Proceedings of the Nova Scotian Institute of Science (2024)
Volume 53, Part 2, pp. 305-319

SOUNDWAVES IN THE NORTH ATLANTIC: DETECTING THE OFFSHORE BATS OF SABLE ISLAND

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ABSTRACT

As Sable Island National Park Reserve approaches a decade of protection under Parks Canada, new data on the island's biodiversity is useful for informing management. An ultrasonic autonomous recording unit was deployed for 15 months over two years (October 5, 2015-January 8, 2017) to quantitatively characterize the presence of bats on Sable Island. A total of 1721 echolocation passes were identified across the 32 nights that bats were detected on the island (6.9% of total recording nights). Of the nights that bats were detected, *Lasionycteris noctivagans* (Silver-haired Bat) was present on 65% of nights, *Myotis* species were present on 53% of nights, *Lasiurus borealis* (Eastern Red Bat) was present on 25% of nights, and *Lasiurus cinereus* (Hoary Bat) was present on 6.25% of nights. All recordings were captured between late-September and early-December. Evidence of bat species on Sable Island, whether deliberately stopping during migration or brought there by external factors such as weather, highlights that the island may be more important for bats than previously thought.

Keywords: bats, bioacoustics, migration, monitoring, Sable Island

INTRODUCTION

Nova Scotia is a permanent home to at least three species of bats and may be a migratory stopover point, or breeding location, for up

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to three more species (Broders *et al.* 2003, Lucas and Hebda 2011). Bat species distributions on mainland Nova Scotia (NS) are reasonably well understood (Broders 2004, ACAP 2015, Segers *et al.* 2013), where three "resident" species (*Myotis lucifugus*, *M. septentrionalis*, and *Perimyotis subflavus*) and three migratory species (*Lasiurus cinereus*, *L. borealis*, and *Lasionycteris noctivagans*) are known to occur. However, records of bats on the offshore Sable Island National Park Reserve (SINPR) are puzzling (Lucas and Hebda 2011) as the island is located 175 km off mainland NS and it lacks trees that would normally provide day-roosts for bats. Indeed, one study reports three species of bats were observed on the island between May and December over a three-year period (Lucas and Hebda 2011). Researchers and other visitors have also observed bats roosting under the eaves of buildings and pieces of wood at Main Station, located in the center of the island (K. Patriquin 2021, pers. obs.).

These observations are of interest as they contradict the long-held assumption that bats follow landscape features, such as coastlines, while migrating (Hatch *et al.* 2013, Eklöf *et al.* 2014). While observations of bats at sea have been recorded as early as the 19th century (Miller 1897, Norton 1930, Peterson 1970, Peterson *et al.* 2014, Hatch *et al.* 2013, Thompson *et al.* 2015, Dowling and O'Dell 2018), records of bats on Sable Island add to increasing evidence that bats may regularly migrate offshore, rather than only occasionally getting blown off course. Such migration behaviour raises concern for potential conflict with offshore wind farms (Sjollema *et al.* 2014, Brabant *et al.* 2021, Lagerveld *et al.* 2021, True *et al.* 2021) and oil platforms (Boshamer and Bekker 2008). Recent observations show a strong correlation between favourable ambient conditions and the detection of bats at sea (Thompson *et al.* 2015, Brabant *et al.* 2021, Lagerveld *et al.* 2021, True *et al.* 2023). Others speculate that bats may be more likely to visit offshore refuges during periods of inclement weather, when strong winds or weather events might be pushing them to sea (Lucas and Hebda 2011).

To gain a better understanding of bat offshore movements, we investigated bat acoustic activity on SINPR. In 2013, Sable Island was established as Canada's 43rd National Park. This designation shifted management priorities to align with Parks Canada's mandate to protect the site's ecological integrity (PCA 2016, GC 2020). Maintaining the integrity of a protected site requires the development of comprehensive indicators that can be used to track ecological shifts and trends. To this end, a Species at Risk (SAR) assessment for SINPR was completed in 2015 to inform management plans and develop ecological integrity monitoring programs to conserve native species (PCA 2016). The assessment generated a species inventory for SINPR which included 573 species of terrestrial invertebrates, 330 species of birds (including migrants and vagrants), and 230 species of vascular plants. Only two mammal species – wild horses (*Equus ferus caballus*) and grey seals (*Halichoerus grypus*) – were included in the inventory (PCA 2016). No bat species were identified, and thus there is no current inclusion of any bat species in the current SINPR Management Plan (PCA 2019). Accordingly, identifying the extent that bats use SINPR is important for Parks Canada and the fulfillment of their mandate. Understanding where, when, and why bats might visit SINPR will help form inclusive ecological integrity monitoring programs and better support bat habitat as they pass over the North Atlantic.

METHODS

ARUs

Autonomous recording units (ARUs) are durable, weather-proof bioacoustic recording devices that can be used to detect and record ultrasonic sounds. ARUs can be deployed in the field for extended periods of time, making them useful for collecting data in remote locations while simultaneously reducing human disturbance in sensitive habitats (Shonfield and Bayne 2017). In 2015, we deployed an ultrasonic ARU (Wildlife Acoustics Song Meter 2) on SINPR at Main Station, a small cluster of buildings that houses Parks Canada staff and visiting researchers. The ARU was hardwired to a power source to allow it to function continuously for roughly 17 months (October 2015 – January 2017). The microphone was attached to a wire that extended up a small post, roughly 2 meters above the roof of a small warehouse. The ARU was set to record when a minimum of two pulses, each between 2 and 500 milliseconds long, and between 8 and 120 kHz, were detected. This setting covers the frequency range of bats known to be in this region (Table 1) (McBurney and Segers 2021).

Acoustic Analyses

Recordings collected by the ARU were analyzed using the bat auto-identification feature in Kaleidoscope Pro Analysis Software (Wildlife Acoustics 2017). This feature gives an estimated species identification specific to geographical regions (Wildlife Acoustics 2017). The auto-identifications were then manually vetted by K. Doucette to confirm species identification based on the species' characteristic echolocation minimum frequency (Table 1). Unclear or ambiguous recordings were verified by K. Patriquin, L. Phinney (Mersey Tobeatic Research Institute), D. Washinger (Canadian Wildlife Health Cooperative), and J. Segers (Canadian Wildlife Health Cooperative). Given the relatively flat and barren habitat that characterizes SINPR, there were no expected disruptions by landscape in the detection of echolocation calls that occurred near the deployed ARU (Patriquin *et al.* 2003). Other variables from the recording, such as maximum frequency and call duration, were used to discern calls that had similar or overlapping minimum frequencies. If a call could not be identified to the species level, it was assigned to a species group (e.g., *Myotis spp.*) based on shared call characteristics.

Once the species was identified, each "pass" (two or more echolocation pulses fitting the kHz criteria) was then classified as presence of an individual, presence of more than one species, or "buzz" calls. "Buzz" calls are a series of increasingly rapid clicking noises that taper in frequency, that bats often emit as they are closing in on prey (Schnitzler *et al.* 2003, Holderied *et al.* 2005). Noise files, triggered by ultrasonic frequencies in wind and other ambient sounds (e.g., insects), were analyzed (automatically and manually) to confirm no bats were present and then removed from the dataset.

Statistical Analyses

Echolocation passes were aggregated into a presence-absence matrix for each species or species group to determine what days they were present on SINPR. Passes that had more than one individual within the same species were only counted once in the species total count, but recordings that had more than one species were counted in both species' total count. Since bioacoustics monitoring can only identify species but not individuals, each pass was only used as evidence of presence, not as a count of individual bats at a given time.

Table 1 **Minimum and maximum frequencies (kHz) used to identify bat species by audio and visual spectrograph analysis in Kaleidoscope Pro (McBurney and Segers 2021).**

	Frequency (kHz)	
	Minimum	Maximum
Lasiurus cinereus	15	30
Lasionycteris noctivagans	25	30
Lasiurus borealis	30	45
Myotis lucifugus; Myotis septentrionalis	35	110

RESULTS

At least four species of bats (Silver-Haired Bats (*L. noctivagans*), Hoary Bats (*L. cinereus*), Eastern Red Bats (*L. borealis*) and *Myotis spp.*) were detected on SINPR over the recording period. A total of 1721 echolocation passes by bats on 32 nights were recorded. In 2015, passes were detected in October (n = 1501), November (n = 26), and December (n = 4). In 2016, passes were detected in September (n = 2), October (n = 4), November (n = 182), and December (n = 2). Buzz calls were rarely recorded (n = 62). Activity was detected almost entirely around dusk (Fig 1). When bats were detected around dawn, they were not detected earlier in the same night, with one exception. Bats were rarely detected on multiple consecutive nights (but see below).

The occurrence of species was classified as either presence or absence on days where at least one species was detected. *L. noctivagans* were detected the most frequently in both years, present on 22 of 32 nights that bat activity was detected on SINPR. *Myotis spp.* were present on 17 nights across both years, *L. borealis* were present on 8 nights across both years, and *L. cinereus* were detected the least frequently, on only 2 nights in 2016.

Over the study period, five peaks in detection were identified from the presence-absence matrix (Table 2). Peaks were defined as periods during which there was a higher number of echolocation passes (100 passes) or when there was a greater diversity of species detected (3 species). The first peak, from 2015-10-12 to 2015-10-17, had the highest number of passes (n = 1277) of the entire survey period. Of these passes, *L. noctivagans* was detected the most frequently (n = 1230, 96.3%). Both *L. borealis* and *Myotis spp.* were also detected. The second peak, on 2015-10-25, had a high number of passes

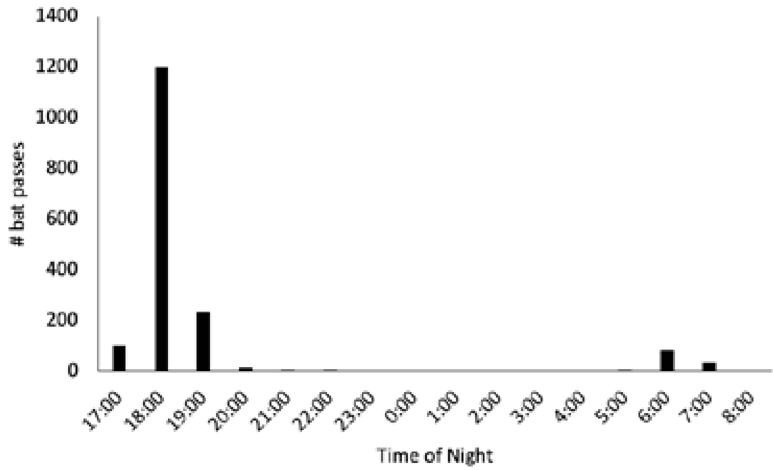

Fig 1 **Temporal distribution of echolocation passes detected over the recording period.**

(n = 115), but only *L. noctivagans* was detected. The third peak, on 2015-11-30, was the only night that all four species were detected at least once. The fourth peak, on 2016-11-08, had three species detected (*L. noctivagans, L. cinereus, Myotis spp.*). The fifth peak, from 2016-11-14 to 2016-11-15, accounted for most detections in 2016 (n = 135, 71% of the 2016 total), with three species (*L. noctivagans, L. borealis, Myotis spp.*) present.

DISCUSSION

Over the recording period, three long-distance migratory bats (*L. noctivagans, L. cinereus, L. borealis*) and at least one regional migrant (*Myotis spp.*) were detected on SINPR 175 km offshore. Long-distance migrating, non-hibernating bats are characterized by flights of over 1000 kilometers to their wintering grounds (Fleming and Eby 2003, Cryan *et al.* 2004, Sjollema *et al.* 2014), whereas regional migrants, such as *Myotis lucifugus*, typically only travel up to 500 kilometers between summer and winter habitats (Fleming and Eby 2003, Norquay *et al.* 2013).

All detections on SINPR roughly aligned with the end of the autumn migration period, with most detections occurring in October and November. All three migratory bats identified have been known to initiate their fall migrations in mid- to late August into

Table 2 **Presence-absence (1-0) and number of passes (n) for each bat species (LANO, *L. noctivagans*; MYOTIS, *Myotis spp.*; LABO, *L. borealis*; LACI, *L. cinereus*) detected on SINPR by acoustic monitoring. Highlighted rows represent peaks in detection (higher or richer bat presence).**

Peaks in Detection	Date	LANO	n	MYOTIS	n	LABO	n	LACI	n
	2015-10-05	1	53	0	0	0	0	0	0
	2015-10-07	1	25	0	0	0	0	0	0
	2015-10-08	1	14	0	0	0	0	0	0
	2015-10-09	1	1	0	0	0	0	0	0
1	2015-10-12	1	571	1	1	0	0	0	0
1	2015-10-13	1	320	0	0	1	1	0	0
1	2015-10-14	1	114	1	2	0	0	0	0
1	2015-10-15	1	61	1	2	1	1	0	0
1	2015-10-16	1	147	1	5	1	34	0	0
	2015-10-17	1	17	1	1	0	0	0	0
	2015-10-21	0	0	1	1	0	0	0	0
	2015-10-22	0	0	1	1	0	0	0	0
	2015-10-23	1	6	0	0	0	0	0	0
2	2015-10-25	1	115	0	0	0	0	0	0
	2015-10-31	1	7	0	0	0	0	0	0
	2015-11-02	1	2	0	0	0	0	0	0
	2015-11-09	1	1	0	0	0	0	0	0
3	2015-11-10	1	19	1	1	1	1	1	1
	2015-11-22	0	0	1	1	0	0	0	0
	2015-12-12	1	4	0	0	0	0	0	0
	2016-09-22	0	0	1	1	0	0	0	0
	2016-09-24	0	0	1	1	0	0	0	0
	2016-10-05	0	0	1	1	0	0	0	0
	2016-10-11	0	0	0	0	1	1	0	0
	2016-10-23	0	0	1	1	0	0	0	0
	2016-10-24	0	0	0	0	1	1	0	0
	2016-11-06	0	0	1	1	0	0	0	0
4	2016-11-08	1	2	1	3	0	0	1	40
	2016-11-10	1	1	0	0	0	0	0	0
	2016-11-14	0	0	1	1	1	35	0	0
5	2016-11-15	1	5	1	10	1	84	0	0
	2016-12-02	1	2	0	0	0	0	0	0

early October (Lucas and Hebda 2011). No calls were recorded in any other season. This suggests that bats used SINPR as a refuge during their southward movements. However, the reason for their visits remains unknown. Earlier research has suggested that ambient temperature, wind speeds and direction, and barometric pressure are likely to influence offshore bat activity. Some studies propose that bats are likely to be present offshore during calm weather, possibly exploiting mild conditions for foraging (Brabanet *et al.* 2021, Lagerveld *et al.* 2021, True *et al.* 2023), whereas others predict more occurrences as bats are displaced during inclement weather (Lucas and Hebda 2011).We therefore explore three hypotheses to explain bats on SINPR: bats are being blown northward from further south along their migratory paths, they are being blown eastward and out to sea while moving to their overwintering habitat, or they are actively navigating to Sable Island.

Bats being blown northward

Birds have been known to become entrained in storms during southward autumn migrations and blown back north as storms move into the North Atlantic (McLaren 2012). These storms, including hurricanes and nor'easters, may be similarly affecting bats. An earlier inventory of Nova Scotian bat sightings also reported three species of bats on SINPR as late as November (*L. borealis, L. cinereus*) and December (*L. noctivagans*), suggesting that windward bats may become stranded and seek refuge after being blown off course (Lucas and Hebda 2011).

The timing of bat detections on SINPR parallels the timing of the latter part of the annual hurricane season in the Atlantic Ocean. In 2015, two major storms were recorded in the autumn: Major Hurricane Joaquin (September 28-October 7) and Hurricane Kate (November 8-11) (Stewart 2016). Although neither hurricane passed directly over SINPR, both dissipated over Atlantic waters just south of the island, coming as close as 575 and 680 kilometers, respectively. Hurricane Joaquin occurred in the days leading up to the first peak in detection, while the third peak in detection occurred during Hurricane Kate.

Further research on offshore bats should consider broad weather patterns to explore whether strong storms indeed push bats back up the Atlantic coast. However, the second, fourth and fifth peaks in detection do not temporally correspond to a major Atlantic storm. This suggests that significant oceanic weather events may not entirely explain the presence of bats on SINPR. Additionally, these storms likely do not account for the presence of *Myotis spp.*, as they do not move southward on the same scale. Interestingly, a bat of unknown species was discovered inside one of the buildings at Main Station in January 2024 (D. Kehler, PCA, pers. comm.). During a necropsy, staff at the Canadian Wildlife Health Cooperative (CWHC) determined the bat is not a Canadian bat species (Dr. M. Jones, CWHC, pers. comm). Despite collecting numerous measurements, the bat's identity currently remains unknown. This appears to corroborate the hypothesis that at least some bats are being blown to SINPR.

Bats being blown seaward

Bats may also be wandering across the North Atlantic under *drift migration*, where they are pushed longitudinally during autumn migrations due to converging air masses (Maunder 1988). This has also been observed in migratory landbirds in Atlantic Canada (McLaren 1981, Lucas and Hebda 2011). Some bats, including lasiurine species, are already known to migrate longitudinally as coastal areas remain mild relative to inland habitats, potentially offering better weather for foraging (Lucas and Hebda 2011, Cryan *et al.* 2014). Drift migration may also help explain the appearance of *Myotis,* which are not expected to make substantial latitudinal migrations.

Bats intentionally moving to Sable Island

Although weather conditions could influence the flights of bats, they may also be using these offshore locales as a rest stop during regular migrations. Insectivorous bats are known to enter torpor at stopover sites during long-distance migrations to conserve energy and may also use a *fly-and-forage* strategy to preserve endogenous fat (McGuire *et al.* 2011, Jonasson 2017, Lagerveld *et al.* 2021). The threshold for insect activity to generally allow for foraging is expected to be around 10°C (Reinhold *et al.* 2018). Minimum temperatures on SINPR during the five peaks in detection ranged from 3.3°C to 15.9°C (GC 2022). The minimum temperature remained above 10°C on six of the eleven days included in the peak detections and was between 8.7 and 10°C for another four (GC 2022). The minimum temperature fell to 3.3°C during the third peak in detection; however, the mean daily temperature remained over 10°C during all eleven days (GC 2022). This suggests that insects may have been available, possibly inferring that bats moved to SINPR on purpose to use the *fly-and-forage* strategy before moving further south. Various insects, including moths, have been documented on SINPR (Wright 1989, Lucas and Horn 2020) and could provide a food source for visiting bats. However, bats appeared to forage very rarely on SINPR within the vicinity of the ARU, despite its proximity to the lights at Main Station which would attract common prey items for bats. The proportion of passes that included buzz calls was low throughout the study period, appearing in only 3.7% of the total passes.

Additionally, buzzes cannot be confidently identified as successful foraging events. Although some individuals may have taken advantage of the opportunity to feed, we speculate that foraging does not appear to be a main driver for bats moving to SINPR.

If SINPR was a routine stopping point, there would also likely be more consistency in detections across years and species. Admittedly, bat activity varies considerably across nights, even in regularly used areas (Hayes 1997). However, the irregular appearance of hoary bats suggests that they are not seeking out SINPR as part of their typical migratory route. Also, the significant difference in detections between the two years (2015, n = 1531; 2016, n = 190) suggests there may have been some underlying event, climatic or otherwise, that drove bats to SINPR (but see below for limitations).

Another potential cause for bats to actively head to SINPR is the presence of lights at Main Station. Though bats typically use echolocation to navigate, they may also use visual cues, such as lights, landscapes, and stars, to navigate while over the open ocean (Hatch *et al.* 2013, Eklöf *et al.* 2014, Brabant *et al.* 2021). There are several lights installed at Main Station that stay on throughout the night, as well as red lights at both East and West Light. Bats may use these lights as beacons to navigate to buildings that can provide refuge before continuing their journey south. Although it may be possible that bats could be taking advantage of foraging opportunities while on SINPR, it seems unlikely they would purposefully travel 175 km to do so. In fact, evidence that most activity occurred around dusk and rarely throughout the night or into dawn may suggest bats were leaving the island soon after arriving (or moving elsewhere on the island). Instead, it is more likely they were blown off course, either during their migrations south or eastward during longitudinal movements to hibernacula.

Limitations & Further Research

The data in this study were collected by one ARU deployed in one location on SINPR. That said, the ARU was deployed at Main Station, where the concentration of buildings provides roosting opportunities that are otherwise lacking due to the absence of trees. It is also lit throughout the night which would attract moths. As such, activity would likely be highest at this location. Nevertheless, deploying ARUs at different points across the island where other structures occur would provide a more comprehensive data set. Including structures that do not remain lit year-round may also provide insights on the light sources at Main Station acting as an attractive beacon to passing bats. Using acoustic monitoring to detect species also has inherent limitations (Gibb *et al.* 2018). For example (or most notably), number of individuals cannot be inferred from detections; only presence or absence of the species on a given day. For instance, the majority of the 2015 detections are attributed to *L. noctivagans* within a 5-day timespan. It is possible a single bat was responsible for this activity, or several bats may have been present at the same time. Multiple detectors across the island could help determine if multiple individuals make use of the island. Additionally, the microphones in ARUs are subject to deterioration with use (Turgeon *et al.* 2017). As the ARU was not serviced during its deployment, it may have experienced a decline in sensitivity which may have led to a detection bias between the beginning of the study period and the end.

Weather, including continental patterns to the north, west, and from the southwest, should also be considered in further research to determine if sustained trends or anomalies could be used to predict when bats are more likely to be detected at offshore sites. Previous studies have used air temperature, wind speed, and barometric pressure to investigate which weather variables may affect bats (Sjollema *et al.* 2014, Brabant *et al.* 2021, Lagerveld *et al.* 2021). Atmospheric winds (streamlines) have also been used to study the effect on bird migrations (McLaren 1981, Lucas and Hebda 2011). Examining these streamlines at the altitude of migratory bats may help account for abnormal wind fluctuations that could blow migrating bats off course.

Management

To better support bats during the autumn migration, Parks Canada and other staff on SINPR could help prepare for their arrival by ensuring appropriate species-specific roosting sites are available, including bat boxes designed to support cavity and foliage roosting bats (Holroyd *et al.* 2023). As SINPR considers Dark Sky Preserve designation, managers should consider the impact that the criteria may have on bats that might be using the light sources as a navigational beacon. From this study, no conclusive statements can be made that SINPR is a regular part of bats' migratory paths; however, the recurring presence of bats over two years, as well as the previous observations reported by Lucas and Hebda (2011), indicates that bats use SINPR to some extent.

Acknowledgements We thank Lori Phinney (Mersey Tobeatic Research Institute), Darrian Washinger (Canadian Wildlife Health Cooperative) and Jordi Segers (Canadian Wildlife Health Cooperative) for helping to verify unfamiliar or unidentifiable echolocation calls. We also thank Mark Brigham and one anonymous reviewer for their insightful comments.

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