Introduction

Human-driven changes in climate and habitat are the two most widely-cited threats to avian biodiversity and community resilience, in both predictive and empirical contexts. Broadly speaking, these changes are expected to drive latitudinal and elevational shifts in species distributions (Langham et al., 2014). Such shifts can already be observed as predicted: red-bellied woodpeckers, Carolina wrens, and tufted titmice have recently expanded Northward (Langham et al., 2014), and Hawaiian honeycreeper ranges have shifted upwards to escape climate-facilitated disease (Atkinson and LaPointe, 2009).

However, the effects of climate and land use change on bird diversity, community structure, and migratory patterns are far more complex than would initially appear. This is widely apparent at the regional scale: birds in the Sierra Nevada have responded to tradeoffs between optimal precipitation and temperature, resulting in both upward and downward range shifts (Tingley et al., 2012); North American breeders have exhibited opposite patterns of change in phenological behavior, with Western migrants arriving increasingly early, and Eastern migrants increasingly late relative to spring green-up (Mayor et al., 2017); and breeding bird communities in Oregon have undergone unique shifts in composition across all habitat types, in response to differing climate and successional pressures (Curtis and Robinson, 2015).

In short, despite the increasing complexity and precision of climate models (Langham et al., 2014), and the recent uptick in resurvey projects, it remains extremely difficult to assess the relative importance of the many anthropogenic factors that influence avian communities, particularly those of long distance migrants, as habitat-level change might impact these species at multiple stages along their migratory route. This uncertainty makes long-term studies of migratory birds all the more important.

For many birds, specific sites present unique opportunities during migration, due to their particular geography, their local topology, the food sources they offer, or some combination thereof: consider the importance of Chesapeake Bay's horseshoe crab spawning grounds for migrating red knots, or the Platte River Basin's rich riparian habitat for staging Sandhill cranes.

In Mackinaw City, the Straits create a bottleneck for many bird taxa, with thousands of raptors utilizing the strong thermals around the channel to make the crossing, and a wide diversity of passerines staging at McGulpin Point to rest and recuperate before continuing to the Upper Peninsula. The site is also a significant confluence point for many species of waterbirds, with thousands observed annually flying between Lake Huron and Lake Michigan. Using a month of daily lake-watches, MSRW sought to determine the species diversity and abundance of birds observed actively crossing, as well as those that used the Straits as a staging ground. Additionally, this Spring the count radius was expanded to encompass two novel locations (Cheboygan State Park, Trails End Bay Marsh) in order to better understand how waterbird migrants were utilizing the multiple habitat types in this region.

Results

Active Migration

10868 individual waterbird migrants were observed passing through Mackinac Straits, (8894 in morning counts (4/3-5/11), and 1974 in evening counts (4/3-4/13), of which 7564 and 640, respectively, were identifiable to species) representing 43 species (Table 1). Loafing birds and birds deemed to be flying locally or otherwise not actively engaged in migration were excluded from these totals to reduce the possibility of recount on successive days. Full species counts (including loafing and locally flying birds) are available at dunkadoo.org.

Species	Morning	Evening	Total
Canada Goose	280	23	303
Mute Swan	2	0	2

Species	Morning	Evening	Total
Mallard	264	9	273
American Black Duck	17	3	20
Northern Pintail	48	11	59
Gadwall	7	0	7
Wood Duck	21	2	23
American Wigeon	85	2	87
Green-winged Teal	13	0	13
Blue-winged Teal	3	2	5
Northern Shoveler	16	8	24
Surf Scoter	2	0	2
Black Scoter	1	0	1
White-winged Scoter	459	5	464
Long-tailed Duck	2572	121	2693
Bufflehead	76	0	76
Greater Scaup	175	0	175
Lesser Scaup	12	1	13
Ring-necked Duck	76	0	76
Redhead	130	6	136
Common Goldeneye	116	7	123
Hooded Merganser	18	0	18
Common Merganser	65	7	72
Red-breasted Merganser	1331	131	1462
Common Loon	639	64	703
Red-throated Loon	5	0	5
Double-crested Cormorant	80	0	80
Horned Grebe	67	1	68
Red-necked Grebe	76	4	80

Species	Morning	Evening	Total
Caspian Tern	6	0	6
Common Tern	14	0	14
Bonaparte's Gull	168	0	168
Parasitic Jaeger	1	0	1
Ring-billed Gull	119	104	223
Herring Gull	433	104	537
Sandhill Crane	105	18	123
Great Blue Heron	15	6	21
Great Egret	0	1	1
Belted Kingfisher	2	0	2
Killdeer	14	0	14
Greater Yellowlegs	1	0	1
Spotted Sandpiper	30	0	30

Table 1: Full species breakdown of passage waterbird migrants through Mackinac Straits.

McGulpin Point (Mornings)

Long-tailed ducks and red-breasted mergansers were the most abundant overall migrants, with over 1000 of each observed actively migrating. Several other species showed in numbers upward of 100: Canada goose, mallard, white-winged scoter, redhead, common goldeneye, common loon, Bonaparte's, ring-billed, and herring gulls, and sandhill crane. Most of the remaining species were relatively sparse in passage, and overall numbers indicate a relatively slow year.

This was particularly true for bay ducks, which passed on only a handful of days, and in smaller numbers than anticipated (only redhead and greater scaup topped 100 birds for the season). Loons showed in more expected numbers, though nearly half of all loons passed in a single day (4/13). Observed gull abundances were also close to expected values, though both local tern species appeared sparsely and late.

Perhaps most surprising was the relative abundance and diversity of dabbling ducks, with 511 identifiable birds of nine species observed actively migrating through the Straits. Loafing or locally flying birds for which an eventual flight direction could not be determined were excluded from this analysis, as were dabbling duck sp., teal sp., and duck sp. which could not be more precisely identified, so overall numbers for this group may have been considerably higher.

Daily numbers and species diversity were highly variable, and appeared related to wind strength and direction, and general weather conditions, though these relationships weren't systematic across taxa. Loons, mergansers, and long-tailed ducks moved in their largest numbers on days with strong W winds: together, the mornings of 4/13 and 5/10—with strong WSW and NW winds, respectively—accounted for 24.3% of total long-tailed duck migrants, 50.9% of total red-breasted merganser migrants, and 43.2% of total common loon migrants. 32% of all white-winged scoters passed on 5/10 as well. Grebes were similarly episodic, with a single day of strong SE winds (4/19) accounting for 25.4% of all horned and 77.6% of all red-necked grebes on the season. Weather conditions did not appear to significantly affect movements of these species.

Dabbler movements, conversely, appeared much more closely tied to weather conditions than wind direction, with the highest abundance and diversity of species occurring most often on overcast days with precipitation and periodic banks of fog. Ducks tended to fly until visibility decreased below ~0.5 mi offshore, whereupon large flocks would often fall out onto the Straits (see "Fallouts," discussed later). 4/23 was the best exemplar of these conditions, and saw a brief fallout of West-flying birds that included 64 mallards, 3 black ducks, 11 pintail, 5 gadwall, 83 wigeon, 13 green-winged teal, and 16 shoveler; all eventually continued West. Migrant dabbler numbers declined steadily over the course of the season, excluding the anomalous fallout day on 4/23 (Fig. 1).

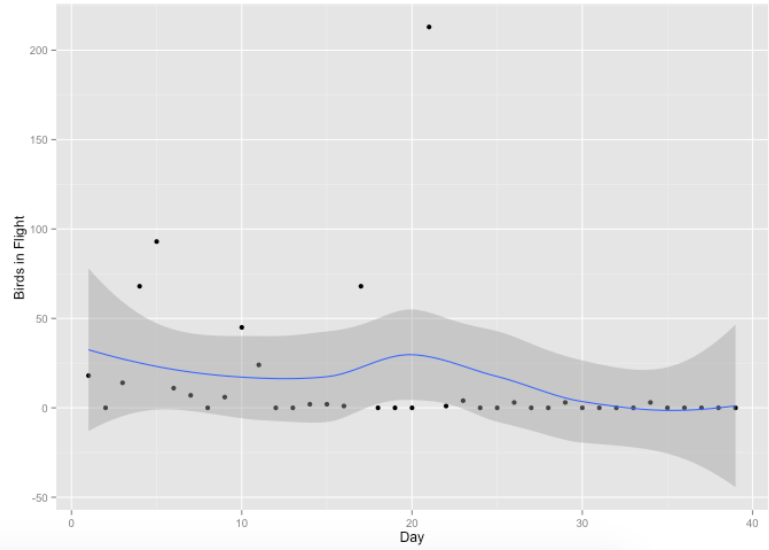


Fig. 1: Number of dabblers actively migrating across the 39-day season (Day 1: 4/3). Blue line represents nonlinear best fit; gray bar is 95% CI.

Bay ducks were the least systematic in their movements of all waterfowl groups, and were present in smaller numbers than expected for a Spring season at McGulpin. Their movements exhibited similar associations with weather conditions (the ideal fallout conditions on 4/23 also produced considerable bay duck fallouts), but in general bay ducks were generally unpredictable. Overall numbers peaked around mid-season, but were skewed upwards near the season's end by an anomalous late move of 65 scaup on 5/10 (Fig. 2).

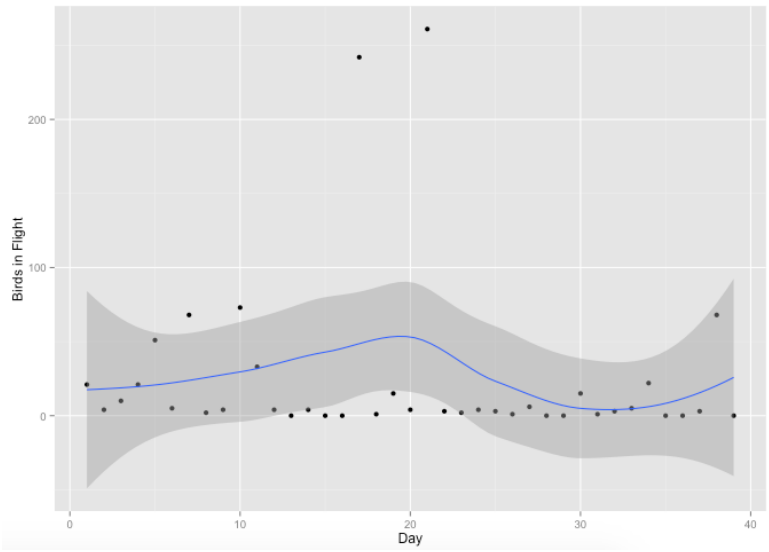


Fig. 2: Number of bay ducks actively migrating across the 39-day season (Day 1: 4/3). Blue line represents nonlinear best fit; gray bar is 95% CI.

Large fowl flights peaked earliest of all waterfowl groups, and followed a similar bimodal trend to dabbler flights (Fig. 3A). Nearly all were Canada geese. Loons and grebes (Fig. 3B) and mergansers (Fig. 3C) were more consistent migrants, with a slight peak in loon and grebe movements at mid-season, and generally minimal but steady numbers of mergansers across the full season. Scoters (Fig 3D) moved latest of all waterfowl groups, with the largest single push on 5/10.

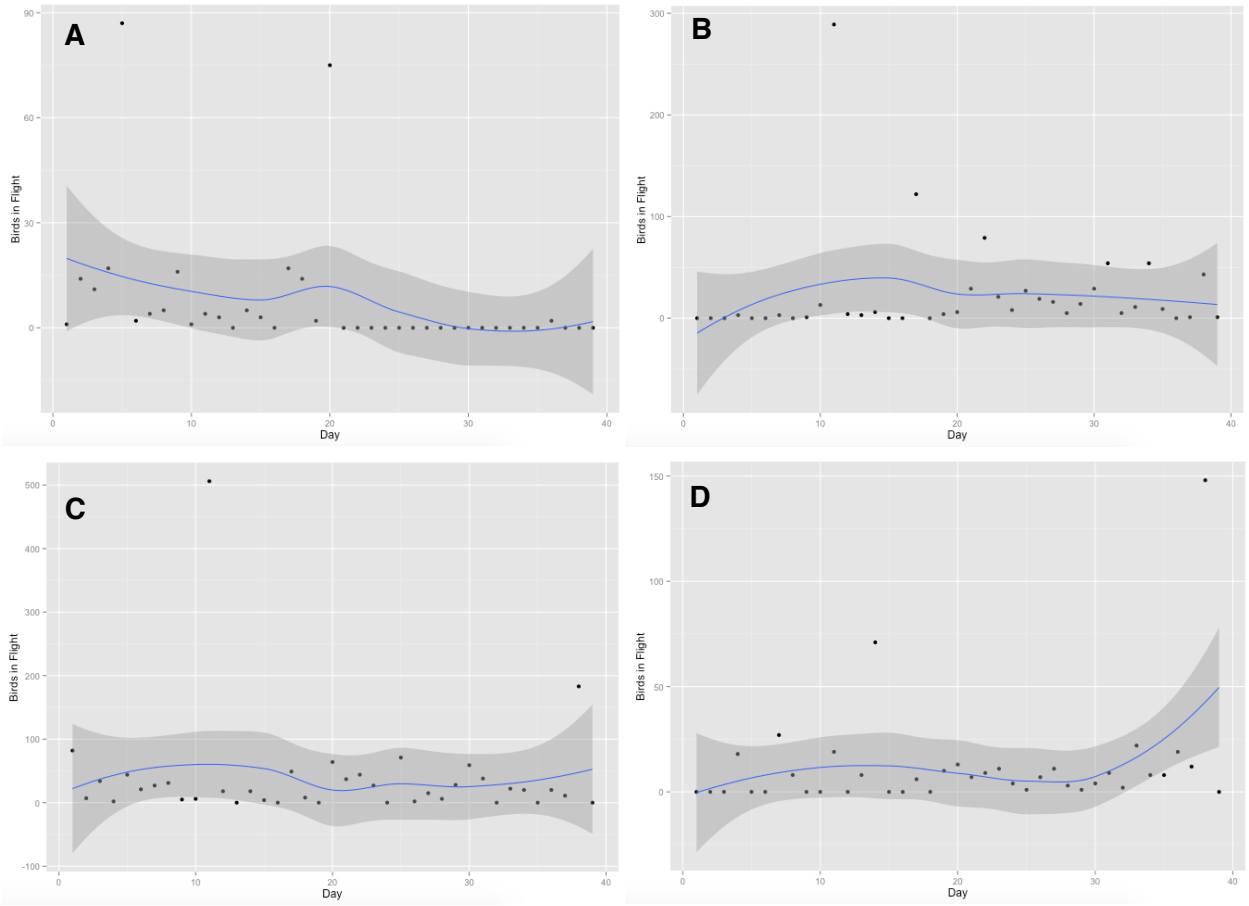


Fig. 3: Number of large fowl (A), loons and grebes (B), mergansers (C), and scoters (D) actively migrating across the 39-day season (Day 1: 4/3). Blue lines represent nonlinear best fit; gray bars are 95% CI.

Gull migration came in two distinct phases, with an early-season push of ring-bills and herrings, and late-season movements of Bonaparte's gulls, and Caspian and common terns (Fig. 4). Shorebird and wader migration through the straits was too sporadic to depict graphically, but early season posted several days of strong sandhill crane flights, and spotted sandpipers moved late in large numbers (30 birds on 5/9).

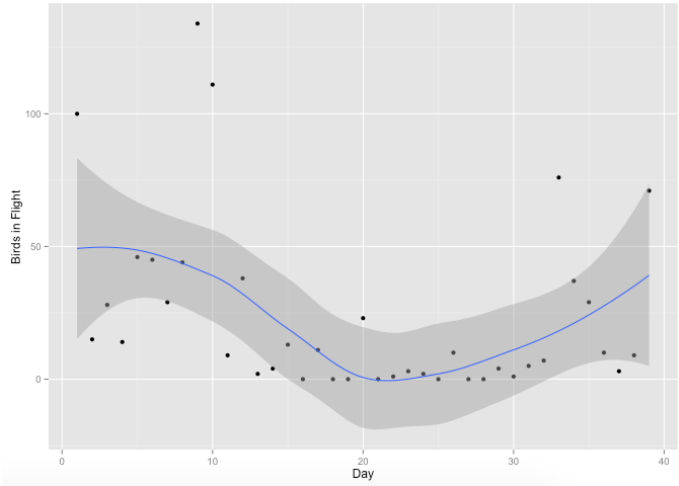


Fig. 4: Number of gulls actively migrating across the 39-day season (Day 1: 4/3). Blue line represents nonlinear best fit; gray bar is 95% CI.

McGulpin Point (Evenings)
Evening counts at McGulpin generally mirrored morning counts in terms of species composition and overall flight direction, but with considerably reduced abundances. Only one night (4/13) saw significant passage numbers in multiple species, with 59 common loon, 61 red-breasted merganser, and 117 long-tailed duck passing in three hours; this followed season-high passage counts for these species during the five-hour morning count of the same day. Another notable event occurred early in the season (4/4), as at least 600 distant gulls were observed flying NW at sunset in a single dense murmuration, with over 800 moving West over the course of the night.

Trails End Bay Marsh
No consistent actively migratory flights occurred among any species at Trails End Bay Marsh. Dabblers and bay ducks occasionally passed, or flew out from resting positions, but most waterfowl appeared to be using the Marsh as a feeding or staging ground. Occasional gull movements were witnessed, with sporadic Bonaparte's flocks and regular Caspian terns seen passing through the area.

This location did produce more shorebird and wader diversity than McGulpin Point, and several species were observed actively migrating (horned lark, killdeer, willet, solitary sandpiper, great egret, great blue heron), though never in large groups. Of note as well were regular showings of migrating raptors on favorable nights, particularly those more tied to aquatic habitats: 8 osprey and 10 harriers passed across the season.

Cheboygan SP
For a week before ice-out in the Straits, waterbirds were counted at Cheboygan SP from a new count location near the Poe Reef Cabin. These counts were unsystematic, and did not follow a consistent protocol, but they still revealed considerable early movements of waterbirds. On two days (3/27 and 3/28), multiple large flocks of dabblers and bay ducks came through close to shore, including FOY bufflehead, white-winged scoter, black duck, pintail, wood duck, shoveler, wigeon, and green-winged teal. Other early species of note were FOY pied-billed grebe, killdeer, and belted kingfisher, plus a wide diversity of moving winter and early-spring passerines, including pine grosbeak, pine siskin, white-winged crossbill, common redpoll, robin, red-winged blackbird, and common grackle.

Wind and ice conditions appeared to play a significant role in determining when, and particularly where, waterbirds would pass. On both of the heaviest flight days, winds ran parallel with the land, and the channel was mostly free of ice, bringing flocks close to shore. Perpendicular winds and greater ice cover on the remaining days at Cheboygan considerably depressed near-shore flights and appeared to push migrants further out, as on several days, multiple large unidentifiable flocks were witnessed flying North around the far side of Bois Blanc Island.

Fallouts
Fallout events were sporadic and appeared closely tied to weather conditions. Two such events are described here in more detail.

4/18: Few birds were visible during the morning count due to heavy fog, but a large, diverse species raft had materialized by midday South of Mackinaw City in a sheltered cove. The raft included 2 Canada geese, 10 blue-winged teal, 24 shoveler, 5 gadwall, 40 wigeon, 25 mallard, 2 black duck, 28 green-winged teal, 5 canvasback (which notably never appeared at McGulpin Point this season), 215 redhead, 137 ring-necked duck, 60 bufflehead, 5 goldeneye, 6 red-breasted mergansers, 1 common merganser, 1 horned grebe, and 310 scaup, which were roughly evenly divided between greater and lesser.

Fog conditions remained throughout the day, and produced a second, smaller fallout of birds at Trails End Bay, which had likely come up the West coast earlier in the day. These included 3 blue-winged teal, 19 shoveler, 21 gadwall, 29 wigeon, 55 mallard, 4 black duck,19 green-winged teal, 9 ring-necked duck, 11 greater scaup, and 3 lesser scaup. All dabblers were feeding in a tight group among the marsh vegetation, and the bay ducks were diving in the shallow creek mouth.

A considerable portion of the Mackinaw City raft passed through the Straits the following morning, though most were flying from overland with a strong tailwind, so many groups were unidentifiable; what's more, many likely passed entirely overland behind the count location before continuing West.

4/23: Fallout conditions began at McGulpin Point during the morning count, with a series of rolling fog banks stranding flocks of passage migrant dabblers and bay ducks just offshore. This fallout assemblage was more mobile than the previous event, as periodic clearing of the weather allowed for continuing flights; this suggests that visibility may be a key factor in determining whether duck migrants will move. The morning count produced 16 shoveler, 5 gadwall, 83 wigeon, 64 mallard, 3 black duck, 11 pintail, 13 blue-winged teal, 31 redhead, 63 ring-necked duck, 49 greater scaup, 7 lesser scaup, and 9 white-winged scoter, as well as 14 horned and 10 red-necked grebe.

Weather conditions worsened over the day to driving rain by evening, and once again, fallouts persisted at Trails End Bay, with another diverse dabbler assemblage feeding in the dense marsh vegetation. This group included 6 blue-winged teal, 26 shoveler, 9 gadwall, 43 wigeon, 42 mallard, and 7 green-winged teal. Most flew West around towards Cecil Bay by sunset, as weather improved slightly.

Staging

Three waterfowl species were observed loafing, feeding, and locally flying in considerable numbers over several weeks in the vicinity of the Straits, indicating that this region provides these species with an important staging ground.

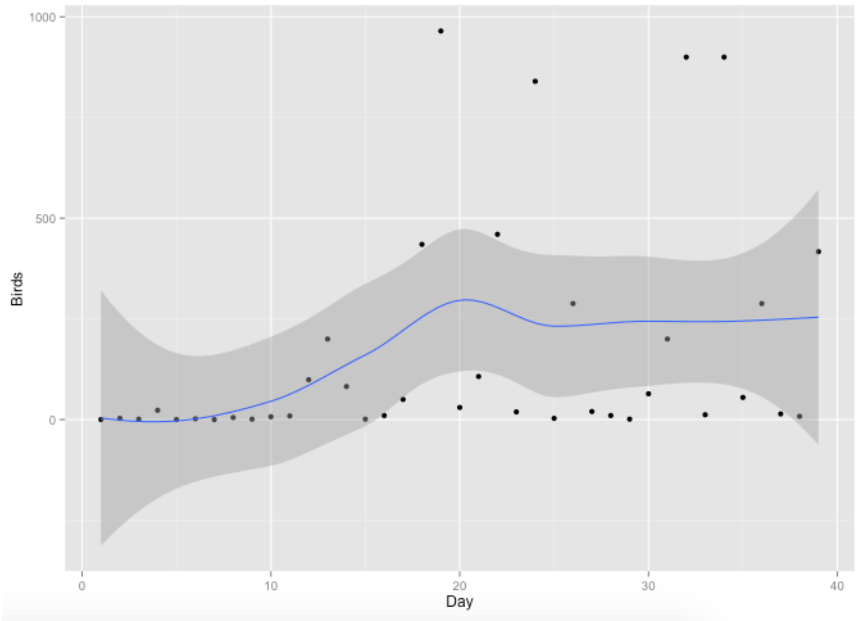


Fig. 5: Daily numbers of staging long-tailed ducks at McGulpin Point over the count season. Much of the late-season variation is due to variable visibility. Blue line represents nonlinear best fit; gray bar is 95% CI.

McGulpin Point
Long-tailed ducks were seen in the greatest numbers, with the first migrants arriving in mid-April, and the assemblage reaching a peak of just under 1000 birds by April 21st (Fig. 5). On days with greatest visibility, small flocks were observed along the length of the straits, often seen in flight for short distances and vocalizing frequently. This staging ground may be an important area for molting, as well, as early-season birds were primarily in winter plumage, while flocks late season had almost entirely developed breeding plumage. Day-to-day numbers were highly variable, as the birds were primarily seen at a distance of several miles, and were hence undetectable on days of poor visibility, but overall numbers did not considerably decline from the initial peak in late April to the end of the count in mid-May.

Red-breasted mergansers also appear to have used the Straits as a staging ground, with the first flocks arriving as soon as the ice had begun to break up on April 3rd, and numbers increasing steadily in parallel with the increase in long-tail numbers over the course of the season (Fig. 6). This increase likely represents an influx of birds that wintered further South to augment the initial numbers of local over-winterers.

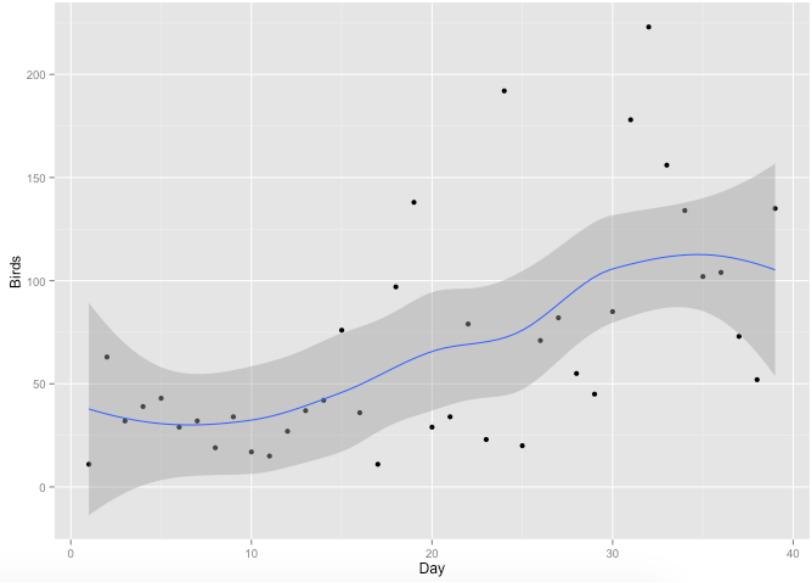


Fig. 6: Daily numbers of staging red-breasted mergansers at McGulpin Point over the count season. Blue line represents nonlinear best fit; gray bar is 95% CI.

Both species were seen actively migrating, as well, during this period, and occasionally in considerable numbers, so it is likely that these staging groups experienced a good deal of individual turnover as the season progressed; thus, both maximum estimates likely under-represent the true abundances of these species.

Trails End Bay Marsh
Buffleheads were observed sporadically from McGulpin Point, but were consistent stagers at Trails End Bay. The first few count days were dominated by adult males, followed by a brief period with a roughly 1:1 sex ratio, and a rapid transition to primarily female flocks by the second week of counts at this location. This greater abundance of females was sustained through the end of the season (Fig. 7, 8). A few likely immature males were observed among female flocks late in the season, but did not drastically alter the sex ratio of staging birds.

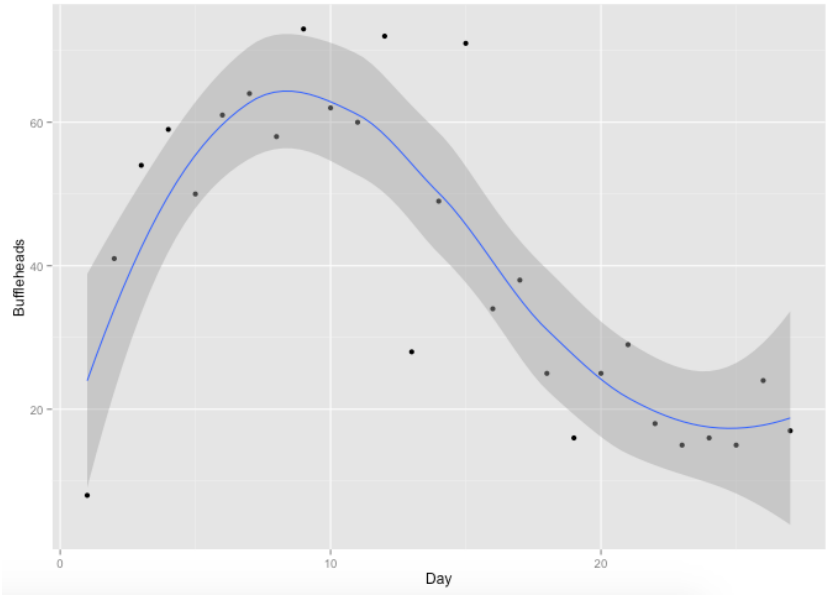
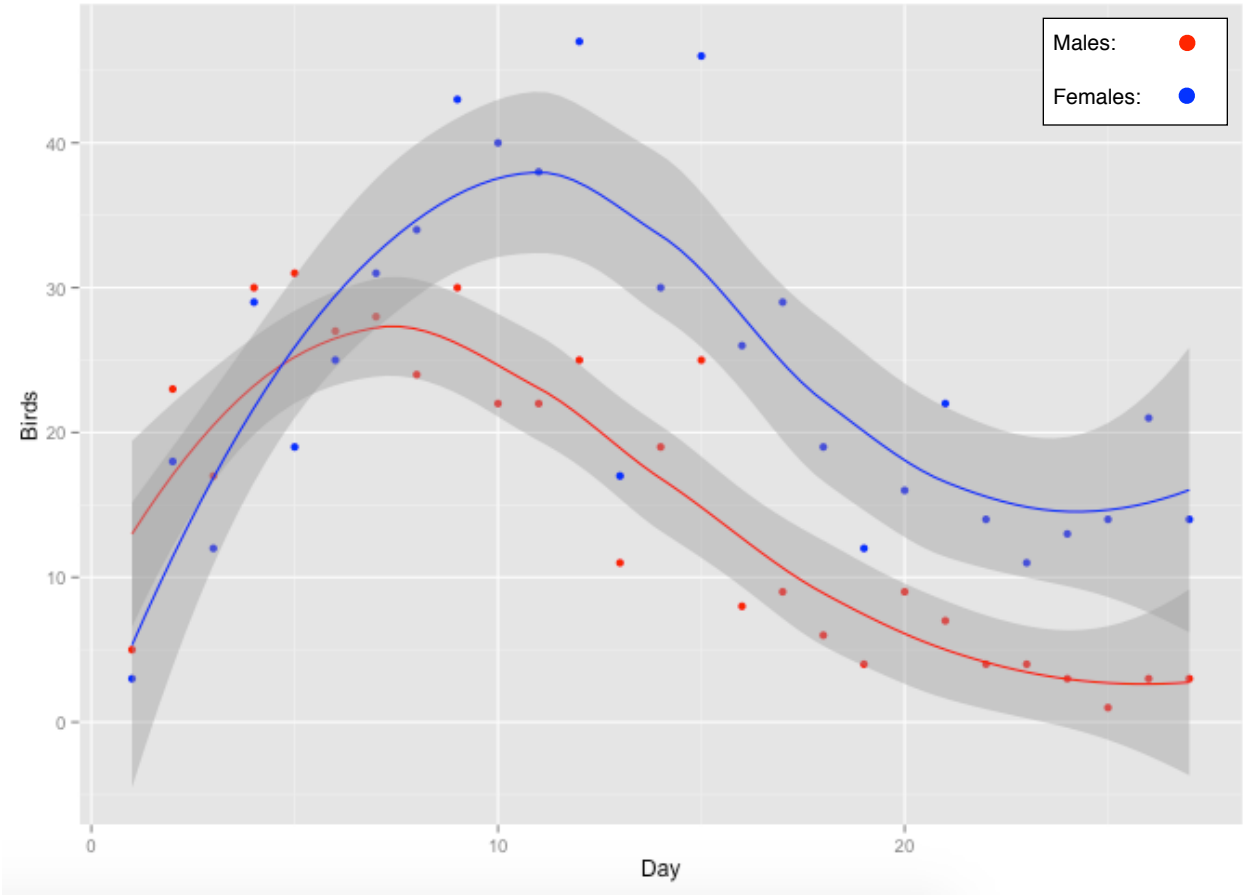


Fig. 7: Daily numbers of staging buffleheads at Trails End Bay Marsh over the count season. Blue line represents nonlinear best fit; gray bar is 95% CI.

Fig. 8: Daily numbers of staging buffleheads at Trails End Bay Marsh separated by sex. Lines represent nonlinear best fit; gray bars are 95% CI.



Rarities

The count season produced four interesting rarities, which are highlighted here in more detail.

4/19-4/25: Eared grebe. A lone bird was first spotted loafing and diving with the local group of buffleheads on April 19th, and remained in this location through the morning of 4/26, disappearing following wild North winds and high surf throughout the day. This was a first for this location, and a new species for the Straits region.

4/28-5/7 Tricolored Heron. Another long-staying local bird, first seen flying out from the creek mouth and around to Cecil Bay. on 4/28 The bird did not appear again until May 4th, when it returned from the West, and was seen daily thereafter, foraging in the dense alders around the creek mouth, preening in the nearby tamarack stand, and in flight between Trails End Bay and Cecil Bay. Extremely unusual, this bird was a first for this location, and another new species for the Straits region. It is a very rare species in Michigan, in general, at all times of the year.

5/2: Willet. A single flyby bird was heard and seen well, headed East in dense fog. Rare in the Straits region, especially on the South shore; most recent sightings have come from Point La Barbe.

5/10: Parasitic Jaeger. Amidst a windy, rainy day of widespread late gull and waterfowl migration, a single jaeger passed NW in the late morning, flying strongly and never observed foraging. The identification challenges of this species are discussed at length in the original eBird report, and long-tailed jaeger was ruled out by the presence of a dark breast-band. After consulting with experienced pelagic birders, the counter is now convinced that this bird can be narrowed down to Parasitic, due primarily to its generally tubular build (photos of Pomarine jaeger we discussed showed distinctly thicker-set, heavier birds), falcon-like flight style, and wings lacking extensive white primary flashes. The bird was likely a subadult due to the apparent absence of tail streamers. This jaeger species has been observed in several previous seasons at McGulpin, but this was the first Spring jaeger record for the Straits.

Discussion

Overall, this appears to have been a relatively slow Spring migration season, particularly among bay ducks, as in previous Springs (particularly 2015), several species have passed in the multiple hundreds. This relative absence is likely a product of several factors: variability in count conditions, long periods of unfavorable wind/weather conditions, and late ice cover.

Bay duck flocks often flew high and far from the South shore, which led to many being unidentifiable, particularly on days where heat shimmer or fog partially obscured distant birds. In contrast, dabbler flocks tended to appear closer to the Lower Peninsula, and passed in their greatest observed numbers on foggy days that produced near-shore fallout conditions, making for more exhaustive species counts. Both groups were certainly undercounted on several days with specifically unfavorable conditions; 4/24 was the best example of this, as strong Southeast winds released the previous day's mass fallout raft with an overland tailwind, leading to primarily quick overhead and extended rear views of passing flocks, which made for difficult identification. Considerable portions of this raft likely either continued undetected overland, or bypassed the Straits by flying up the East coast of the U.P.

Wind and weather conditions appeared to be significant factors in determining whether flights through the Straits would occur. Extended periods of minimal wind produced low numbers among all taxa, but increasing wind speed, alone, did not necessarily produce stronger flights, as each waterfowl group, and to some extent each species, appeared to move most strongly under a specific combination of conditions. For dabblers, periodic fog and moderate lateral winds appeared to be ideal conditions, and perhaps the frequency of foggy/rainy mornings was partly responsible for the relatively high abundance and diversity of dabbler species passing the Point this Spring. For larger, heavier scoters, and for similarly strong-flying mergansers (and to a lesser extent bay ducks as well), days of strong winds (particularly along the NW/SE axis) produced the largest observed flights. Such conditions appeared ideal for loons

and grebes as well, though the relatively weaker-flying grebes moved in greatest numbers with SE tailwinds, while the larger, heavier loons migrated in the greatest abundance when moving against a W or NW headwind (likely to gain support in generating lift).

Possibly the most important factor, however, in driving the relatively low abundances this season was the late retention of ice cover. The main sheet in the Straits did not begin to break up until April 3rd, and for the next week, shifts in wind often carried large sheets back into place across the Straits; instantly depressing migration.

Dabblers and bay ducks, in particular, exhibited a strong aversion to flying over ice (witnessed firsthand at Cheboygan SP: a day of heavy flights was immediately halted by a raft of ice sheets blown South by a NW wind; all passing flocks fell out to loaf). This may be a predator-avoidance response, as an ice sheet provides no last-ditch escape option from a stooping raptor. The apparent lack of similar aversion among mergansers may be explained by their stronger, faster flight style, though large shifts of ice periodically depressed movements of these species, as well.

The straits did not become consistently ice-free until the season was nearing mid-April, a time of year when many bay ducks have typically already passed Northwards. Indeed, in the week of counts at Cheboygan SP in late March, multiple large flocks of ducks (likely *Aythya sp.*) were witnessed bypassing the Straits entirely and heading North around Bois Blanc Island. It is therefore very likely that a considerable portion of the region's migrating bay ducks had already flown North by the time of ice-out, and never came through the Straits.

The Mackinac Straits Raptor Watch has generated several years of rigorous data, but there is much about the passing waterbirds that remains uncertain. For instance, in the absence of longer-term data, it is difficult to assess how decade- or century-scale changes in climate, food sources, lake conditions, and habitat type have influenced the species distribution and abundance of waterbird migrants through the Straits. Unknown, as well, (though suspected), is the extent to which some species bypass the Straits in favor of alternate routes, regardless of wind and ice conditions in a particular year.

It is also important to note that the associations drawn above have been primarily qualitative, and a more rigorous quantitative analysis across multiple years that incorporated numerical wind and weather data (which were not possible to access from dunkadoo.org) would be necessary to draw firmer conclusions about year-to-year variation in species abundances and species-specific weather effects.

Still, it is clear from this season, alone, that the Straits and its associated rocky coastline, peninsulas, and marshlands represent a significant ecological entity, with broad importance for multiple species of migrating, staging, and breeding waterbirds.

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