed to indicate re-nesting. Three cameras were deployed at potential nest sites identified by territorial and courtship behaviors of Black Terns. One out of three potential nests laid and began incubating 3 eggs, but inclement weather shut the camera off before final results. Two chicks and 1 egg were observed in front of one of the nest cameras by a volunteer on July 12th.

Shiawassee Nesting Substrate

Few nests were found to confirm a dominant nest substrate, but those that were found used root muck mats from either water lily or large-leaved pondweed (Figure 10A & B). While water lily and pondweed vegetation coverage was extensive, with very little to no root muck-mats present in 2023 (Figure 10C), similar to Wigwam during the same year. We are not sure if this is due to the extreme drought conditions and shallow waters or another cause.

Figure 10. Images of one confirmed Black Tern nest (A & B) that hatched at least one chick (B) at Shiawassee NWR. The habitat surrounding this nest was dominated by water lily and pondweed but very little to no root mats for nesting (C).

Shiawassee Habitat Summary by Year (2022-2023)

2022: The dominant vegetation was cattail with slight presence of floating dead vegetation within the Maankiki South Unit. The area was covered by 30% emergent vegetation and the remainder was open water.

2023: The Maankiki South Unit was observed by the same volunteer as in 2022. Photos showed areas with interspersion of open water with water lily, some rushes, and cattail stands on the perimeter (Figure 11A). Dense stands of cattail were observed along the road on the eastern side (Figure 11B). The open water areas were noted to be much shallower than in 2022 (Figure 11C).

Figure 11. Photo examples of the habitat at Shiawassee National Wildlife Refuge in 2023.

Map of Shiawassee National Wildlife Refuge

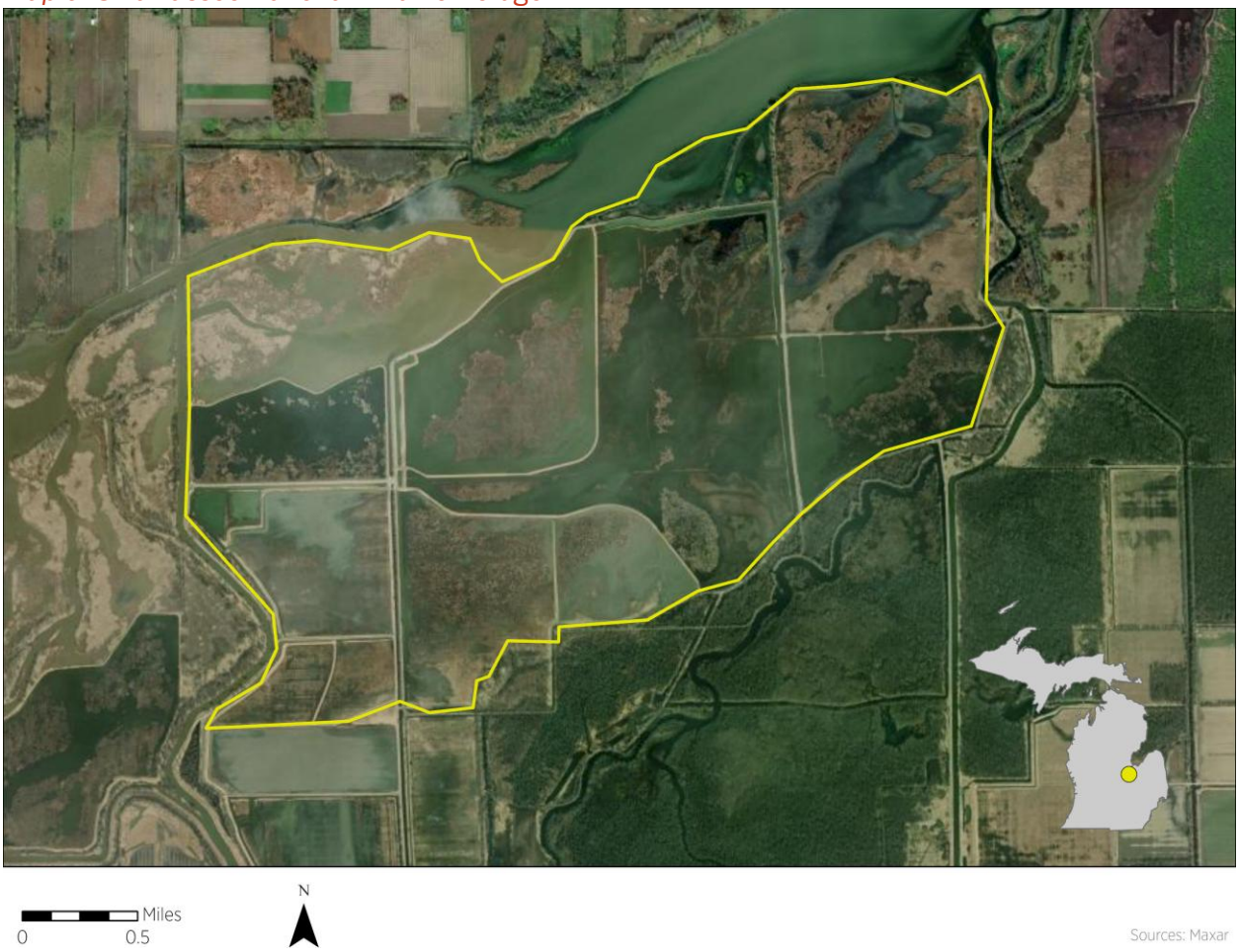

Figure 12. Map of the Shiawassee National Wildlife Refuge area where Black Terns were surveyed for.

Shiawassee Threats

Disturbance: There is little to no disturbance by boaters since this is a protected area and the cars and birdwatchers on the dike did not seem close enough to be detrimental. Carp were abundant on the Shiawassee River (kayak survey location, Figure 12), though there were no muck mat nests or sub-colonies here.

Habitat Availability: While there appeared to be extensive hemi-marsh with high interspersion, we saw little to no mats for nesting in 2023. This may change from year to year as a result of water level and habitat management and weather patterns.

Predators: There appeared to be several potential predators at Shiawassee NWR, particularly raccoons. One was spotted in broad daylight within Maankiki South, along with several egrets. Black Terns were nesting in this area in 2022, but in 2023 the habitat was shallower and dominated by other species (egrets, herons, and ducks**;** Figure 11C). Four raccoons were spotted just south of Grefe Pool before turning onto Spaulding Drain (unit just south of Figure 11A). The area also appears to attract large raptors such as Northern Harriers which could potentially target chicks.

Shiawassee Data Gaps

Colony Size: Full extent of the colony is not well known, and some parts of the marsh were not fully explored due to accessibility issues, timing, and necessary equipment. USFWS staff reported that several Black Terns were sighted in the State Game Area in 2021 and 2022 (Eric Dunton, pers. comm). This area would be worth searching more thoroughly in the future.

Fledgling Output: Due to severely limited nesting activity observed in 2022 and 2023, nesting success and fledgling outputs were unknown at Shiawassee.

Habitat Availability: We are unsure what causes the fluctuation in available nesting mats such as water lily, or what other substrates might be used in the region.

Predators and Weather: While raccoon predation is likely, we did not have confirmed evidence of predators accessing eggs or chicks, and therefor do not know the level of pressure predators may have on nesting success. We also did not have confirmed evidence of weather impacts (e.g., wind, waves, water fluctuation) on nesting success.

SHIAWASSEE OBJECTIVES AND ACTIONS

Habitat, Predators, Other, and Data Gaps: Because of the lack of root muck mats for nesting in 2023, we recommend gaining a better understanding of what is causing the fluctuations in available nesting substrate. This can be achieved through more thorough on-the-ground habitat monitoring and the use of nest cameras. Nest camera monitoring would also provide a better understanding of predator threats, impacts of weather events on nesting areas, and potential presence and impact of carp.

To supplement the lack of nesting substrate, we recommend shearing cattails during winter if the marsh freezes and allows for access on the ice. The sheared vegetation can be left to form floating mats and provide nesting opportunities for the Black Terns. In areas where cattails have formed dense stands, we recommend using existing water level control structures to add water to the marsh and increase the interspersion of water relative to the emergent vegetation. This will offer improved hemi-marsh habitat for the Black Terns and other marsh birds (Kaminski et al., 2018; Sojda and Solberg, 1993).

Management of the vegetation and habitat through our suggested means may also offer more opportunities to evade predators such as raccoon. Additional predator protection may be achieved through testing of different platform designs (see "Other recommendations" below) and potential addition of roof spikes on nest cameras to dissuade gulls.

Statewide Survey Results

Of the 93 different sites selected for monitoring, 14 sites were considered active (adults present between May and July) for at least one year between 2021 and 2023 (Figure 13).

28 sites were considered active and also breeding (nests or breeding behaviors present). The remaining 50 sites were inactive (at least one year of confirmed inactivity and no other years with activity present) and 1 site was data deficient across all three years (Canadian Lakes). Both the Upper and Lower Peninsula had 46 sites each with data collected either by volunteers, contracted monitors, eBird, or a combination of these (eBird, 2024). Seventy percent of the lower peninsula historical breeding colonies monitored (n = 32) were either still active or active and confirmed breeding at some point between 2021 and 2023. Twenty-four percent of sites in the Upper Peninsula (n = 11) were still active or confirmed breeding during this timeframe. further illustrates the regional Black Tern activity throughout the state. The largest active colonies included St. Clair Flats (200 breeding adults), Munuscong SWMA's diked unit and Allard's Bay (172), Tawas Lake (136), Wigwam Bay SWA (66), Dollarville Flooding (38), and Shiawassee National Wildlife Refuge (35). However, it should be noted that accessibility played a significant role in identifying sites with large breeding colonies, and many of these active breeding areas may have had more Black Terns than what was currently documented. For example, a small portion of Black Terns were observed from the shoreline at Tawas Lake and required extensive kayaking into the marsh before discovering the majority of the breeding population. See Table 2 in the Appendices for detailed results of the statewide survey.

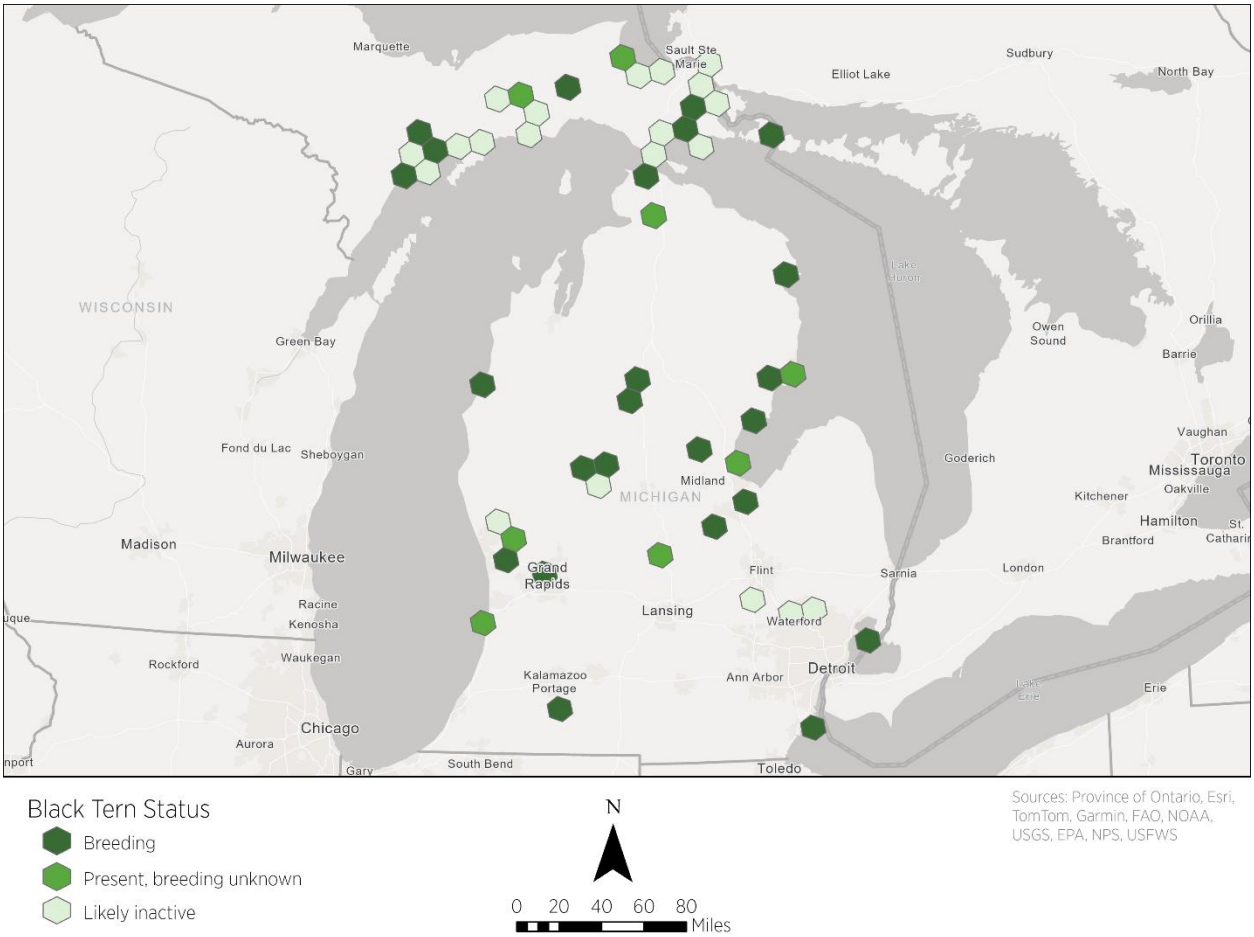

Figure 13. Black Tern presence and breeding activity status across Michigan, derived from volunteer, contracted monitors, and eBird data. Light green regions only contain sites that are likely inactive, green regions contain sites that have Black Terns present, but breeding is unknown, and dark green regions contain at least one site with a breeding colony.

General Recommendations

Platforms

The application of floating, artificial nest platforms may help with Black Tern population recovery by addressing several threats at one time. A well-designed platform can potentially offer multiple benefits, including:

- Preventing nests from sinking if natural materials become too waterlogged by storms
- Preventing nests from breaking apart from wind, waves, or animal disturbance
- Increasing nesting habitat availability in areas where this may be periodically or stochastically limited due to environmental factors (e.g., high water, severe storms, water lily root-mats not rising during breeding season)
- Dissuading aerial predators and possibly larger mammals like raccoon and mink with the addition of a chicken wire nest exclosure

Nest platforms improved nesting habitat availability and success in multiple study locations including British Columbia (Campbell and Nyhof 2015), Wisconsin (Shealer et al. 2006), and the Netherlands (van der Winden 2018). Platforms have also been tested at Portage Marsh SWA, Ogontz Bay, and St. Clair Flats colonies in Michigan with varying amounts of success. Platform design selection depends on three important factors detailed below.

1. **Platform attractiveness:** Black Terns may or may not have interest in using certain designs. The attractiveness of a design may depend on factors such as the habitat type and availability. For example, Black Terns in Ogontz Bay used a small, 30 x 30 cm platform of 3 cm thick foam surrounded by PVC. However, these platforms were entirely avoided by Black Terns at Portage Marsh in 2023 and St. Clair Flats in 2020 despite a severe lack of nesting habitat that year due to high water levels. While reasons for this are unclear, Black Terns at St. Clair Flats readily used a flat, flexible canvas platform design in 2023 and 2024. It may be because these platforms more closely emulated the colony's natural nesting material. In general, it is important to initially test which platforms are attractive to a particular colony, and ensure platforms are similar to the nest substrate as much as possible (e.g., adding muck, grass, or cut vegetation over the top).
2. **Threats:** The type of platform needed in an area will also depend on the primary threats that need to be addressed. For example, for an area with heavy predator activity, a platform with an exclosure may be beneficial, with the caveat that these do pose a risk to adult mortality and avoiding this may outweigh any potential benefit to nesting success. For areas with high levels of wave action, canvas platforms provide a combination of high floatation and flexibility. Canvas platforms may also be more beneficial for large-scale deployments due to ease of transport and low cost per platform.
3. **Deployment feasibility:** Current platforms fall across a wide range of designs, from simple canvas mats to anchored, wooden platforms surrounded with chicken wire. Any design must first attract Black Terns in that area (as noted in bullet 1), address primary local threats, and be feasible to deploy, considering funding, equipment, personnel, time, and site accessibility.

Monitoring and Evaluation

Monitoring is essential for understanding the state of Black Tern populations, their overall productivity, threats, and mitigation needs. At active or potentially active sites with lower conservation management priority, annual eBird counts during peak breeding season (May-June) are recommended. These counts can take place along the shoreline, or by boat if the area is accessible. If the counts occur by boat and a colony is flushed, the observer should take care to avoid getting too close to any nests and should be brief (<10 minutes). This helps provide an overall understanding of where Black Tern colonies are active from year to year, and where more detailed monitoring may be of interest.

High Priority Sites

If the site has been identified as high priority in this report, a continuation of thorough annual monitoring is recommended. For areas with considerable gaps in overall population estimates and sub-colony locations (Munuscong SWMA, Shiawassee NWR, and Tawas Lake), we recommend a rapid assessment of the area during peak breeding season that tries to avoid disturbing chicks (mid-May to early June). This assessment would require enough monitors to cover the majority of the area at the same time, ideally in one day. For sites that are recommended for management interventions (e.g., Wigwam Bay SWA), full population counts are ideal, especially done pre- and post-management implementation to capture management impacts on populations. Population counts are explored in greater detail in the following section. For sites with limited knowledge of nesting success, habitat preferences, and potential threats, nest monitoring may be useful in informing more detailed management recommendations (e.g., predator removal and nesting platforms). If a manager plans to apply management to improve nesting success, nest monitoring before and after implementation is highly recommended to properly assess its efficacy and to inform future management decisions. More details on nest monitoring are included below. For all monitoring types, we also recommend including a rapid assessment of the vegetation for each sub-colony, following the adapted version of the Integrated Waterbird Management and Monitoring protocol (Loges et al. 2021).

Population Counts

Approximating the overall population and productivity can be done at a minimum by performing flush counts of the colony. Flush counts involve exploring an area where Black Tern nesting activity is suspected (e.g., individuals are seen landing or dive-bombing). These ideally capture locations where nesting sub-colonies are concentrated, as this will be the most informative when planning targeted management/restoration in breeding areas. Flush counts should be taken once or every other week and counts of the nesting sub-colonies should be brief (<10 min) to avoid significant disturbance. Additionally, flush counts should completely avoid flushing or significant disturbance during chick-hatching and rearing periods as chicks are easily startled off of nests and become particularly vulnerable to predation, drowning, or exposure.

- **Courtship and nest initiation (early to mid-May):** The first set of counts should start around May 15th when breeding adults begin courting and prospecting nesting areas. This is helpful in determining where subsequent flush counts should occur and where to set platforms early in the breeding season, especially when surveying larger areas. Early flush counts should also determine when courtship has predominantly switched to nesting, where adults can be seen landing and appear to be incubating rather than standing or walking in the nesting area. Adults also typically become more aggressive and are more likely to dive-bomb intruders.

- **Peak adult counts (mid-May to early June):** Counts should ideally continue until the approximate week of peak hatching, which is typically in early to mid-June, roughly 21 days after incubation of eggs is initiated. If capacity is limited, at least one additional count between nest initiation and peak hatching is ideal for capturing the peak adult breeding count of the area. Monitors should take care to avoid disturbing nests that may have hatched early as well by checking nests with binoculars or a scope from a distance, if possible.

- **Peak hatching counts (early to mid-June):** We do not recommend counting during this time due to high sensitivity of chicks to disturbance. However, if it is necessary to do so, monitors should take great care to conduct counts at a safe distance to prevent chicks from being disturbed off nests. Monitors will need to use their best judgment along with the level of adult aggression (e.g., dive bombing) to assess this.

- **Peak fledgling counts (late June to early July):** Counts should resume around late June, roughly 42 days after nest incubation is initiated to capture fledgling counts if possible. These counts should be particularly careful to avoid approaching nesting areas too closely, as there may be delayed hatching due to nest failure and subsequent re-nesting attempts. Fledglings are as mobile as adults and usually will not stay close to their original nest, so observers will need to use their best judgement in avoiding double-counting, similar to adult counts.

Rapid Assessments

If sites cannot be visited for more frequent population counts, a rapid assessment during the peak breeding season may be appropriate. These counts should prioritize capturing peak adult counts (mid-May to early June) as described in the previous section (Population Counts). If possible, a second visit to capture fledgling counts (late June to early July) can provide a valuable estimate of productivity and is also recommended.

Nest Monitoring

Nest monitoring can be performed in addition to flush counts. Collecting nest monitoring data can be beneficial, but the pros and cons of capacity requirements, level of disturbance required, accessibility, and information needs should all be considered before implementation. Nest monitoring is particularly helpful for approximating when chick hatching and fledging periods will occur, allowing monitors to better time flush counts. Identifying the locations of most, if not all nests in an area can be additionally helpful for assessing nest-specific habitat variables and extrapolating the population size during that visit (e.g., if the flush count of the area is lower than double the number of nests). Finally, nest monitoring, especially with cameras, can help provide detailed nesting success metrics and assess local, nest-specific threats and management needs (e.g., predator and storm mitigation).

Ideally, close-up nest checks should occur well before peak chick-hatching periods and utilize cameras or viewing nests from a safe distance to capture nesting success. When a nest is found, observers should record a unique nest ID, GPS coordinates, number of eggs, nest substrate, and any other pertinent habitat variables (e.g., water depth, dominant vegetation, etc.). Nest checks should also take great care not to damage mats or nests themselves. If a nest can be safely approached, floating the eggs can help determine the age of the nest and approximate hatch date (Hays and LeCroy 1971). If the nest cannot be safely approached, an observer may be able to use binoculars to determine the number of eggs (especially early in the season), where 1 egg means ~23 days from hatching, and 2 eggs ~22 days. Nest checks are typically performed at a frequency of around once a week, every other week at minimum. Subsequent visits will check if the nest is still actively incubating, hatched, or failed. If a nest has failed, observers should note whether there is adequate evidence the nest was abandoned (e.g., eggs present but adults are gone), predated (e.g., holes in the eggs), or damaged by weather (e.g., nest has been flooded). If chicks are suspected at a nest, this should be observed from a distance with binoculars, recorded, and otherwise left alone. This applies to setting up cameras as well.

Like nest-checks, cameras should be set up early in the nesting season, well before hatching begins, if possible. If cameras are suspected to attract local aerial predators, deterrent roof spikes may be a consideration. Camera use should be avoided if they appear to be attracting mammalian predators (e.g., raccoons).

Camera Monitoring

Cameras are essential for (ideally) capturing detailed monitoring information at the lowest possible disturbance and required visit effort. Cameras should be placed while nests still contain eggs, and not on nests that have hatched chicks. Disturbance may prevent chicks from returning. In general, entering the marsh should be avoided when chicks hatch as much as possible. Floating eggs at the beginning of the season can help monitors with timing their visits (i.e., eggs that start to float in water are later in their incubation period vs. eggs that sink). In general, a timelapse of 30-min optimizes the battery life and is helpful for determining the relative time a nest remains active and whether it was successful or not. Including motion capture (e.g., Timelapse +) is critical for capturing predation events and nocturnal motion capture ability is a necessity.

In order to capture desired information with minimal disturbance and equipment damage, camera set-up should carefully consider the following:

1. **Post set-up:** Camera posts may include a simple rebar or garden t-post where cameras are secured by zip-ties, bungee-chords, and/or wingnuts. Using rebar or garden posts however requires field monitors to ensure the bar is standing securely in the marsh without risk of tipping during high winds/adverse weather. These also need to be high enough out of the water to prevent flooding damage. Flood height and wind or adverse weather will need to be considered on a site-by-site basis, as this can vary considerably depending on the location, where diked units are generally at a lower risk of these hazards. Hardier camera posts have been designed by volunteer/technician David Fuller which includes a dock post with a plastic auger secured to the bottom. This design allows the field monitor to twist the post into the marsh bottom and greatly

prevents tipping during adverse weather. These posts also include wooden "housing" around the camera that is designed to look similar to a nest box. These are especially useful in areas where cameras can attract unwanted attention from recreationists resulting in potential nest disturbance or destruction, and possibly stolen cameras. These also can prevent cameras from overheating in the direct sun. It should be noted that aerial predators such as gulls could use cameras as platforms. If this is observed, perch-dissuasion such as spikes may need to be implemented. Finally, the custom posts included a custom 12V rechargeable battery holder to increase battery life, discussed in more detail in section 2.

2. **Batteries and Settings:** Camera settings will depend significantly on the monitoring goals and battery type. Ideally, cameras should be able to monitor a nest as long as possible without any field-monitors having to stand beside the nest to place new batteries, which would defeat the purpose of mitigating disturbance. While the exact time a camera will last will depend on the battery type and the camera model, the more photos taken, the faster the battery life will be depleted. Thus, there is a tradeoff between the amount of data captured and the length of time a camera can run. Currently the best compromise is to use a 30-minute timelapse to capture the overall timing of major events (eggs laid, chicks hatching, failure) combined with motion detection (especially nighttime) to capture predation events. Currently, non-rechargeable lithium batteries will last the longest in the field but are both expensive and can be wasteful. An alternative to this is plugging the camera into a rechargeable 12-volt battery pack used for power tools (e.g., Milwaukee). These battery packs however need to be properly secured to the post and watertight. Details on battery life and camera settings may be found in the camera manual or may require field testing prior to the monitoring season.

3. **Camera Angle and Direction:** One major difficulty in the field with monitoring nests is cameras having the correct field of view. Monitors should take great care to double check the angle of the camera from different viewpoints to ensure that the lens is facing the nest. Monitors can either remove the camera if the angle can be set (e.g., with a bendable metal base), or use a pole to point from the lens as an aid. More recent cellular models will also alleviate this issue by providing an image of the nest after setting it in place. Monitors should also be sure to avoid facing the camera directly South, as the direct sun can ruin photos (lens flare, backlighting, overexposure) and can result in false triggers from the sun's movement. Finally, monitors should avoid as much emergent vegetation between the nest and the camera to avoid false motion triggering and low visibility. This however can be difficult given that much of the emergent vegetation will grow in during the nest's duration.

Funding Needs

Platforms

A variety of platform designs have been suggested and/or deployed for Black Tern colonies in Michigan and elsewhere, the decision of which to use at a certain site will depend on the factors listed under General Recommendations. Designs have been created by groups such as Stantec Consulting Ltd. (Preston et al. 2024; Figure 14), Detroit Bird Alliance volunteers (Figure 15A, 16), CCRC (Figure 15B), and the Netherlands Black Tern Working Group (Figure 15C). Details and considerations for each platform design, including materials, threats addressed, relative cost, deployment difficulty, previous success, potential issues, and locations used are covered in Table 2.

Table 2. Details and considerations for each platform design, including materials, threats addressed, relative cost, deployment difficulty, previous success, potential issues, and locations used.

GROUP	PLATFORM DESIGN	MATERIALS	THREATS ADDRESSED	RELATIVE COST (PER PLATFORM)	DEPLOYMENT DIFFICULTY	PREVIOUS SUCCESS	POTENTIAL ISSUES	LOCATIONS USED
STANTEC	PVC/Mesh	• 20 x 20 cm (400 cm2) • 1/2" galvanized steel netting surrounded by 2" thick, 12" long PVC pipe and 90-degree elbows. Includes a water noodle foam insert • Fastened with metal zap straps • Secured with PVC cement • 2 "hose" ramps with bolts and Loctite threat locker, or 2 "turf" ramps with tubing and rivets • Anchored with brick, chain, carabiner, and a float • Optional 2" wire fence	Nest Habitat Loss, Flooding	$120-130	Medium (no anchor), High (with anchor)	Readily used, high nest success. Similar British Columbia design had little nest failure after 7 years	Rigid design may not be as stable in areas with lots of wave activity (boats, storms). Anchor may not be advisable in areas with high boat traffic.	Inland (British Columbia)
	with exclosure		Nest Habitat Loss, Flooding, Predation	$140-150	High (no anchor, with exclosure), Very High (with anchor and exclosure)		Adult & Juvenile mortality unlikely but possible, may only deter aerial predators	

GROUP	PLATFORM DESIGN	MATERIALS	THREATS ADDRESSED	RELATIVE COST (PER PLATFORM)	DEPLOYMENT DIFFICULTY	PREVIOUS SUCCESS	POTENTIAL ISSUES	LOCATIONS USED
DETROIT BIRD ALLIANCE/DAVID FULLER	Canvas Platform	• Average 60 x 90 cm (5,400 cm2) • 3-4 1/2" thick foam "slabs" sewn into heavy duty canvas drop cloth	Nest Habitat Loss, Flooding, Wind/Waves	$10-20	Low	Readily used, high nest success. In 2024, 10/11 platforms were used (Figure 16 A, B). Three flooded natural nests renested on adjacent platforms (Figure 16C, D). Almost 90% platform nests with known status hatched.	Canvas is somewhat more difficult to clean than PVC design.	Coastal (St. Clair Flats, MI)
CCRC/JOE KAPLAN	PVC/Foam	• 20 x 20 cm (400 cm2) • 7 1/4", 1" thick extruded foam surrounded by 1/2" thick, 7 1/4" long schedule 40 PVC pipe and 90-degree elbows • Fastened with zip ties and surrounded by optional plastic poultry netting (9 1/2" x 20") added to platform • Secured with PVC cement	Nest Habitat Loss, Flooding	$50-60	Medium	Not readily used at all sites/years. Prevented nest flooding at Oogontz Bay. Chicks used platforms adjacent to natural nests at St. Clair Flats.	Rigid design may not be as stable in areas with lots of wave activity (boats, storms). Platforms not often readily used (e.g., Portage Marsh and St. Clair Flats).	Coastal (Ogontz Bay, Portage Marsh, St. Clair Flats, MI)

GROUP	PLATFORM DESIGN	MATERIALS	THREATS ADDRESSED	RELATIVE COST (PER PLATFORM)	DEPLOYMENT DIFFICULTY	PREVIOUS SUCCESS	POTENTIAL ISSUES	LOCATIONS USED
NETHERLANDS BLACK TERN WORKING GROUP/LEEN HEEMSKERK	Wood/Foam	• 40 x 50 cm (2,000 cm2) • Foam wrapped in wind-netting (i.e., burlap) • 2 x 4 cm wood edges on two sides to absorb waves • Anchored with brick and chain • Optional 2" wire fence	Nest Habitat Loss, Flooding	$60-80	Medium (no anchor), High (with anchor)	Readily used, high nest success. Clutch survival and fledgling production increased from the 20-40% range up to 70-95% range between 1995 and 1999. Increase of 75 to 271 breeding pairs.	Rigid design may not be as stable in areas with lots of wave activity (boats, storms). Anchor may not be advisable in areas with high boat traffic.	Agricultural Canals/Inland (Netherlands)
	with exclosure		Nest Habitat Loss, Flooding	$80-100	High (no anchor, with exclosure), Very High (with anchor and exclosure)	Results from above and prevented aerial predation	Issues from above and 3 adults and 1 juvenile perished due to mesh wire between 2018 and 2022. New design with larger wire gaps should hopefully address this.	

Figure 14. Photos provided by Stantec Consulting Ltd. in the Great Lakes Black Tern Nest Platform Assessment (Preston et al. 2024) to describe their proposed design, used previously in the British Columbia. Note that a brick is recommended over the anchor pictured in Photo 2.

Figure 15. Platforms before and after deploying in the field, including A) Canvas design by David Fuller, Detroit Bird Alliance volunteer, B) PVC/Foam design by Joe Kaplan, CCRC, and C) Wood/foam design by the Netherlands Black Tern Working Group.

Figure 16. Canvas platforms used by Black Terns in 2024 at St. Clair Flats (Credit: Detroit Bird Alliance). A and B images show early-season platforms used by Black Terns with pair beginning nest (A) and adult with three large chicks (B). C and D images show re-nesting by a Black Tern nest from original natural nest (C) to the platform (D) after several rainstorms.

Camera Recommendations

In order to properly capture nesting data, camera models should ideally be able to use lithium-ion batteries and/or have a 12V connecting port to an external battery pack. Cameras should be able to run timelapse day and night and motion capture at the same time (at least at night). The current best camera on the market for nest monitoring (2024) is the SpyPoint Flex-M. This model has the best combination of battery life, cost ($80/each), settings (includes Timelapse +, e.g., concurrent motion and timelapse), and tracking. As a cellular model, it can keep track of battery life and SD card status remotely and send periodic photos, preventing previous issues with not knowing whether the camera is on or off, the battery is still working, the nest floated out of view, etc.

Stakeholder Engagement

Looking ahead, Audubon will continue to engage with new and existing partners across the region, while seeking feedback on and participation with the data collection process. The outcomes of these joint endeavors will be used to inform action basin wide. This report will be used as a discussion starter about Black Tern conservation, both with partners and the public. Audubon intends to actively pursue habitat restoration projects with partners at several locations noted in this report. Many of these efforts will have full feasibility stages, where a broad array of stakeholders and interested parties will be engaged to inform potential designs or changes to management approaches. If you have interest in contributing to Black Tern conservation planning or participating in the Great Lakes Black Tern Conservation Initiative, which meets annually, please reach out to AudubonGreatLakes@audubon.org.

Conclusions

Black Terns face unique challenges across various regions in Michigan, particularly at their breeding sites where the main issue is the scarcity of suitable habitat. Despite this study being the most comprehensive since the last Michigan Breeding Bird Atlas, many uncertainties remain about the Black Terns' population due to the difficulty of accessing some breeding sites. Ironically, the inaccessibility of these sites may benefit the terns by reducing human disturbances.

At five priority wetland sites, efforts were made to investigate and address the challenges to enhance Black Tern breeding success:

- **Wigwam Bay** faces challenges such as limited hemi-marsh habitat, high predator activity in suitable habitat areas, and unmanageable water levels. The thick vegetation and access from the dike have led to increased predation by raccoons. Future work should focus on managing water levels to improve habitat and limit predator access.
- **Portage Marsh** struggles with a cattail monoculture and exposure to wave action from Lake Michigan, which can wash away nesting mats. Recommendations include potholing and channeling to create more hemi-marsh habitat, using dredge material to create islands, and employing nesting platforms to supplement natural mats.
- **Munuscong** has several years of nest monitoring data, yet access difficulties hinder a full understanding of the site. Preliminary counts suggest it may host one of Michigan's largest colonies, warranting a concentrated census before further action.
- **Tawas Lake** faces access challenges due to its size and shallow depth, but Black Terns seem to be successful here. Issues such as Eurasian water-milfoil management and wild rice restoration require community engagement to address misconceptions and invasive vegetation concerns.
- **Shiawassee** also presents access challenges, with steep dike banks making it difficult to launch kayaks. Cattail monocultures are an issue here, similar to other sites, requiring further monitoring and management efforts.

A statewide survey was able to review Black Tern activity at 92 out of 93 surveyed historic colony locations through volunteer and/or partner monitoring and supplementary eBird records. Of the 92 sites, 67 had some form of Black Tern activity during the breeding season between 2021 and 2023, 70% in the Lower Peninsula were still active, compared to only 24% in the Upper Peninsula. Access issues and site size may have impacted these findings.

The study revealed that Black Terns use various wetland sites across Michigan with varying success. Notably, only a portion of historic sites identified in previous surveys remain active. Future management should focus on priority sitesthat represent essential breeding habitats in need of targeted conservation efforts.

Key takeaways from the study include the variability of floating mats used for nesting, emphasizing the need to promote management that creates these mats and restores of hemimarsh to ensure suitable nesting sites. Lack of water level management leads to static water levels and limited habitat diversity. Artificial platforms can supplement natural mats, and nest cameras can help monitor predation and weather-related pressures.

Each wetland site requires close monitoring to determine the best management approach. Prioritizing management at large Black Tern colonies with known challenges and solutions is essential. High-priority sites with access issues need concentrated efforts for better understanding. Success in enhancing Black Tern populations depends on a network of partners and public engagement to protect and enhance Michigan's wetlands. Further action is needed to involve diverse stakeholders and community members in these efforts.

References

Audubon Great Lakes. 2021. Restoring Wigwam Bay for Breeding Marsh Birds: 2018-2020 Report & Conservation Action Plan.
Campbell, R.W., and M. Nyhof. 2015. The Black Tern Enigma in British Columbia: Issues of Assumptions, Monitoring, Nest Searches and Conservation. Wildlife Afield 12:23-41.
Chartier, A.T., Baldy, J.J., and J. Brenneman. 2013. Michigan Breeding Bird Atlas II. Kalamazoo Nature Center.
Cuthbert, F.J. and Wires, L. 2013. The fourth decadal U.S. Great Lakes Colonial Waterbird Survey (2007-2010): Results and recommendations to improve the scientific basis for conservation and management. Dept. Fisheries, Wildlife & Conservation Biology, University of Minnesota – Twin Cities.
eBird. 2024. eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. (Accessed: September 30, 2024).
Great Lakes Phragmites Collaborative. 2024. Control and management: Timing of Phragmites treatments. Great Lakes Phragmites Collaborative. Retrieved from https://www.greatlakesphragmites.net (Accessed: August 30, 2024).
Hays, H., and M. LeCroy. 1971. Field criteria for determining incubation stage in eggs of the Common Tern. The Wilson Bulletin 83:425-429.
Johnson, W.C., and K.A. Poiani. 2016. Managing wetland vegetation for avian communities: Restoration and creation efforts for Black Terns and other marsh birds. Wetlands Ecology and Management 2:183-198.
Kaminski, R., H. Murkin, and C. Smith. 2018. Control of cattail and bulrush by cutting and flooding. Coastal Wetlands, pp: 253-262.
Loges, B.W. and Others. 2021. National Protocol Framework for the Inventory and Monitoring of Waterbirds and their Habitats: An Integrated Waterbird Management and Monitoring (IWMM) Approach [Version 2.1]. This protocol is available from ServCat: [https://iris.fws.gov/APPS/ServCat/Reference/Profile/135419]
O'Brien, M., and J.B. Zedler. 2020. Barrier islands as natural coastal defenses: Enhancing resilience to storms and seiches. Journal of Coastal Conservation 14:421-438.
Preston, M. S., J. Costa, and K. Barfoot. 2024. Great Lakes Black Tern Floating Nest Platform Assessment. Stantec Consulting Ltd.
Sauer, J. R., Link, W. A., & Hines, J. E. 2020. The North American Breeding Bird Survey, Analysis Results 1966—2019 [Dataset]. U.S. Geological Survey. https://doi.org/10.5066/P96A7675
The Sault Tribe of Chippewa Indians. "Inland Fish and Wildlife Department." The Sault Tribe of Chippewa Indians Official Website, 2024. https://www.saulttribe.com/membership-services/19-membership-services/natural-resources/35-inland-fish-and-wildlife-department
Shealer, D.A., J.M. Buzzell, and J.P. Heiar. 2006. Effect of floating nest platforms on the breeding performance of Black Terns. Journal of Field Ornithology 77:184-194.
Sojda, R.S., and K. L. Solberg. 1993. Management and Control of Cattails. Waterfowl Management Handbook, U.S. Fish and Wildlife Service.
Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation 142: 2282-2292.
Thompson, M.C. "Mapping Wild Rice Restoration at Tawas Lake, East Tawas Michigan- A mapping project for education use by the Native Wild Rice Coalition." Unity College, 2020. https://storymaps.arcgis.com/stories/36907a36b6da44faabf59a1f5795fb4d
Tozer, D. C. 2016. Marsh bird occupancy dynamics, trends, and conservation in the southern Great Lakes basin: 1996 to 2013. Journal of Great Lakes Research, 42(1), 136–145. https://doi.org/10.1016/j.jglr.2015.10.015
van der Winden, J. 2018. Zwarte sterns in Zuid-Holland in 2018. Rapport 2018-10. December 2018. Jan van der Winden Ecology, Utrecht.

Appendices

Table A1. Summary of nest monitoring data gathered from cameras at priority sites (Wigwam SWA, Munuscong SWGA, Tawas Lake, Shiawassee NWR, and Portage Marsh SWA).

SITE	YEAR	# NESTS MONITORED	# HATCHED (% OF INCUBATING NESTS)	# FLEDGED (% OF HATCHED NESTS)	NOTES
Wigwam SWA	2020	5	2 (40%)	0	3 incubating nests failed
	2021	6	2 (33%)	2 (100%)	2 incubating nests failed
	2022	12	3 (25%)	0	7 incubating nests and 1 hatched nest failed
	2023	9	2 (22%)	0	1 incubating nest failed and 1 hatched nest failed
Munuscong SWGA	2022	6	0 (0%)	0	
	2023	6	3 (50%)	1 (33%)	
Tawas Lake	2023	2	1 (50%)	0	
Shiawassee NWR	2023	1	1 (100%)	0	
Portage Marsh SWA	2022	11	1 (9%)	1 (100%)	10 incubating nests failed
	2023	6	1 (17%)	1 (100%)	5 incubating nests failed
	2024	2	0 (0%)	0	2 incubating nests failed

*Table A2. Summary table of statewide monitoring and status by year. Status was determined by volunteer and contracted surveyors, and supplemented with eBird data. Maximum counts derived from eBird are denoted by a *. If breeding occurred during any of the three years, the final status was denoted as "Active, Breeding", if the site was active but breeding was not determined across the three years, the final status was denoted as "Active". If the site was determined inactive during any of the three years and neither active or breeding, the final status was determined as "Likely Inactive".*

COUNTY	SITE NAME	MAX COUNT	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Allegan	Kalamazoo River--Newport Harbor Allegan	2*	Active	Inactive	Inactive	Active
Alpena	Devil's Lake, Alpena	1*	No Data	Active, Breeding	No Data	Active, Breeding
	Partridge Point	2*	Active	Inactive	No Data	Active
Arenac	Wigwam Bay	66	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
Bay	Nayanquing Point State Wildlife Area	2*	Active	Active	Active	Active
Cheboygan	Dingman Marsh	7*	Active, Breeding	Active	Active, Breeding	Active, Breeding
	Indian River	15*	Active	Active	Active	Active

COUNTY	SITE NAME	MAX COUNT	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Chippewa	Drummond Island	10	Inactive	Inactive	Active, Breeding	Active, Breeding
	Edmonds Yard, Brimley Chippewa	0*	Inactive	Inactive	Inactive	Likely Inactive
	Munuscong SWMA - Allards Bay	73	Active, Breeding	Active	Active, Breeding	Active, Breeding
	Munuscong SWMA - Diked Unit	99	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
	Neebish Island SE	0	No Data	Inactive	No Data	Likely Inactive
	Pendills Lake	0	Inactive	Inactive	No Data	Likely Inactive
	Rock Island	0	No Data	Inactive	No Data	Likely Inactive
	Sugar Island E	0	No Data	Inactive	No Data	Likely Inactive
	Sugar Island W	0	Inactive	No Data	No Data	Likely Inactive
	Tahquamenon River Mouth Chippewa	4*	Active	No Data	No Data	Active
Clare	Jackson Ave marsh Clare	3*	Active	Active, Breeding	Active	Active, Breeding
Clinton	Maple River Main Unit - Central	0	Inactive	Inactive	Inactive	Likely Inactive

COUNTY	SITE NAME	MAX COUNT	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Delta	DELT-01	0	No Data	Inactive	Inactive	Likely Inactive
	DELT-02	0	No Data	Inactive	No Data	Likely Inactive
	DELT-03	0	No Data	Inactive	No Data	Likely Inactive
	DELT-04	0	No Data	Inactive	No Data	Likely Inactive
	DELT-05	0	Inactive	Inactive	Inactive	Likely Inactive
	DELT-07	0	No Data	Inactive	No Data	Likely Inactive
	DELT-08	0	No Data	Inactive	Inactive	Likely Inactive
	DELT-09	0	No Data	Inactive	Inactive	Likely Inactive
	Fishdam River Boat Launch	0	Inactive	Inactive	No Data	Likely Inactive
	Moss Lake	0	Inactive	Inactive	Inactive	Likely Inactive
	Nahma Marsh	0	Inactive	Inactive	Inactive	Likely Inactive
	Ogontz Bay	18*	Active, Breeding	Inactive	Active, Breeding	Active, Breeding
	Portage Marsh SWA	20	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
	Rapid River	2*	Active	Inactive	Inactive	Active
	Saint Vital Point	0	Inactive	No Data	Inactive	Likely Inactive
	Whitefish Rivermouth	1*	Active, Breeding	Inactive	No Data	Active, Breeding
Emmet	Crooked River Emmet	2*	Active	No Data	No Data	Active
Genesee	Fenton Millpond	0	Inactive	Inactive	No Data	Likely Inactive
	Swan Lane Wetlands	0	Inactive	Inactive	No Data	Likely Inactive
Gladwin	Gladwin SF-Katzer Rd. Wetland	6	Active	Active, Breeding	Active	Active, Breeding
Gratiot	Maple River East Unit	0	Inactive	Inactive	No Data	Likely Inactive
	West Maple Rd Boat launch	0*	Active	No Data	Inactive	Active

COUNTY	SITE NAME	MAX COUNT	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Iosco	Tawas Lake	136	Active	Inactive	Active, Breeding	Active, Breeding
	Tuttle Marsh Wildlife Area	12*	Active	Active	Active	Active
Kalamazoo	Barton Lake	1*	No Data	Active, Breeding	Active, Breeding	Active, Breeding
	Thrall Lake	6*	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
Kent	Reeds Lake	1*	Active, Breeding	Inactive	Inactive	Active, Breeding
Luce	Dollarville Flooding	38*	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
Mackinac	Duck Bay	0	Inactive	Inactive	No Data	Likely Inactive
	Hessel Marsh	0	Inactive	Inactive	Inactive	Likely Inactive
	Hill Channel	4*	Inactive	Active	Active, Breeding	Active, Breeding
	Prentiss Bay	0	Inactive	Inactive	Inactive	Likely Inactive
	Pte. La Barbe	0	Inactive	Inactive	No Data	Likely Inactive
	Saint Martin Bay	0	Inactive	No Data	Inactive	Likely Inactive
Manistee	Bar Lake Manistee	10*	Active	Active, Breeding	Active, Breeding	Active, Breeding
	Manistee River Delta	4*	Active	Inactive	Inactive	Active
Mecosta	Canadian Lakes	No Data	No Data	No Data	No Data	No Data
	Martiny Lake State Game Area	6*	Active, Breeding	Active, Breeding	Active	Active, Breeding
	Tubbs Island	6*	Active, Breeding	Active	Active	Active, Breeding
Midland	Kawkawlin Creek Flooding	22*	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
Missaukee	Reedsburg Dam State CG - Dead Stream Flooding	22*	Active	Active	Active, Breeding	Active, Breeding
Monroe	Pointe Mouillée, South Rockwood, Monroe	25*	Active	Active, Breeding	Active, Breeding	Active, Breeding

COUNTY	SITE NAME	MAX COUNT (EBIRD*)	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Muskegon	Muskegon County Wastewater	1*	Active	Inactive	No Data	Active
	Muskegon State Game Area	0	Inactive	No Data	No Data	Likely Inactive
Oakland	Drayton Plains Nature Center	0	Inactive	Inactive	Inactive	Likely Inactive
	Eagle Lake	0	Inactive	Inactive	No Data	Likely Inactive
	Mud Lake and Carpenter Lake	0	Inactive	No Data	No Data	Likely Inactive
	Pontiac Lake SRA - Below Robinson Lake	0	Inactive	No Data	No Data	Likely Inactive
	Pontiac Lake SRA - Crosby Lake	0	Inactive	No Data	No Data	Likely Inactive
	Pontiac Lake SRA - Foley Lake	0	Inactive	No Data	No Data	Likely Inactive
	Pontiac Lake SRA - Robinson Lake	0	Inactive	No Data	No Data	Likely Inactive
	Tremper Lake	0	Inactive	No Data	No Data	Likely Inactive
	Woodhull Lake	0	Inactive	No Data	No Data	Likely Inactive
Ottawa	Bruce Bayou/Grand Haven State Game Area	2*	No Data	Active, Breeding	No Data	Active, Breeding
Roscommon	Houghton Lake Flats Flooding - North	0*	Inactive	Inactive	Inactive	Likely Inactive
	Houghton Lake Flats Flooding - South	20*	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
	Houghton Lake Sewage Ponds Region	0*	Active	Active	Active	Active
	Michelson's Landing	20*	Active	Active	Active	Active

COUNTY	SITE NAME	MAX COUNT	STATUS 2021	STATUS 2022	STATUS 2023	FINAL STATUS
Saginaw	Crow Island State Game Area	21*	Active	Active, Breeding	Active	Active, Breeding
	Shiawasee National Wildlife Refuge	35*	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding
Schoolcraft	SCHO-01	0	Inactive	Inactive	Inactive	Likely Inactive
	SCHO-02	0	Inactive	Inactive	Inactive	Likely Inactive
	SCHO-03	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-04	0	No Data	Inactive	Inactive	Likely Inactive
	SCHO-05	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-06	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-07	0	No Data	Inactive	Inactive	Likely Inactive
	SCHO-08	1*	Inactive	Inactive	Active	Active
	SCHO-09	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-10	0	Inactive	Inactive	Inactive	Likely Inactive
	SCHO-11	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-12	0	No Data	Inactive	No Data	Likely Inactive
	SCHO-13	0	Inactive	Inactive	Inactive	Likely Inactive
St. Clair	St. Clair Flats	200	Active, Breeding	Active, Breeding	Active, Breeding	Active, Breeding

Table 3A. Summary table of years monitored and personnel. Monitors included volunteers and contractors through Audubon Great Lakes, LSSU, the Sault Tribe, CCRC, and Detroit Bird Alliance. If no monitoring occurred in a given year, data was supplemented with eBird records if available.

MONITORING BY YEAR AND PERSONNEL				
COUNTY	**SITE NAME**	**2021**	**2022**	**2023**
Allegan	Kalamazoo River--Newport Harbor Allegan	eBird	AGL Volunteers	eBird
Alpena	Devil's Lake, Alpena		eBird	
	Partridge Point	eBird	AGL Volunteers	
Arenac	Wigwam Bay	AGL Contractor	AGL Contractor	AGL Contractor
Bay	Nayanquing Point State Wildlife Area	AGL Volunteers	eBird	eBird
Cheboygan	Dingman Marsh	AGL Volunteers	AGL Volunteers	AGL Volunteers
	Indian River	AGL Volunteers	eBird	eBird
Chippewa	Drummond Island	LSSU	LSSU	LSSU
	Edmonds Yard, Brimley Chippewa	eBird	eBird	eBird
	Munuscong SWMA - Allards Bay	eBird	eBird	Sault Tribe
	Munuscong SWMA - Diked Unit	Sault Tribe	Sault Tribe	Sault Tribe
	Neebish Island SE		LSSU	
	Pendills Lake	LSSU	LSSU	
	Rock Island		LSSU	
	Sugar Island E		LSSU	
	Sugar Island W	LSSU		
	Tahquamenon River Mouth Chippewa	eBird		
Clare	Jackson Ave marsh Clare	eBird	AGL Volunteers	eBird
Clinton	Maple River Main Unit - Central	AGL Volunteers	AGL Volunteers	eBird

COUNTY	SITE NAME	2021	2022	2023
Delta	DELT-01		CCRC	eBird
	DELT-02		CCRC	
	DELT-03		CCRC	
	DELT-04		CCRC	
	DELT-05	eBird	CCRC	eBird
	DELT-07		CCRC	
	DELT-08		CCRC	eBird
	DELT-09		CCRC	eBird
	Fishdam River Boat Launch	CCRC	CCRC	
	Moss Lake	eBird	CCRC	eBird
	Nahma Marsh	eBird	CCRC	eBird
	Ogontz Bay	CCRC	CCRC	CCRC
	Portage Marsh SWA	CCRC	CCRC	CCRC
	Rapid River	eBird	CCRC	eBird
	Saint Vital Point	eBird		CCRC
	Whitefish Rivermouth	CCRC	CCRC	
Emmet	Crooked River Emmet	eBird		
Genesee	Fenton Millpond	AGL Volunteers	AGL Volunteers	
	Swan Lane Wetlands	AGL Volunteers	AGL Volunteers	
Gladwin	Gladwin SF-Katzer Rd. Wetland	AGL Volunteers	AGL Volunteers	eBird
Gratiot	Maple River East Unit	AGL Volunteers	AGL Volunteers	
	West Maple Rd Boat launch	AGL Volunteers		eBird
Iosco	Tawas Lake	eBird	eBird	AGL Contractor
	Tuttle Marsh Wildlife Area	AGL Volunteers	AGL Volunteers	eBird, AGL Volunteers
Kalamazoo	Barton Lake		eBird	eBird
	Thrall Lake	eBird	eBird	eBird
Kent	Reeds Lake	AGL Volunteers	eBird	AGL Volunteers
Luce	Dollarville Flooding	LSSU	LSSU	eBird

COUNTY	SITE NAME	2021	2022	2023
Mackinac	Duck Bay	LSSU	LSSU	
	Hessel Marsh	LSSU	LSSU	eBird
	Hill Channel	LSSU	LSSU	LSSU
	Prentiss Bay	LSSU	LSSU	eBird
	Pte. La Barbe	LSSU	eBird	
	Saint Martin Bay	LSSU		eBird
Manistee	Bar Lake Manistee	eBird	eBird	eBird
	Manistee River Delta	AGL Volunteers	eBird	eBird
Mecosta	Canadian Lakes			
	Martiny Lake State Game Area	eBird	eBird	eBird
	Tubbs Island	AGL Volunteers	AGL Volunteers	eBird
Midland	Kawkawlin Creek Flooding	AGL Volunteers	AGL Volunteers	AGL Volunteers
Missaukee	Reedsburg Dam State CG - Dead Stream Flooding	eBird	AGL Volunteers	eBird
Monroe	Pointe Mouillée, South Rockwood, Monroe	eBird	AGL Volunteers	eBird
Muskegon	Muskegon County Wastewater	eBird	AGL Volunteers	
	Muskegon State Game Area	AGL Volunteers		
Oakland	Drayton Plains Nature Center	AGL Volunteers	AGL Volunteers	eBird
	Eagle Lake	AGL Volunteers	AGL Volunteers	
	Mud Lake and Carpenter Lake	AGL Volunteers		
	Pontiac Lake SRA - Below Robinson Lake	AGL Volunteers		
	Pontiac Lake SRA - Crosby Lake	AGL Volunteers		
	Pontiac Lake SRA - Foley Lake	AGL Volunteers		
	Pontiac Lake SRA - Robinson Lake	AGL Volunteers		
	Tremper Lake	AGL Volunteers		
	Woodhull Lake	AGL Volunteers		
Ottawa	Bruce Bayou/Grand Haven State Game Area		eBird	

COUNTY	SITE NAME	2021	2022	2023
Roscommon	Houghton Lake Flats Flooding - North	eBird	eBird	eBird
	Houghton Lake Flats Flooding - South	AGL Volunteers	AGL Volunteers	AGL Volunteers
	Houghton Lake Sewage Ponds Region	AGL Volunteers	eBird	eBird
	Michelson's Landing	AGL Volunteers	AGL Volunteers	eBird
Saginaw	Crow Island State Game Area	AGL Volunteers	AGL Volunteers	eBird
	Shiawassee National Wildlife Refuge	eBird	AGL Contractor and Volunteers	AGL Contractor and Volunteers
Schoolcraft	SCHO-01	eBird	CCRC	eBird
	SCHO-02	eBird	CCRC	eBird
	SCHO-03		CCRC	
	SCHO-04		CCRC	eBird
	SCHO-05		CCRC	
	SCHO-06		CCRC	
	SCHO-07		CCRC	eBird
	SCHO-08	eBird	CCRC	eBird
	SCHO-09		CCRC	
	SCHO-10	eBird	CCRC	eBird
	SCHO-11		CCRC	
	SCHO-12		CCRC	
	SCHO-13	CCRC	CCRC	CCRC
St. Clair	St. Clair Flats	Detroit Bird Alliance	Detroit Bird Alliance	Detroit Bird Alliance

Table 4A. Summary table of statewide habitat data, including broad habitat metrics (dominant species and percentage of major habitat types).

SITE NAME	SUB-COLONY NAME	YEAR	DOMINANT SPECIES	% OPEN WATER	% EMERGENT VEGETATION	% SCRUB-SHRUB	% BARE GROUND	MUD (% OF NON-VEGETATED AREA)
Munuscong SWMA	1	2021	Cattail, water lily, water willow	25	70	5	0	0
	2		Cattail, smartweed, arrowhead, water lily	30	70	0	0	0
	3		Cattail, grasses/sedges	40	55	5	0	0
	Munus-cong Bay	2022	Cattail	40	58	2	0	0
		2023	Cattail	50	45	5	0	0
Portage Marsh	N/A	2021	Cattail	35	60	5	0	0
Shiawassee NWR	Maankiki South	2022	Cattail	70	0	30	0	5
Tawas Lake	A	2023	Wild rice, pickerel weed, water lily	20	80	0	0	0
	B		Wild rice, pickerel weed, water lily	10	90	0	0	0
	C		Wild rice, pickerel weed, water lily	4	96	0	0	4
	D		wild rice, pickerel weed, water lily, rushes	5	95	0	0	5
	E	2023	Wild rice, pickerel weed, water lily	10	90	0	0	0
	F		Wild rice, water lily, rushes	5	95	0	0	1

SITE NAME	SUB-COLONY NAME	YEAR	DOMINANT SPECIES	% OPEN WATER	% EMERGENT VEGETATION	% SCRUB-SHRUB	% BARE GROUND	MUD (% OF NON-VEGETATED AREA)
Wigwam Bay	North	2021	Water lily	40	60	0	0	10
		2022	Water lily and cattail	30	60	0	10	10
		2023	Water lily	8	90	0	2	30
	East	2021	Cattail and water lily	20	80	0	0	5
		2022	Cattail, water lily, and grasses/sedges	89	10	0	1	10
		2023	Water lily, cattail, pickerel weed	20	78	0	2	1
	Sedge	2021	Water lily, cattail, grasses/sedges, pickerel weed, purple loosestrife, and shrub	8	91	1	0	60
		2022	Cattail, water lily, grasses/sedges, purple loosestrife, water willow, pickerel weed, and fern	20	60	20	0	0
		2023	Water lily, grasses/sedges, pickerel weed, and cattail	3	97	0	0	1
	South	2021	Pickerel weed, cattail, grasses/sedges, and water lily	40	60	0	0	30
		2022	Cattail, water lily, and pickerel weed	50	25	25	0	10
		2023	Water lily, pickerel weed, and cattail	55	43	0	2	2
	North - W side	2023	Cattail and water lily	50	50	0	0	5
	East - N end	2023	Cattail and water lily	25	75	0	0	5