



Acoustic Monitoring for Bats at Voyageurs National Park

Data Summary Report for 2015–2019

Natural Resource Data Series NPS/GLKN/NRDS—2022/1342



ON THE COVER

Bat acoustic monitoring equipment at Voyageurs National Park.
NPS

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Data Summary Report for 2015–2019

Natural Resource Data Series NPS/GLKN/NRDS—2022/1342

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Contents

	Page
Figures.....	v
Tables.....	vii
Appendices.....	ix
Abstract.....	xi
Acknowledgments.....	xi
Introduction.....	1
Methods.....	5
Site Selection.....	5
Data Collection.....	6
Data Management and Analysis.....	7
Results.....	9
Survey Effort.....	9
Automated Classification.....	9
Spatial and Temporal Distribution.....	15
Manual Vetting.....	16
Summary and Conclusions.....	17
Big Brown Bat.....	19
Eastern Red Bat.....	19
Hoary Bat.....	19
Silver-haired Bat.....	20
Little Brown Bat.....	20
Northern Long-eared Bat.....	20
Tricolored Bat.....	20
Literature Cited.....	23

Figures

	Page
Figure 1. Bat monitoring sites at Voyageurs National Park.....	6
Figure 2. Yearly survey effort at Voyageurs National Park, 2015–2019.....	9
Figure 3. Percent of audio files classified by Kaleidoscope Pro as bat species vs. unknown bats vs. noise, corrupt, and excluded files, Voyageurs National Park, 2015–2019.....	10
Figure 4. Proportion of files classified to each species each year in the baseline versus expanded analysis, Voyageurs National Park, 2015–2019.	11
Figure 5. Proportion of files classified to each species each year relative to all other species, Voyageurs National Park, 2015–2019.....	12
Figure 6. Parkwide call files per recording night by species and year for the expanded analysis, Voyageurs National Park, 2015–2019.	13
Figure 7. Call files per recording night for each species and for all species combined, by year, for the expanded analysis, Voyageurs National Park, 2015–2019.....	14
Figure 8. Proportion of monitoring sites where each species was detected each year, Voyageurs National Park, 2015–2019.	15
Figure 9. Proportion of recording nights on which each species was detected each year, Voyageurs National Park, 2015–2019.	16
Figure F1. Percent of audio files classified as noise for each detector model (mean $\pm$ 95% confidence interval).	41
Figure F2. Percent of audio files classified as noise for each sampling site at Voyageurs National Park, 2016–2019.	42
Figure I1. Percent of audio files classified as each bat species by Kaleidoscope Pro in the baseline analysis for each park and year.	58

Tables

	Page
Table 1. Bat species occurrences recorded at Voyageurs National Park prior to the initiation of the GLKN acoustic monitoring program in 2015, and method(s) by which the species were documented.....	2
Table 2. Summary of bat species documented at Voyageurs National Park through automated classification and manual vetting of acoustic files.....	18
Table A1. Nine bat species are found in the Great Lakes region.....	27
Table B1. Bat species included as possible candidates during Kaleidoscope Pro species classification, where an “X” means yes and an en-dash (–) means no.	29
Table D1. Earliest and latest dates equipment was deployed, number of deployments in each category, and total number of files recorded for each survey year, Voyageurs National Park, 2015–2019.	33
Table D2. Total number of sites, recording nights, files recorded, and mean recording nights per site, mean files per site, and mean files per recording night for each survey year’s valid deployments only, Voyageurs National Park, 2015–2019.....	33
Table E1. Total number of audio files recorded, and number and percent classified by Kaleidoscope Pro as bat species vs. unknown bats vs. noise for each year and analysis type, Voyageurs National Park, 2015–2019.	35
Table E2. Total number of audio files classified as each bat species by Kaleidoscope Pro for each year and analysis type, Voyageurs National Park, 2015–2019.....	36
Table E3. Percent of audio files classified as each bat species by Kaleidoscope Pro for each year and analysis type, Voyageurs National Park, 2015–2019.....	36
Table E4. Total number of monitoring sites and count of sites where each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019.....	37
Table E5. Total number of monitoring sites, and percent of sites where each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019.....	38
Table E6. Total number of recording nights, and count of recording nights on which each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019.....	39
Table E7. Total number of recording nights, and percent of recording nights on which each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019.....	39

Tables (continued)

	Page
Table F1. Mean percent of audio files classified as noise for each sampling site at Voyageurs National Park, 2016–2019.	43
Table G1. Total number of files manually vetted, and the results of manual vetting for each year, analysis type, and species, Voyageurs National Park, 2015–2019.	45
Table H1. Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019.	47

Appendices

	Page
Appendix A: Bat Species of the Great Lakes Region.....	27
Appendix B: Baseline and Expanded Species Lists.....	29
Appendix C: Analysis Settings for Kaleidoscope Pro.	31
Appendix D: Yearly Deployment Data.....	33
Appendix E: Automated Classification Results.....	35
Appendix F: Noise Assessment.	41
Appendix G: Manual Vetting Results for Entire Park.	45
Appendix H: Manual Vetting Results by Site.....	47
Appendix I: Species Composition Across Parks.....	57

Abstract

The Great Lakes Inventory and Monitoring Network initiated an acoustic monitoring program for bats in 2015. This report presents results for 2015–2019 surveys at Voyageurs National Park. Acoustic recordings were analyzed using the software program Kaleidoscope Pro and a subset of files were manually reviewed to confirm species identifications. The three bat species previously documented at the park were reconfirmed: silver-haired bat, little brown bat, and northern long-eared bat. Four additional species were documented through both automated Kaleidoscope classification and manual vetting: big brown bat, eastern red bat, hoary bat, and tricolored bat. Apart from the tricolored bat, the presence of these species was expected since the park lies well within their known ranges. The park is northwest of the typical range of the tricolored bat, but this species has been recorded in other parts of northern Minnesota, which prompted us to include it in our expanded analysis. We obtained one manually verified tricolored bat recording, suggesting that this species is at least occasionally present in the park. Activity levels for big brown bat, hoary bat, and silver-haired bat appear to be stable or increasing slightly. Activity levels for eastern red bat, little brown bat, northern long-eared bat, and tricolored bat show decreasing trends.

Acknowledgments

This work would not have been possible without all the park employees, partners, and volunteers who completed field surveys and provided logistical support, including S. Windels, S. Johnson-Bice, G. Fuller, K. Pawlaczyk, A. Keller, T. Pichler, C. Wiley, and S. Cooper. We thank K. Gilland and others at Normandeau Associates for data processing and manual vetting, and R. Key for database development and assistance with data management. S. Windels, E. Burke, and T. Gostomski reviewed earlier drafts of this report. Funding for this monitoring effort was provided by the National Park Service’s Natural Resource Stewardship and Science Directorate White-Nose Syndrome program.

Introduction

North American bat populations are threatened by a number of environmental pressures including the fungal disease white-nose syndrome (WNS), mortality from wind turbines, and changing land use and climatic conditions. Due to these conservation concerns, the National Park Service (NPS) and other federal agencies have begun implementing or expanding bat research and monitoring programs (Loeb et al. 2015, Rodhouse et al. 2016, Rodriguez et al. 2019). The NPS has funded over 150 bat-focused research, conservation, and education projects at 78 parks since 2013 (National Park Service 2016).

In 2015, the Great Lakes Inventory and Monitoring Network (GLKN) and the network parks established a bat acoustic monitoring program with a particular focus on documenting the impacts of WNS. When the project was initiated, the Great Lakes region was at the leading edge of the disease's spread, with WNS documented within 50 miles of most parks (U. S. Geological Survey 2019). GLKN's monitoring program is helping parks to document baseline data on park bat populations and assess changes over time. Voyageurs National Park (VOYA) has participated in this monitoring program since 2015.

Nine species of bats are found in the Great Lakes region (Kurta 2017), detailed in Appendix A. All are insectivores belonging to the Family Vespertilionidae, the largest and most common group of bats in North America. Great Lakes bat species can be divided into two groups: tree-roosting, migratory bats and cavity-roosting, hibernating bats. The hibernating species are highly susceptible to WNS, except for big brown bats (*Eptesicus fuscus*), which show greater resistance to the disease and experience less severe infections (Frank et al. 2014, Moore et al. 2018).

The U.S. Fish and Wildlife Service lists the Indiana bat (*Myotis sodalis*) as federally endangered and the northern long-eared bat (*Myotis septentrionalis*) as federally threatened under the Endangered Species Act (U.S. Fish and Wildlife Service 1967, 2016). Furthermore, all nine Great Lakes bat species are listed by one or more states as endangered, threatened, or of special concern (Michigan Natural Features Inventory 2009, Minnesota Department of Natural Resources 2013, Wisconsin Department of Natural Resources 2016, Indiana Division of Fish and Wildlife 2020) (Appendix A).

Prior to the initiation of the GLKN bat acoustic monitoring program, only three species had been confirmed at VOYA (Table 1). Mist-netting and roost observations conducted in 2001 recorded the little brown bat (*Myotis lucifugus*), northern long-eared bat, and silver-haired bat (*Lasionycteris noctivagans*) (Route and Schaberl 2013). In 2010, five park buildings were surveyed for bat activity. Little brown bats were the only species observed and several locations were identified as likely maternity colonies (Dixon 2010). In addition to the three confirmed species, the park's NPSpecies list classifies the big brown bat, eastern red bat (*Lasiurus borealis*), and hoary bat (*Lasiurus cinereus*) as "Probably Present" (<https://irma.nps.gov/NPSpecies/Search/SpeciesList/VOYA>). Likewise, all six species are included in a list of the park's flora and fauna from 1995, though no further details are given (Blair and Losher 1995).

Table 1. Bat species occurrences recorded at Voyageurs National Park prior to the initiation of the GLKN acoustic monitoring program in 2015, and method(s) by which the species were documented. Data sources include Dixon (2010) and Route and Schaberl (2013). Ranges are as shown in Kurta (2017).

Species Name	Prior Records	Methods Used
Big Brown Bat <i>Eptesicus fuscus</i>	No, within range	n/a
Eastern Red Bat <i>Lasiurus borealis</i>	No, within range	n/a
Hoary Bat <i>Lasiurus cinereus</i>	No, within range	n/a
Silver-haired Bat <i>Lasionycteris noctivagans</i>	Yes	Capture, Genetic Voucher
Little Brown Bat <i>Myotis lucifugus</i>	Yes	Capture, Genetic Voucher, Direct Observation
Northern Long-eared Bat <i>Myotis septentrionalis</i>	Yes	Capture, Genetic Voucher
Indiana Bat <i>Myotis sodalis</i>	No, well outside of range	n/a
Evening Bat <i>Nycticeius humeralis</i>	No, well outside of range	n/a
Tricolored Bat <i>Perimyotis subflavus</i>	No, close to edge of range	n/a

Records from St. Louis and Koochiching Counties, adjacent to the park, suggest that big brown, eastern red, and hoary bats are likely present within the park. The Minnesota Department of Natural Resources undertook comprehensive bat surveys in the 1980s. Their records for St. Louis and Koochiching Counties include these three species, but the exact locations of the observations within the counties are not specified (Nordquist and Birney 1985). The Minnesota Biodiversity Atlas lists hoary bat specimens collected in 1966 from both counties (Minnesota Biodiversity Atlas 2020), and big brown bat echolocation calls were recorded at the Soudan Underground Mine near Tower, Minnesota, approximately 50 miles away from the park (Nordquist et al. 2006).

In 2015–2017, the Minnesota Department of Natural Resources and the University of Minnesota–Duluth’s Natural Resources Research Institute completed extensive bat survey work in forested regions of the state. Mist-netting surveys resulted in captures of six species in St. Louis County: big brown bat, eastern red bat, hoary bat, silver-haired bat, little brown bat, and northern long-eared bat (Swingen et al. 2018). No sites were mist-netted in Koochiching County. Acoustic surveys yielded confirmed recordings of the same six species at multiple locations in both counties (Moen et al. 2018). Notably, possible recordings of tricolored bat (*Perimyotis subflavus*) and evening bat

(*Nycticeius humeralis*) were also collected from the two counties but there were no captures of either of these two species in the northern half of the state (Moen et al. 2018, Swingen et al. 2018).

VOYA lies near the edge of the known range for tricolored bats. Although this species has not previously been recorded at VOYA, it has been documented hibernating at the nearby Soudan Underground Mine (Nordquist et al. 2006). There are also records from Palisade Head near Silver Bay, Minnesota (Knowles 1992) and from the Hovland, Minnesota, area (Abel and Moen 2011). Given these observations from other parts of northern Minnesota, and the unconfirmed calls from the above-mentioned acoustic surveys, we believe this species may potentially be present in the park.

The ranges of the Indiana bat and evening bat lie well to the south and east, therefore these species are not expected to be present at VOYA.

Methods

Bat acoustic monitoring at VOYA was conducted according to the protocol and standard operating procedures developed by GLKN (Goodwin 2020). Initial protocol development was done in coordination with an outside consultant, Western EcoSystems Technology, Inc. (Gruver et al. 2016). Although methods were revised by GLKN after the 2015 season of monitoring, the majority of the sampling procedures were consistent across all years.

Site Selection

GLKN utilizes a probabilistic sample design based on the creation of a master sample, as described by Larsen et al. (2008). The sampling frame for each park consists of a finite grid of 1-km² cells. For some parks certain areas were excluded from the sampling frame *a priori* based on inaccessibility from roads, trails, or shorelines. Using the Generalized Random Tessellation Stratified (GRTS) algorithm, cells within the sampling frame were arranged into an ordered list, referred to as the “master sample”; this list is both randomized and spatially balanced (Stevens and Olsen 2004). Cells to be sampled were identified by working through the master sample list in numerical order, starting with Cell #001. Each cell was evaluated for accessibility and safety to determine if it should be included. Omitted cells were documented to justify the reason for exclusion.

At VOYA, the GRTS design was used beginning in 2016. A total of 18 cells were selected for sampling, equivalent to approximately 4% of the park’s sampling frame. The selected cells have been used from 2016 onward.

The *cell* is defined as the 1-km² area that is selected for sampling. The *site* is defined as the exact location within the cell where the acoustic recording equipment is placed. Sites were chosen by identifying locations that were reasonably accessible and had suitable bat habitat such as travel corridors (e.g., cut line, road, trail, or forest edge) or foraging areas (e.g., wetland). As much as possible, sites were located away from dense vegetative clutter, buildings, or open water to optimize recording quality. Each site was assigned a Site ID based on the cell’s GRTS order number, in the format VOYA001A. A map of VOYA sample sites is provided in Figure 1.

Different sampling areas were used in VOYA’s first year of monitoring (2015) (Johnson-Bice 2015). Sampling areas were limited to within 1 km of main lake shorelines and established trails and were selected using a random number generator (“mobile” sites) or subjectively (“fixed” sites). Within each sampling area, the exact location was selected as described above by identifying good bat foraging habitat or travel corridors.

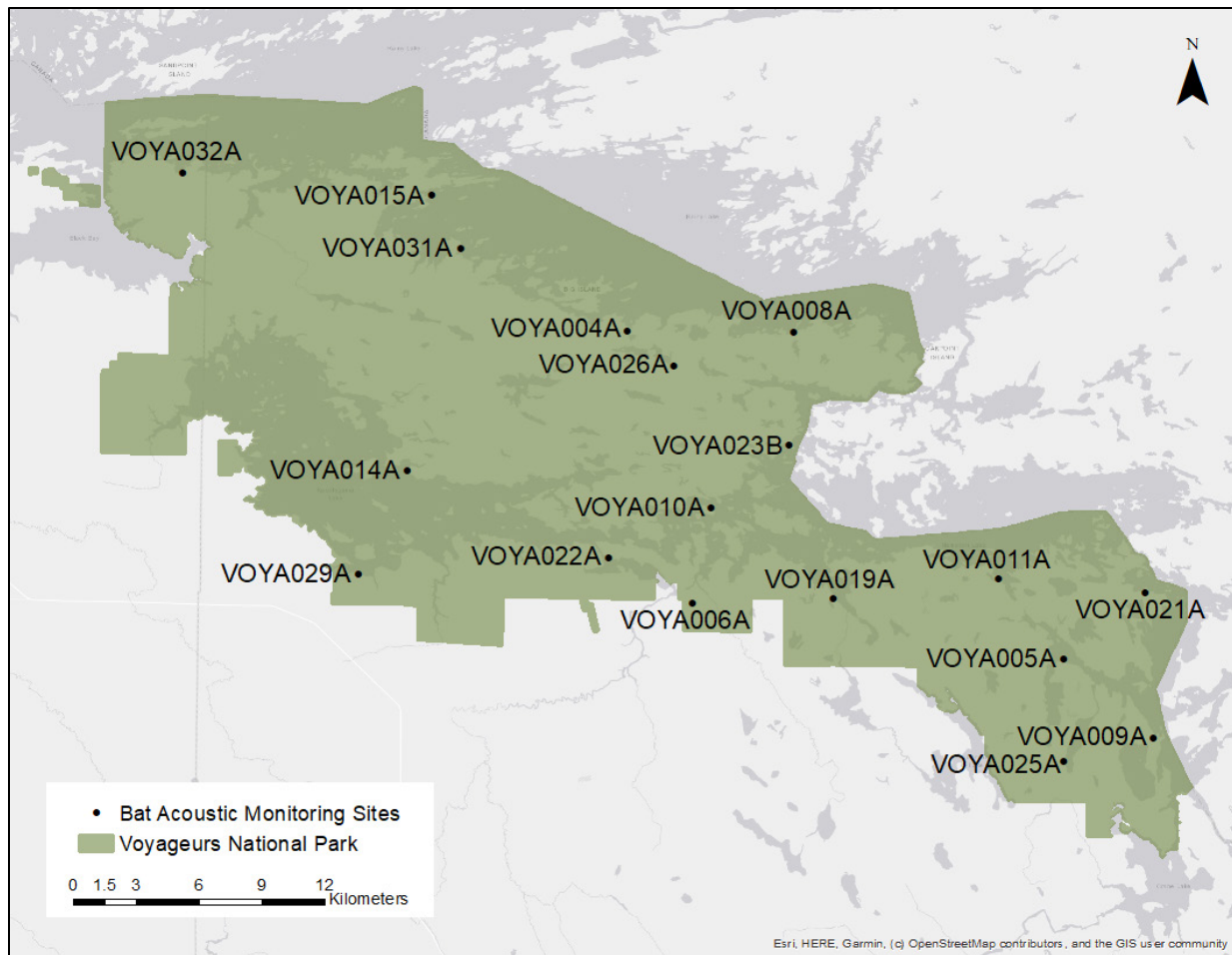


Figure 1. Bat monitoring sites at Voyageurs National Park. Sites shown were established in 2016 and used each year since, with the exception of VOYA023, which was relocated from the “A” site to the “B” site in 2018. Sites used in 2015 were different and are not shown.

Data Collection

Acoustic monitoring is conducted during the summer, from 1 June through 15 August. The same sites are monitored each year in approximately the same order and at approximately the same time of year to facilitate estimation of long-term trends. Each site is sampled once per year, for a period of 7–14 consecutive nights. Detectors are programmed to record every night from 6:00 p.m. to 8:00 a.m.

One acoustic detector with an external ultrasonic microphone is deployed at each survey site to passively record bat echolocation calls. Equipment used at VOYA includes Wildlife Acoustics Song Meter SM3BAT and Song Meter SM4BAT-FS detectors and Wildlife Acoustics SMM-U1 microphones. Recordings are collected in full-spectrum format and stored as WAV files on SD cards mounted in the detector. Field technicians complete a datasheet for each deployment and collect site photographs and GPS coordinates. After retrieving equipment, the WAV files and detector program/status files are downloaded.

Data Management and Analysis

Field technicians are responsible for data organization and securely storing data at the VOYA office. At the conclusion of the field season, all data are submitted to GLKN for quality assurance/quality control, entry into the bat monitoring database, data analysis, and data archiving.

For 2015–2019 data, GLKN contracted with an outside consultant (Normandeau Associates) to process acoustic files and obtain species classifications. Each deployment was categorized as valid or not valid. Valid deployments were those that had at least four nights of successful recording during the protocol sampling period (1 June–15 August). In some cases, there was more than one valid deployment per year at a particular site. When this occurred, the first valid deployment was categorized as “valid” and the remaining were categorized as “valid (duplicate)”. A deployment categorized as “failed” indicated it was unsuccessful due to equipment malfunction, improper programming, and/or vandalism. “Failed (short)” indicated the deployment was unsuccessful only because the minimum required four nights of recording were not completed. “Early” and “late” categories designate deployments that occurred either before 1 June or after 15 August, and thus were outside the protocol sampling period. Finally, “nonprotocol” indicates deployments that were completed for park-specific monitoring goals at locations that were selected intentionally, rather than following the GRTS sample design. Non-valid deployments (including those categorized as “valid (duplicate)”) were excluded from all further analyses.

Normandeau Associates used an automated acoustic analysis software program to filter out noise and assign species classifications to audio files. The specific program used was Wildlife Acoustics Kaleidoscope Pro Version 4.0.0 (2015–2018) or Version 5.0.3 (2019), with the Bats of North America Classifier Version 3.1.0 and the “–1 More Sensitive” setting. During Kaleidoscope processing, the software assigned each audio file a species-level classification where possible. Files not classified to a particular species were labeled “No ID” if they contained unknown bat calls, otherwise they were labeled “Noise”. The software did not process files that were corrupt or unreadable. Files from incomplete recording nights (less than six hours of recording) were also excluded from processing.

Kaleidoscope Pro allows the user to customize a list of possible bat species that will be considered during the classification process. This allows for the exclusion of any species not found in the study area, reducing the chance of obtaining false positive results. GLKN determined which species have known ranges within the boundaries of VOYA based on published range maps (Harvey et al. 2011, Rodhouse et al. 2016, Kurta 2017). These species were considered the “baseline” species list. We also created an “expanded” list, adding species that are documented relatively close to the park and may possibly be present. All audio files were run through Kaleidoscope Pro twice, once using the baseline list and once using the expanded list. The baseline and expanded species lists for VOYA are provided in Appendix B. Analysis settings used in Kaleidoscope Pro are provided in Appendix C.

Kaleidoscope Pro and other similar acoustic analysis programs are not 100% accurate. Software classification results are expected to include some errors due to the similarity of echolocation calls among different species, variation of calls within the same species, poor quality or truncated calls, clutter effects, or multiple bats recorded simultaneously (Britzke et al. 2013, Reichert et al. 2018).

Therefore, manual review (manual vetting) of call files by a qualified biologist is an important secondary step to verify the results produced by the software.

Due to the enormous quantity of data collected by the GLKN monitoring program, it is not feasible to manually review all files. From each year's dataset, Normandeau Associates randomly selected approximately 1% of the files that Kaleidoscope Pro identified to the species level (i.e., excluding noise and unknown bats). To ensure all species were proportionally represented, this consisted of 1% of the files identified to each species, with a required minimum of 10 files per species unless there were fewer than 10 files available. This procedure was used for the baseline analysis; for the expanded analysis, additional files were selected only for the new species not already represented by the baseline analysis. Files selected for manual vetting were chosen and prepared by a different individual than the biologist doing the reviewing. Potentially identifying information such as site location and date were removed from the file name. Manual vetting was performed by a qualified biologist from Normandeau Associates, who was provided with a list of possible species to consider. However, to ensure an independent assessment, the manual reviewer did not know how the Kaleidoscope software had identified each file. Manual identifications were based on call characteristics such as shape, frequency, and duration, using published reference materials and call libraries. The manual reviewer assigned a species or species group (e.g., unknown high frequency or unknown low frequency) to each audio file, assuming it contained bat calls of sufficient quality. The reviewer could also determine that a file did not contain bat echolocation calls and contained only noise. Following processing, results of both automated software classification and manual vetting were incorporated into GLKN's bat monitoring database.

Acoustic monitoring by the above-described methods does not allow estimation of population size or number of individual bats detected. Instead, data are presented in terms of species composition (percent of total files assigned to each species), activity levels (call files per recording night), and spatial and temporal distribution (percent of sites and percent of recording nights with positive detections), using the results of the Kaleidoscope Pro analysis. Manual vetting results are presented in terms of the number of vetted calls that were verified. For simplicity, results for vetted calls that were not verified are not broken down by species in this report, but those data are available if needed for future analyses. Misclassification rates, as derived from the manual vetting process, have not been applied to the Kaleidoscope Pro results; data presented reflect the original outputs from the software.

Results

Survey Effort

Acoustic monitoring took place at VOYA during the years 2015 to 2019. There were 7 to 18 valid deployments per year. This report provides results only for the sites that had valid deployments.

Monitoring occurred over a total of 67 to 261 nights of recording. The number of audio files collected per year ranged from 8,397 to 28,662. Yearly survey effort and deployment information are summarized in Figure 2 and Appendix D.

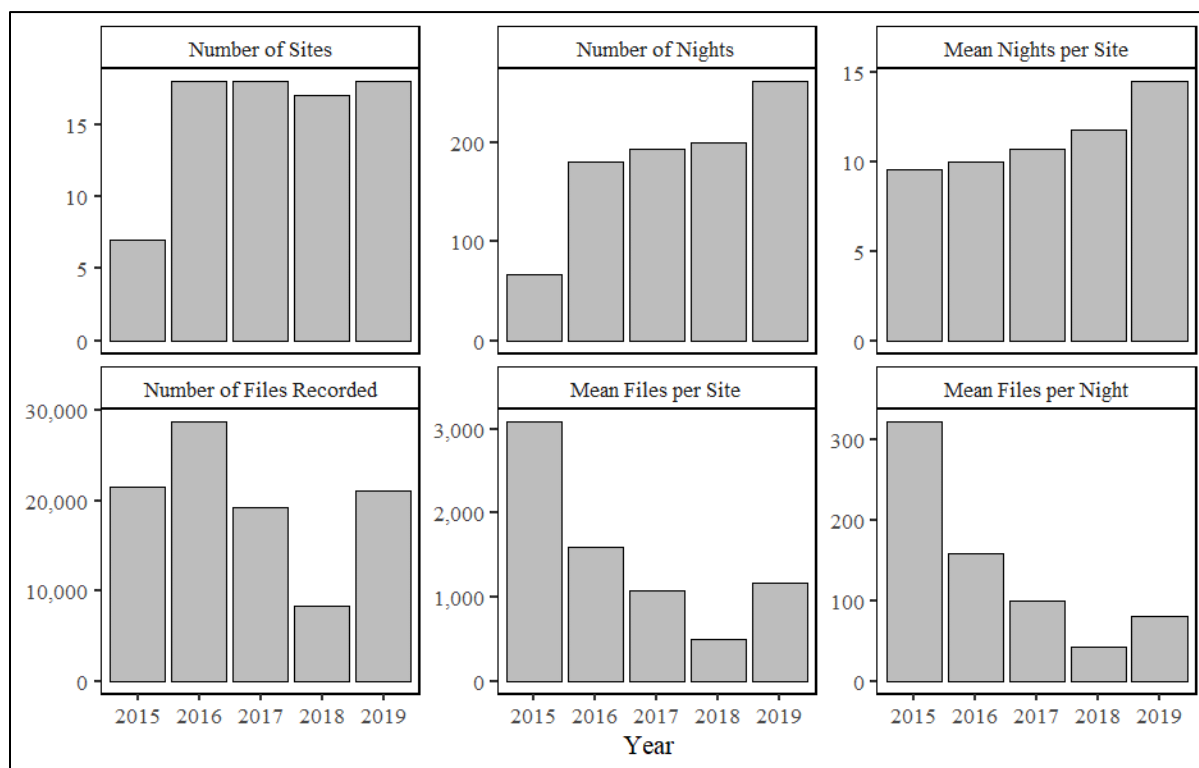


Figure 2. Yearly survey effort at Voyageurs National Park, 2015–2019. *Top, left to right:* Number of sites, number of nights, and mean nights per site; *bottom, left to right:* total number of audio files recorded, mean files per site, and mean files per night. Number of files is prior to classification (i.e., includes noise).

Automated Classification

Most files (78%–89% per year) were identified to the species level by Kaleidoscope Pro (Figure 3 and Appendix E). The proportion of files assigned to a species versus noise or unknown was similar for the baseline and expanded analyses (Figure 3). The two detector models, SM3BAT and SM4BAT-FS, were similar in terms of percent noise (data from all parks combined), but noise was highly variable across the different VOYA sampling sites (Appendix F).

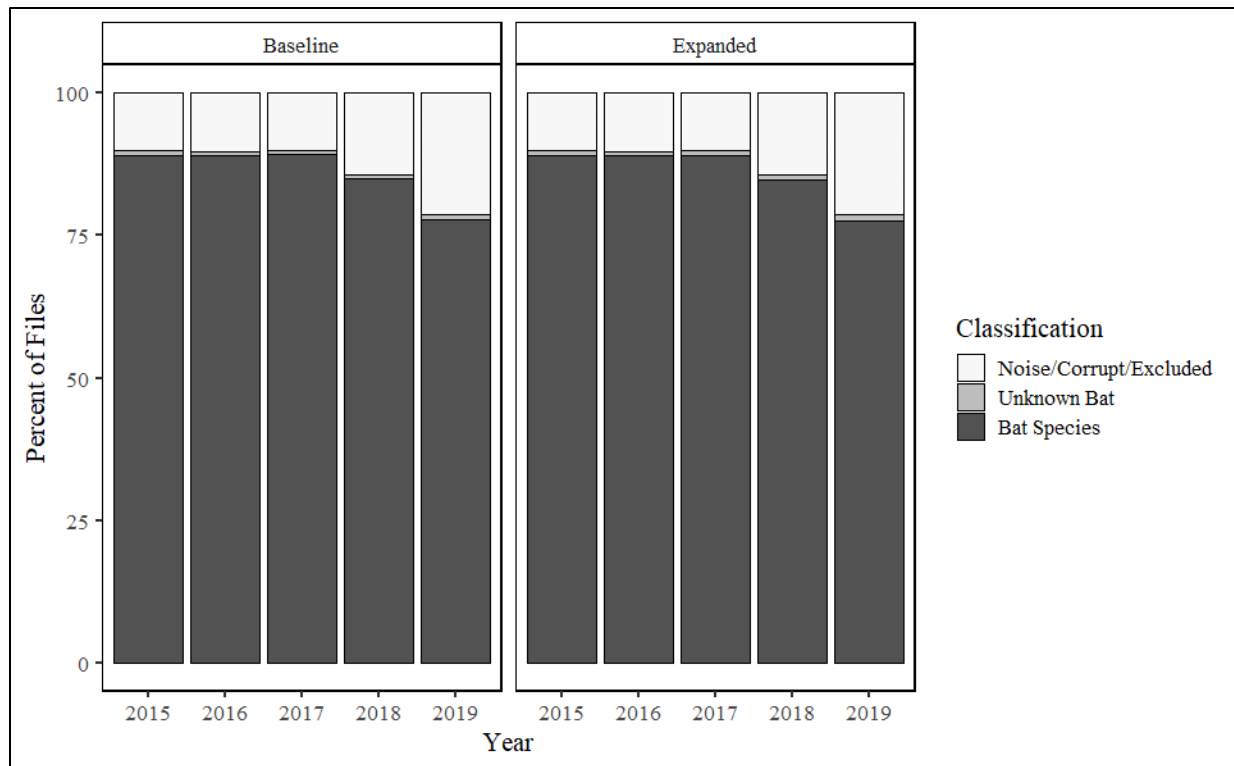


Figure 3. Percent of audio files classified by Kaleidoscope Pro as bat species vs. unknown bats vs. noise, corrupt, and excluded files, Voyageurs National Park, 2015–2019. Proportions are shown for the baseline (left) and expanded (right) analyses.

Kaleidoscope Pro automated classification resulted in a total of six species documented in the baseline analysis and seven species documented in the expanded analysis. For the subset of files that were successfully assigned a species-level classification, the percent classified to each species was almost identical between the baseline and expanded analyses, but varied from year to year, particularly for hoary, silver-haired, and little brown bats (Figure 4). In both the baseline and expanded analyses, the largest proportion of files was classified as little brown bat in 2015–2017, and hoary bat in 2018–2019. After 2016, the proportion of files attributed to the three most WNS-susceptible species (little brown, northern long-eared, and tricolored bats) showed a strong decrease relative to the proportion attributed to the other species (Figure 5). The most notable changes for individual species were an increase in the percentage of hoary bat files after 2016, and a decrease in the percentage of little brown bat files, especially by 2018–2019. File counts and percentages are provided in Appendix E.

Call files per recording night were calculated on both the park level and individual site level, using the results of the automated classification by Kaleidoscope Pro. Parkwide, total call files per recording night were at least two times higher in 2015 than in any of the later years (Figure 6). Most of this decrease in bat activity can be attributed to the decline in little brown bat activity.

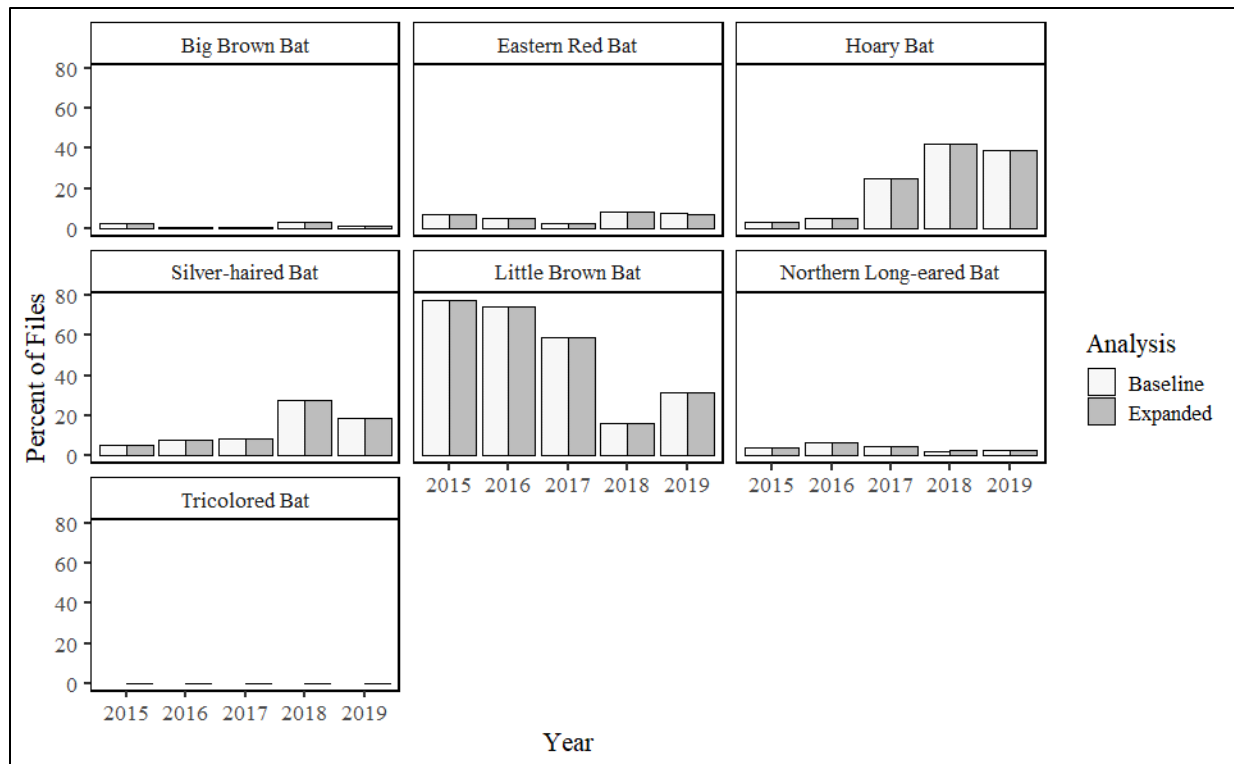


Figure 4. Proportion of files classified to each species each year in the baseline versus expanded analysis, Voyageurs National Park, 2015–2019. Tricolored bat was only allowed as a possible species in the expanded analysis. Includes only the subset of files successfully assigned a species-level classification by Kaleidoscope Pro.

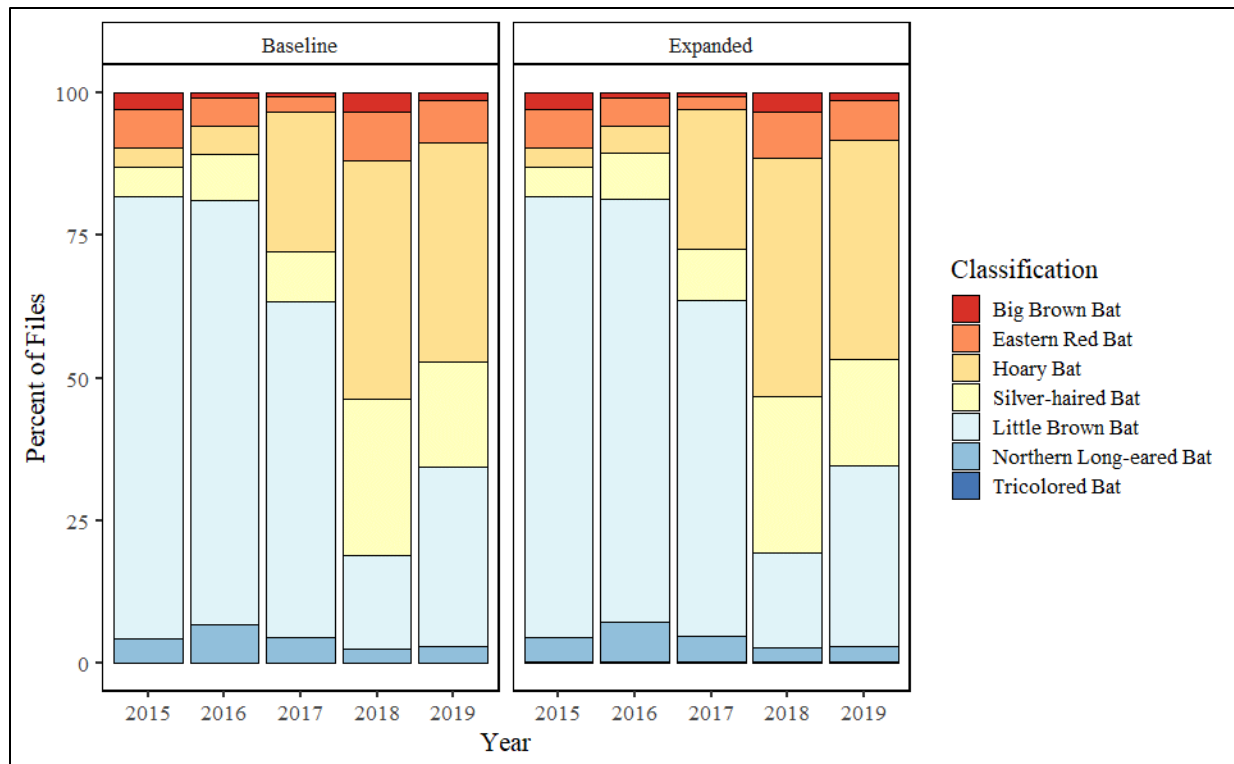


Figure 5. Proportion of files classified to each species each year relative to all other species, Voyageurs National Park, 2015–2019. The three most WNS-susceptible species (little brown, northern long-eared, and tricolored bats) are shown in shades of blue while less susceptible species are shown in red, orange, and yellow. Tricolored bat was only allowed as a possible species in the expanded analysis. Includes only the subset of files successfully assigned a species-level classification by Kaleidoscope Pro.

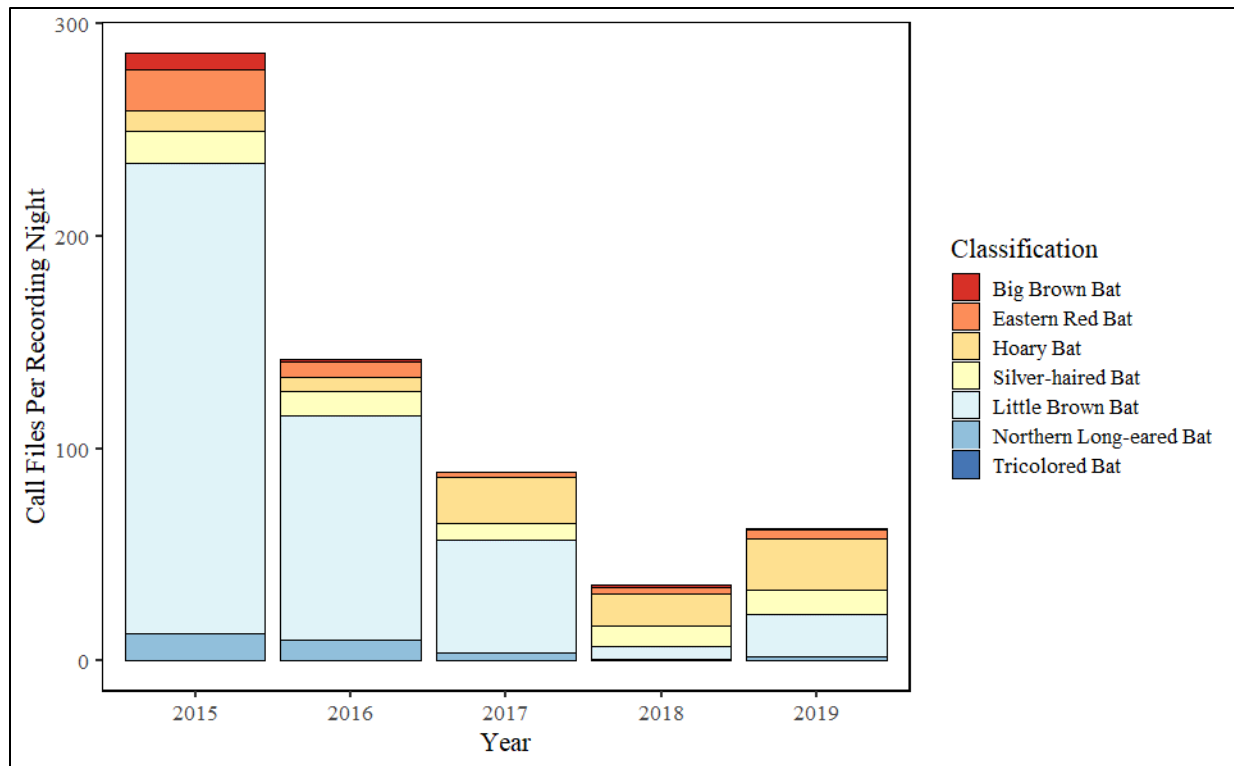


Figure 6. Parkwide call files per recording night by species and year for the expanded analysis, Voyageurs National Park, 2015–2019. The three most WNS-susceptible species (little brown, northern long-eared, and tricolored bats) are shown in shades of blue while less susceptible species are shown in red, orange, and yellow. Results were similar for baseline and expanded analysis so only the expanded analysis is shown.

At the site level, when looking at all species combined, the median call files per recording night was considerably higher in 2015 and 2016 (over 100) than in 2017–2019 (less than 40) (Figure 7, lower right panel). The median call files per recording night decreased after 2016 for eastern red bat, little brown bat, northern long-eared bat, and tricolored bat (Figure 7). For big brown, hoary, and silver-haired bats, we observed relatively consistent call files per recording night across all years with the exception of a much higher value in 2015 for big brown bat (Figure 7). Adding the tricolored bat as a possible species in the expanded analysis did not substantially change the call files per recording night values for other species, because only a small number of files were reassigned to tricolored bat.

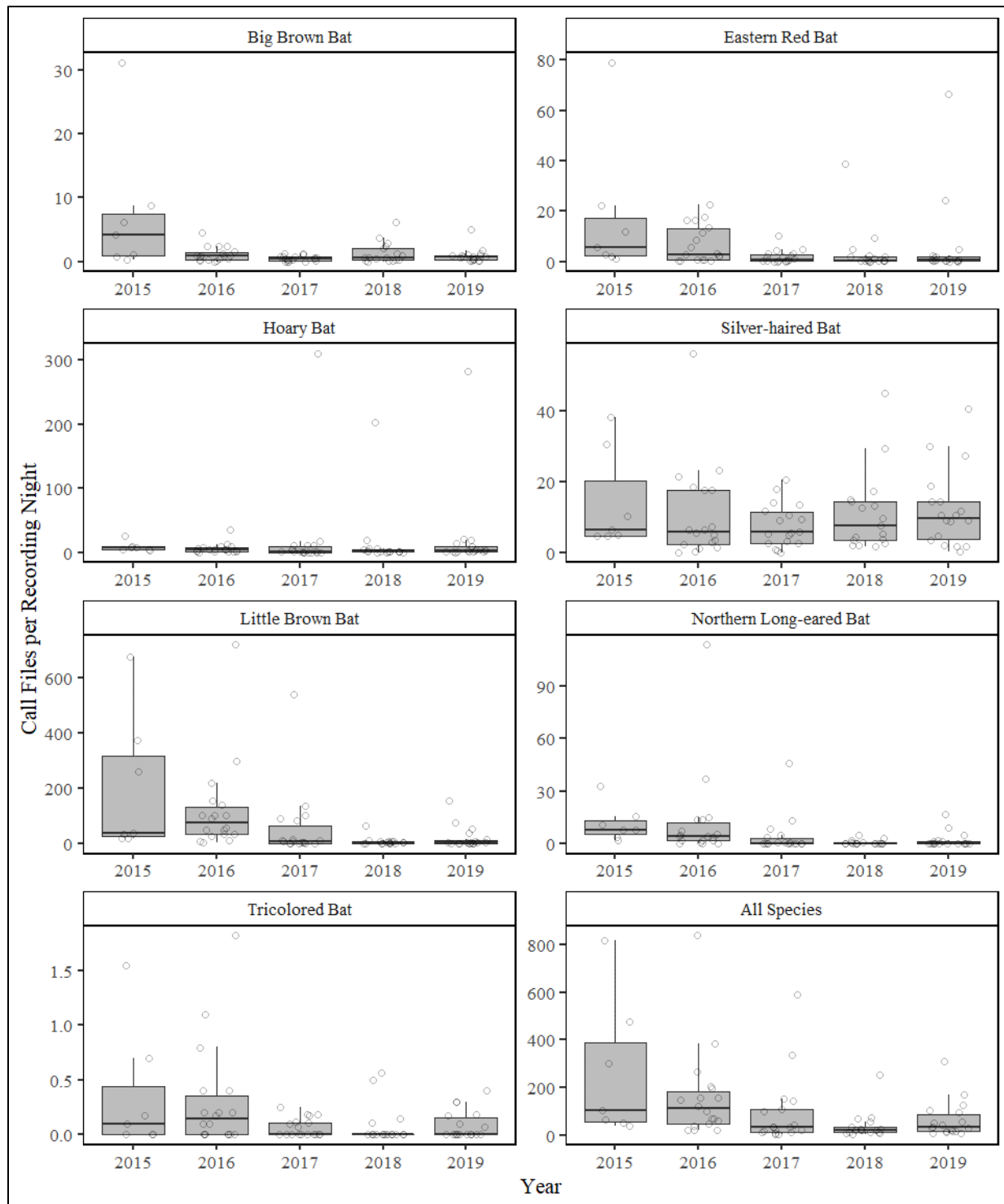


Figure 7. Call files per recording night for each species and for all species combined, by year, for the expanded analysis, Voyageurs National Park, 2015–2019. Each point represents call files per recording night at a particular survey site. The dark line across the boxplot represents the median. Note that the y-axis scale is different for each species. Results were similar for baseline and expanded analysis so only the expanded analysis is shown.

Spatial and Temporal Distribution

Spatial and temporal species distributions were assessed using the results of the automated classification. A species was considered to be detected at a site if at least one audio file was classified as that species by Kaleidoscope Pro. Most species were widely distributed across the park, with detections at greater than 75% of monitoring sites every year (Figure 8 and Appendix E). Hoary and silver-haired bats were detected at 100% of sites every year.

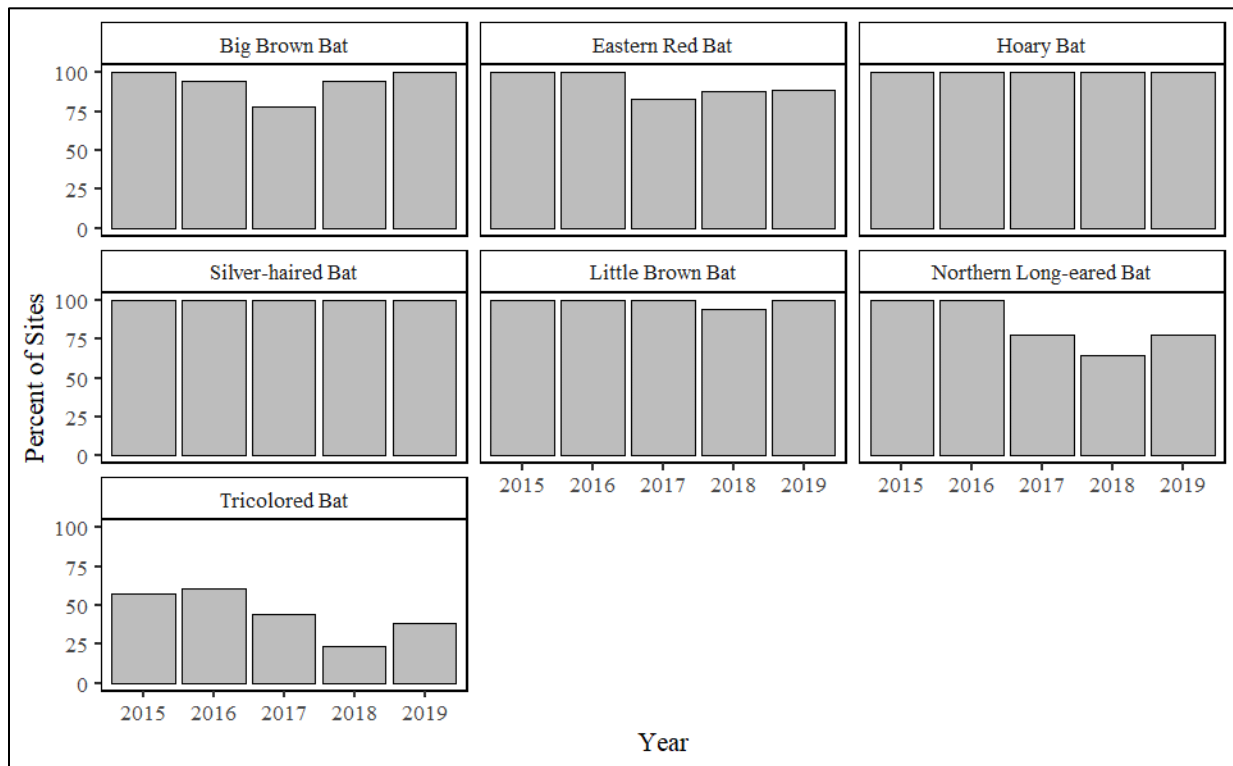


Figure 8. Proportion of monitoring sites where each species was detected each year, Voyageurs National Park, 2015–2019. A species was considered to be detected at a site if at least one audio file was classified as that species by Kaleidoscope Pro. Results were similar for baseline and expanded analysis so only the expanded analysis is shown.

In 2015, most species were recorded frequently, with detections on 75%–100% of recording nights (Figure 9 and Appendix E). However, all species were detected less frequently (on fewer nights) after 2015. Even so, the hoary, silver-haired, and little brown bat were detected on at least 65% of nights every year. On average, the silver-haired bat was detected on the highest percentage of nights. When included in the expanded analysis, the tricolored bat was detected at 24%–61% of sites and on 4%–24% of nights.

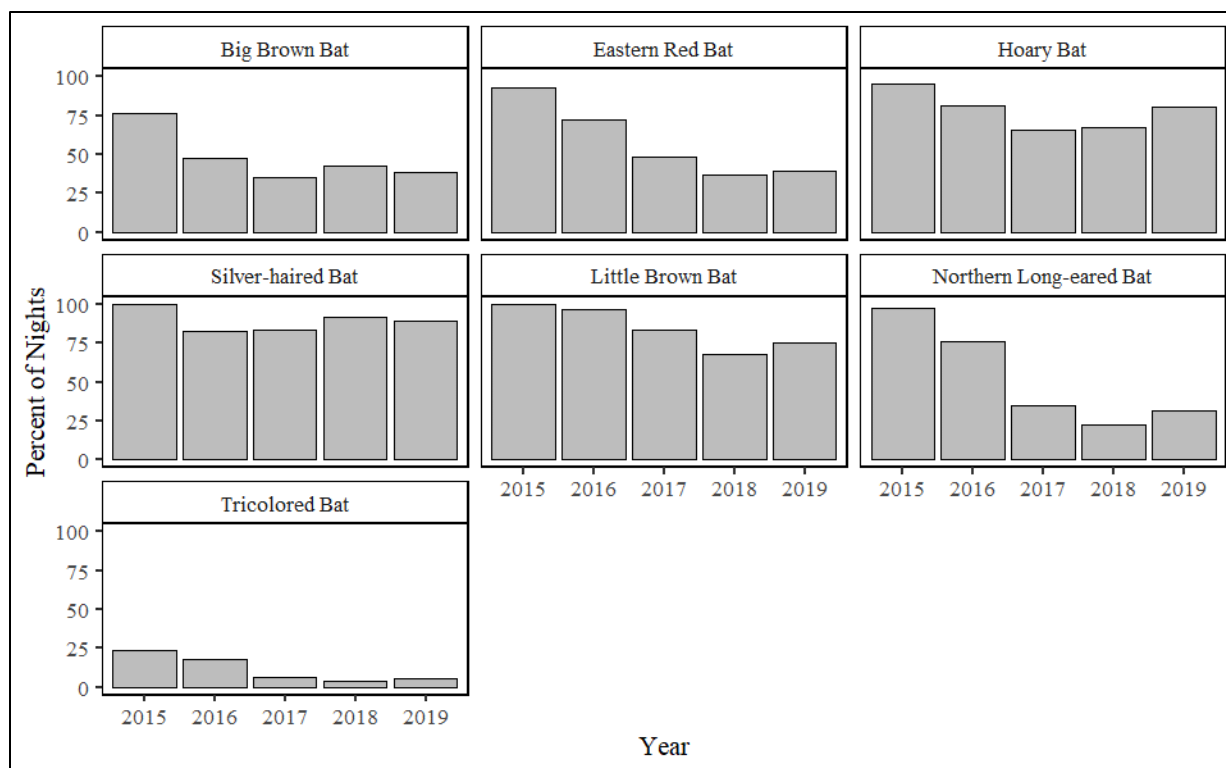


Figure 9. Proportion of recording nights on which each species was detected each year, Voyageurs National Park, 2015–2019. A species was considered to be detected on a night if at least one audio file was classified as that species by Kaleidoscope Pro. Results were similar for baseline and expanded analysis so only the expanded analysis is shown.

Manual Vetting

A small subset of audio files—approximately 1% of files identified to each species—was manually vetted. Because the 1% sometimes equated to only a few files, we required a minimum of 10 files per species to be vetted unless there were fewer than 10 files available (see Methods). Manual vetting resulted in a total of seven species being verified between 2015 and 2019. Detailed manual vetting results for the park as a whole are provided in Appendix G, and for each monitoring site in Appendix H.

The percentage of files that were verified by manual vetting varied widely by species. The mean percentage verified (calculated parkwide, across all survey years) ranged from 2% for the tricolored bat to 86% for the little brown bat (Appendix G). The variation in percentage verified is related to how difficult the calls are to identify. Ease of identification can depend on both call structure and recording environment. For example, the hoary bat consistently vocalizes at a much lower frequency than any other bat in the region, making its call signature unique and relatively easy to distinguish. On the other hand, the three *Myotis* species (little brown bat, northern long-eared bat, and Indiana bat) all produce very similar calls with highly overlapping call characteristics. Northern long-eared and little brown bat calls tend to be more distinctive from each other in cluttered environments, such as under a closed forest canopy, than in open environments (Broders et al. 2004) and can therefore sometimes be identified.

Summary and Conclusions

The three bat species previously documented at VOYA—silver-haired bat, little brown bat, and northern long-eared bat—were reconfirmed through this monitoring effort. Three additional species that were considered likely to be present at VOYA, based on nearby occurrences and published range maps, were also confirmed: big brown bat, eastern red bat, and hoary bat. Finally, our acoustic surveys suggest that a seventh species, the tricolored bat, is also present in the park. VOYA is located near the edge of the tricolored bat's range. Although there are records from elsewhere in northern Minnesota, tricolored bats have not been confirmed at VOYA through physical captures. We obtained one manually verified tricolored bat recording. This recording came from site VOYA009A (Sand Point Portage trail) and was collected in 2017. It is important to note that only about one third of the call files identified by the Kaleidoscope software as tricolored bats have so far been manually reviewed (49 files). Conducting additional manual review on the remaining files could increase the number of locations or years with positive records of this species.

Parkwide, total call files per recording night were significantly higher in 2015 than in any of the later years. This could be related to the different survey sites used in 2015 versus 2016–2019. Although the exact sites used were different, the habitat types being sampled were similar (trail corridors, forest clearings, rocky outcrops). Another consideration is that sampling in 2015 started a month later than sampling in 2016–2019. This means that 2015 data does not include the “pre-volant” period in early summer before juvenile bats begin to fly. The higher number of calls per night we documented in 2015 may reflect the fact that we only sampled when both adults and juveniles were active.

Our results indicate that activity levels for three of the seven species (big brown bat, hoary bat, and silver-haired bat) appeared to be stable or slightly increasing. The remaining four species appeared to have decreasing trends in activity levels. Three of these (little brown bat, northern long-eared bat, and tricolored bat) are highly susceptible to WNS and the disease is mostly likely causing the observed declines. The fourth species (eastern red bat) is not susceptible to WNS but is one of the most frequently killed at wind energy facilities (Arnett et al. 2015). Although there are many wind energy facilities in Minnesota, they are located primarily in the southwestern part of the state, not near VOYA. Migration routes of migratory bats are not well understood, but red bats are thought to move south and east, concentrating on the Atlantic and Gulf coasts for the winter (Cryan 2003). Hoary and silver-haired bats also have high fatality rates at wind facilities but do not seem to be declining at VOYA. Therefore, the decrease in red bat activity may be due to other unknown factors.

Results for each species are summarized below and in Table 2. For comparison purposes, species composition over time across all GLKN parks is provided in Appendix I.

Table 2. Summary of bat species documented at Voyageurs National Park through automated classification and manual vetting of acoustic files.

Species	Year	Detected	
		Automated	Manual
Big Brown Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	Yes
	2018	Yes	No
	2019	Yes	Yes
Eastern Red Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	Yes
	2018	Yes	Yes
	2019	Yes	Yes
Hoary Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	Yes
	2018	Yes	Yes
	2019	Yes	Yes
Silver-haired Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	Yes
	2018	Yes	Yes
	2019	Yes	Yes
Little Brown Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	Yes
	2018	Yes	Yes
	2019	Yes	Yes
Northern Long-eared Bat	2015	Yes	Yes
	2016	Yes	Yes
	2017	Yes	No
	2018	Yes	No
	2019	Yes	Yes

Table 2 (continued). Summary of bat species documented at Voyageurs National Park through automated classification and manual vetting of acoustic files.

Species	Year	Detected	
		Automated	Manual
Tricolored Bat	2015	Yes	No
	2016	Yes	No
	2017	Yes	Yes
	2018	Yes	No
	2019	Yes	No

Big Brown Bat

- Documented in every year of surveys via automated identification and verified manually in every year except 2018.
- Widely distributed: Present at over 75% of survey sites each year.
- Recorded rarely compared to other species: less than 3% of total files each year.
- Recorded on 76% of nights in 2015, then decreased to only 35%–47% of nights in 2016–2019.
- Median call files per recording night highest in 2015 (about five), then decreased to about one-to-two in the last four years.

Eastern Red Bat

- Documented in every year of surveys (both automated and manual identification).
- Widely distributed: Present at over 80% of survey sites each year.
- Percent of total files ranged from 2%–8% with little change from year to year.
- Recorded on over 70% of nights in 2015–2016, then decreased to only 37%–49% of nights in 2017–2019.
- Median call files per recording night higher and similar in 2015–2016 (about five), then decreased to about one-to-two in the last three years.

Hoary Bat

- Documented in every year of surveys (both automated and manual identification).
- Widely distributed: Present at 100% of survey sites each year.
- Accounted for less than 5% of total files in 2015–2016, but then became much more prominent. Percent of total files increased to 25%–42% in 2017–2019 and this was the most commonly recorded species in 2018–2019.
- Recorded on a majority of nights every year, from 66%–96%.
- Median call files per recording night was around two-to-eight each of the five years, with the highest median value observed in 2015. One site, VOYA032A (Dove Bay), had significantly

more hoary bat calls per recording night than any other site in every year 2016–2019. This site is located adjacent to a stream corridor, typical foraging habitat for this species.

Silver-haired Bat

- Documented in every year of surveys (both automated and manual identification).
- Widely distributed: Present at 100% of survey sites each year.
- Accounted for 5%–9% of total files in 2015–2017, but then became much more prominent. Percent of total files increased to 18%–28% in 2018–2019. This was the second or third most commonly recorded species in 2017–2019.
- Recorded on a majority of nights every year, from 82%–100%.
- Median call files per recording night slightly lower in 2015–2017 (about six) than in 2018–2019 (8–10). One site, VOYA005A (Grassy Bay), was in the top three for call files per recording night in every year 2016–2019. This site is located in a small forest clearing, a typical foraging habitat used by this species.

Little Brown Bat

- Documented in every year of surveys (both automated and manual identification).
- Widely distributed: Present at over 90% of survey sites each year.
- Most commonly recorded species by far in the first three years (2015–2017), more than all other species combined. Second or third most commonly recorded species in 2018–2019. Percent of total files ranged from 16%–78%.
- Recorded on over 95% of nights in 2015–2016, then decreased slightly to 68%–83% of nights in 2017–2019.
- Median call files per recording night much higher in 2015 and 2016 (approximately 40 and 75, respectively) than in 2017–2019 (approximately 5–10).

Northern Long-eared Bat

- Documented in every year of surveys via automated identification and verified manually in 2015, 2016, and 2019.
- Widely distributed: Present at 65% or more of survey sites each year but decreasing after 2016.
- Percent of total files ranged from 2%–7% with slight decrease in last two years.
- Recorded on over 75% of nights in 2015–2016, then decreased sharply to only 23%–36% of nights in 2017–2019.
- Median call files per recording night much higher in 2015–2016 (approximately eight and 4.5, respectively) than in 2017–2019 (less than one).

Tricolored Bat

- Documented in every year of surveys via automated identification (expanded analysis only) and verified manually in 2017.

- Less widely distributed than other species: Present at 24%–61% of sites each year and decreasing after 2016.
- Recorded rarely compared to other species: less than 1% of total files each year.
- Recorded on only 4%–24% of nights each year, with a sharp decrease after 2016.
- Median call files per recording night very low compared to all other species. Median values were less than one call file per recording night every year and approached zero in the last three years. One site, VOYA005A (Grassy Bay), was in the top two for call files per recording night in every year 2016–2019. This site is located in a small forest clearing; forest edges are typical foraging habitat used by this species.

Literature Cited

- Abel, R., and R. Moen. 2011. North shore bat activity and habitat use. Natural Resources Research Institute Technical Report NRRI/TR-2011/11. University of Minnesota-Duluth, Duluth, Minnesota.
- Arnett, E. B., E. F. Baerwald, F. Mathews, L. Rodrigues, A. Rodriguez-Duran, J. Rydell, R. Villegas-Patraca, and C. C. Voigt. 2015. Impacts of wind energy development on bats: A global perspective. Pages 295–323 in C. C. Voigt and T. Kingston, editors. *Bats in the Anthropocene: Conservation of Bats in a Changing World*. Open access book available at: <https://link.springer.com/book/10.1007/978-3-319-25220-9>.
- Blair, S., and A. Losher. 1995. Flora and fauna of Voyageurs National Park. Unpublished report to the National Park Service.
- Britzke, E. R., E. H. Gillam, and K. L. Murray. 2013. Current state of understanding of ultrasonic detectors for the study of bat ecology. *Acta Theriologica* 58(2):109–117.
- Broders, H. G., C. S. Findlay, and L. Zheng. 2004. Effects of clutter on echolocation call structure of *Myotis septentrionalis* and *M. lucifugus*. *Journal of Mammalogy* 85(2):273–281.
- Cryan, P. 2003. Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. *Journal of Mammalogy* 84(2):579–593.
- Dixon, M. D. 2010. July 2010 Voyageurs bat survey—Final report. Unpublished report to the National Park Service.
- Frank, C. L., A. Michalski, A. A. McDonough, M. Rahimian, R. J. Rudd, and C. Herzog. 2014. The resistance of a North American bat species (*Eptesicus fuscus*) to white-nose syndrome (WNS). *PLoS ONE* 9(12):e113958.
- Goodwin, K. R. 2020. Bat monitoring protocol for the Great Lakes Inventory and Monitoring Network: Version 1.0. Natural Resource Report NPS/GLKN/NRR—2020/2126. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2274095>.
- Gruver, J., P. Rabie, L. A. Starcevich, M. Romanski, and B. Route. 2016. Monitoring protocol for bats in the Great Lakes Inventory and Monitoring Network. Unpublished National Park Service report, Ashland, Wisconsin.
- Harvey, M. J., J. S. Altenbach, and T. L. Best. 2011. *Bats of the United States and Canada*. The Johns Hopkins University Press, Baltimore, Maryland.
- Indiana Division of Fish and Wildlife. 2020. Endangered and special concern species list. Available at: www.in.gov/dnr/naturepreserve/files/fw-Endangered_Species_List.pdf (accessed 18 September 2020).

- Johnson-Bice, S. M. 2015. Bat monitoring at Voyageurs National Park 2015. Unpublished report to the National Park Service.
- Knowles, B. 1992. Bat hibernacula on Lake Superior's North Shore, Minnesota. *Canadian Field-Naturalist*. 106(2):252–254.
- Kurta, A. 2017. *Mammals of the Great Lakes Region*. Third Edition. University of Michigan Press, Ann Arbor, Michigan.
- Larsen, D. P., A. R. Olsen, and D. L. Stevens, Jr. 2008. Using a master sample to integrate stream monitoring programs. *Journal of Agricultural, Biological, and Environmental Statistics* 13(3):243–254.
- Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, T. E. Ingersoll, J. T. H. Coleman, W. E. Thogmartin, J. R. Sauer, C. M. Francis, M. L. Bayless, T. R. Stanley, and D. H. Johnson. 2015. A plan for the North American Bat Monitoring Program (NABat). General Technical Report SRS-208. U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina.
- Michigan Natural Features Inventory. 2009. Michigan's special animals: Endangered, threatened, special concern, and probably extirpated. Available at: <https://mnfi.anr.msu.edu/species/animals> (accessed 18 September 2020).
- Minnesota Biodiversity Atlas. 2020. Available at: <https://bellatlas.umn.edu/index.php> (accessed on 16 October 2020).
- Minnesota Department of Natural Resources. 2013. Minnesota's list of endangered, threatened, and special concern species. Available at: http://files.dnr.state.mn.us/natural_resources/ets/endlist.pdf (accessed 18 September 2020).
- Moen, R., M. Swingen, M. Walker, R. Baker, G. Nordquist, T. Catton, K. Kirschbaum, B. Dirks, and N. Dietz. 2018. Bat acoustic surveys in Minnesota, 2015–2017. Natural Resources Research Institute Technical Report NRRI/TR-2018/39 Release 1.0. University of Minnesota, Duluth, Minnesota.
- Moore, M. S., K. A. Field, M. J. Behr, G. G. Turner, M. E. Furze, D. W. F. Stern, P. R. Allegra, S. A. Bouboulis, C. D. Musante, M. E. Vodzak, M. E. Biron, M. B. Meierhofer, W. F. Frick, J. T. Foster, D. Howell, J. A. Kath, A. Kurta, G. Nordquist, J. S. Johnson, T. M. Lilley, B. W. Barrett, and D. M. Reeder. 2018. Energy conserving thermoregulatory patterns and lower disease severity in a bat resistant to the impacts of white-nose syndrome. *Journal of Comparative Physiology B* 188(1):163–176.
- National Park Service. 2016. Protecting bats in parks. Available at: www.nps.gov/subjects/bats/protecting-bats-in-parks.htm (accessed 18 September 2020).

- Nordquist, G. E. and E. C. Birney. 1985. Distribution and status of bats in Minnesota. Final report. Nongame Wildlife Program, Minnesota Department of Natural Resources.
- Nordquist, G. E., K. A. Lynch, and C. A. Spak. 2006. Timing and pattern of bat activity at Soudan Underground Mine. Final report to the State Wildlife Grants Program, Minnesota Department of Natural Resources. MNDNR Biological Report No. 88.
- Reichert, B., C. Lausen, S. Loeb, T. Weller, R. Allen, E. Britzke, T. Hohoff, J. Siemers, B. Burkholder, C. Herzog, and M. Verant. 2018. A guide to processing bat acoustic data for the North American Bat Monitoring Program (NABat). U.S. Geological Survey Open-File Report 2018–1068. U.S. Geological Survey, Reston, Virginia. Available at: <https://doi.org/10.3133/ofr20181068> (accessed 18 September 2020).
- Rodhouse, T. J., T. E. Phillipi, W. B. Monahan, and K. T. Castle. 2016. A macroecological perspective on strategic bat conservation in the U.S. National Park Service. *Ecosphere* 7:1–17.
- Rodriguez, R. M., T. J. Rodhouse, J. Barnett, K. M. Irvine, K. M. Banner, J. Lonneker, and P. C. Ormsbee. 2019. North American Bat Monitoring Program regional protocol for surveying with 34 stationary deployments of echolocation recording devices: Version 1.0, Pacific Northwestern US. Natural Resource Report NPS/UCBN/NRR—2019/1975. National Park Service, Fort Collins, Colorado.
- Route, B., and J. Schaberl. 2013. A cursory survey of bats in Voyageurs National Park, Minnesota. Natural Resource Technical Report NPS/GLKN/NRTR—2013/701. National Park Service, Ashland, Wisconsin.
- Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99:262–278.
- Swingen, M., R. Moen, M. Walker, R. Baker, G. Nordquist, T. Catton, K. Kirschbaum, B. Dirks, and N. Dietz. 2018. Bat radiotelemetry in forested areas of Minnesota 2015–2017. Natural Resources Research Institute, Technical Report NRRI/TR-2018/42 Release 1.0. University of Minnesota, Duluth, Minnesota.
- U. S. Fish and Wildlife Service. 1967. Native fish and wildlife—Endangered species. Federal Register 32(48). Available at: www.fws.gov/endangered/species/pdf/32FedReg_pg%204001.pdf (accessed 18 September 2020).
- U. S. Fish and Wildlife Service. 2016. Endangered and threatened wildlife and plants; Determination that designation of critical habitat is not prudent for the northern long-eared bat. Federal Register, 81(81). Available at: www.govinfo.gov/content/pkg/FR-2016-04-27/pdf/2016-09673.pdf (accessed 18 September 2020).
- U. S. Geological Survey. 2019. White-nose syndrome spread maps (August 30, 2019 version). www.whitenosesyndrome.org/resources/map (accessed 18 September 2020).

Wisconsin Department of Natural Resources. 2016. Wisconsin Natural Heritage working list.
Available at: <https://dnr.wi.gov/topic/NHI/documents/NHIWorkingList.pdf> (accessed 18
September 2020).

Appendix A: Bat Species of the Great Lakes Region.

Table A1. Nine bat species are found in the Great Lakes region. Species affected by white-nose syndrome (WNS) are listed as “Confirmed” if they have been identified with diagnostic symptoms of the disease, or “Pd Positive” if the causative fungus *Pseudogymnoascus destructans* has been detected but without diagnostic symptoms of the disease. Federal/state status is indicated as E (Endangered), T (Threatened), or SC (Special Concern).

Species Name	Roosting/Wintering Behavior	WNS Affected? ^a	Federal Status ^b	State Status ^c
Big Brown Bat <i>Eptesicus fuscus</i>	Cavity-roosting/ Hibernating	Confirmed WNS	–	T (WI) SC (MN)
Eastern Red Bat <i>Lasiurus borealis</i>	Tree-roosting/ Migratory	Pd Positive	–	SC (IN)
Hoary Bat <i>Lasiurus cinereus</i>	Tree-roosting/ Migratory	–	–	SC (IN)
Silver-haired Bat <i>Lasionycteris noctivagans</i>	Tree-roosting/ Migratory	Pd Positive	–	SC (IN, WI)
Little Brown Bat <i>Myotis lucifugus</i>	Cavity-roosting/ Hibernating	Confirmed WNS	–	E (IN) T (WI) SC (MI, MN)
Northern Long-eared Bat <i>Myotis septentrionalis</i>	Cavity-roosting/ Hibernating	Confirmed WNS	T	E (IN) T (WI) SC (MI, MN)
Indiana Bat <i>Myotis sodalis</i>	Cavity-roosting/ Hibernating	Confirmed WNS	E	E (IN, MI)
Evening Bat <i>Nycticeius humeralis</i>	Tree-roosting/ Migratory	–	–	E (IN) T (MI)
Tricolored Bat <i>Perimyotis subflavus</i>	Cavity-roosting/ Hibernating	Confirmed WNS	–	E (IN) T (WI) SC (MI, MN)

^a White-nose Syndrome Response Team, www.whitenosesyndrome.org.

^b U. S. Fish and Wildlife Service (1967, 2016).

^c Indiana Division of Fish and Wildlife (2020), Michigan Natural Features Inventory (2009), Minnesota Department of Natural Resources (2013), Wisconsin Department of Natural Resources (2016).

Appendix B: Baseline and Expanded Species Lists.

Table B1. Bat species included as possible candidates during Kaleidoscope Pro species classification, where an “X” means yes and an en-dash (–) means no. The first column shows the “baseline” species group (known ranges within the boundaries of the park). The second column shows the “expanded” species group (documented near the park, possibly present).

Species Name	Baseline Analysis	Expanded Analysis
Big Brown Bat <i>Eptesicus fuscus</i>	X	X
Eastern Red Bat <i>Lasiurus borealis</i>	X	X
Hoary Bat <i>Lasiurus cinereus</i>	X	X
Silver-haired Bat <i>Lasionycteris noctivagans</i>	X	X
Little Brown Bat <i>Myotis lucifugus</i>	X	X
Northern Long-eared Bat <i>Myotis septentrionalis</i>	X	X
Tricolored Bat <i>Perimyotis subflavus</i>	–	X

Appendix C: Analysis Settings for Kaleidoscope Pro.

The following software settings were used during Kaleidoscope Pro analysis for species classification. Although two different software versions were used, the classifier did not change, so results are still comparable.

Software Version: Kaleidoscope Pro 4.0.0 (2015–2018 data) and Kaleidoscope Pro 5.0.3 (2019 data)

Classifier: Bats of North America 3.1.0

Classifier Sensitivity: –1 More Sensitive/Liberal

Signal Parameters:

Frequency: 8-120 kHz

Duration: 2–500 ms

Maximum inter-syllable gap: 500 ms

Minimum Number of Pulses: 2

Full spectrum WAV files were converted to zero crossing format before analysis.

Zero crossing conversion/analysis was enhanced with advanced signal processing option.

Appendix D: Yearly Deployment Data.

Tables D1 and D2 show the yearly deployment data from 2015 through 2019.

Table D1. Earliest and latest dates equipment was deployed, number of deployments in each category, and total number of files recorded for each survey year, Voyageurs National Park, 2015–2019.

Year	Earliest	Latest	Deployment Category ^a							Total Files
			Early	Failed	Failed (short)	Late	Non-protocol	Valid	Valid (dupl.)	
2015	6 July	16 September	0	0	4	8	0	7	2	27,503
2016	7 June	18 September	0	0	0	0	6	18	0	44,542
2017	7 June	7 August	0	0	0	0	0	18	0	19,288
2018	23 May	16 August	2	1	3	0	0	17	0	8,821
2019	11 June	13 August	0	0	0	0	0	18	0	21,024

^a “Early” = deployment occurred before 1 June, outside the protocol sampling period.

“Failed” = deployment was unsuccessful due to equipment malfunction, improper programming, and/or vandalism.

“Failed (short)” = deployment was unsuccessful because the minimum required four nights of recording were not completed.

“Late” = deployment occurred after 15 August, outside the protocol sampling period.

“Non-protocol” = deployment was completed for park-specific monitoring goals at a location selected intentionally, rather than following the GRTS sample design.

“Valid” = deployment with at least four nights of successful recording during the protocol sampling period (1 June–15 August).

“Valid (dupl.)” = valid deployment at a particular site in addition to the first valid deployment.

Table D2. Total number of sites, recording nights, files recorded, and mean recording nights per site, mean files per site, and mean files per recording night for each survey year’s valid deployments only, Voyageurs National Park, 2015–2019. This table corresponds to Figure 2 in the main text.

Year	Total Sites	Total Nights	Mean Nights Per Site	Total Files	Mean Files Per Site	Mean Files Per Night
2015	7	67	9.6	21,544	3,078	322
2016	18	180	10.0	28,662	1,592	159
2017	18	193	10.7	19,288	1,072	100
2018	17	200	11.8	8,397	494	42
2019	18	261	14.5	21,024	1,168	81

Appendix E: Automated Classification Results.

Tables E1 through E7 show the automated classification results from 2015 through 2019.

Table E1. Total number of audio files recorded, and number and percent classified by Kaleidoscope Pro as bat species vs. unknown bats vs. noise for each year and analysis type, Voyageurs National Park, 2015–2019. Noise category includes files classified as noise and files that were corrupt, unreadable, or excluded because the recording night was less than six hours long. Only data from valid deployments are shown. This table corresponds to Figure 3 in the main text.

Year	Analysis	Total Files	# Bat Species	# Bat Unknown	# Noise	% Bat Species	% Bat Unknown	% Noise
2015	baseline	21,544	19,205	163	2,176	89.14	0.76	10.10
2015	expanded	21,544	19,185	183	2,176	89.05	0.85	10.10
2016	baseline	28,662	25,529	173	2,960	89.07	0.60	10.33
2016	expanded	28,662	25,518	184	2,960	89.03	0.64	10.33
2017	baseline	19,288	17,217	120	1,951	89.26	0.62	10.12
2017	expanded	19,288	17,198	139	1,951	89.16	0.72	10.12
2018	baseline	8,397	7,129	63	1,205	84.90	0.75	14.35
2018	expanded	8,397	7,125	67	1,205	84.85	0.80	14.35
2019	baseline	21,024	16,355	180	4,489	77.79	0.86	21.35
2019	expanded	21,024	16,328	207	4,489	77.66	0.98	21.35

Table E2. Total number of audio files classified as each bat species by Kaleidoscope Pro for each year and analysis type, Voyageurs National Park, 2015–2019. Tricolored bat was allowed as a possible species only in the expanded analysis. Only data from valid deployments are shown.

Year	Analysis	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	531	1,330	639	982	14,911	812	n/a
2015	expanded	533	1,312	641	981	14,871	820	27
2016	baseline	200	1,284	1,246	2,057	19,018	1,724	n/a
2016	expanded	203	1,254	1,246	2,059	18,955	1,745	56
2017	baseline	100	449	4,239	1,520	10,138	771	n/a
2017	expanded	100	384	4,240	1,520	10,167	774	13
2018	baseline	235	603	2,983	1,964	1,168	176	n/a
2018	expanded	235	575	2,983	1,964	1,173	182	13
2019	baseline	214	1,210	6,309	3,018	5,145	459	n/a
2019	expanded	214	1,119	6,308	3,018	5,186	466	17

Table E3. Percent of audio files classified as each bat species by Kaleidoscope Pro for each year and analysis type, Voyageurs National Park, 2015–2019. Tricolored bat was allowed as a possible species only in the expanded analysis. Only data from valid deployments are shown. This table corresponds to Figures 4 and 5 in the main text.

Year	Analysis	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	2.76	6.93	3.33	5.11	77.64	4.23	n/a
2015	expanded	2.78	6.84	3.34	5.11	77.51	4.27	0.14
2016	baseline	0.78	5.03	4.88	8.06	74.50	6.75	n/a
2016	expanded	0.80	4.91	4.88	8.07	74.28	6.84	0.22
2017	baseline	0.58	2.61	24.62	8.83	58.88	4.48	n/a
2017	expanded	0.58	2.23	24.65	8.84	59.12	4.50	0.08
2018	baseline	3.30	8.46	41.84	27.55	16.38	2.47	n/a
2018	expanded	3.30	8.07	41.87	27.56	16.46	2.55	0.18
2019	baseline	1.31	7.40	38.58	18.45	31.46	2.81	n/a
2019	expanded	1.31	6.85	38.63	18.48	31.76	2.85	0.10

Table E4. Total number of monitoring sites and count of sites where each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019. A species was considered to be detected at a site if at least one audio file was classified by Kaleidoscope Pro to that species. Tricolored bat was allowed as a possible species only during the expanded analysis.

Year	Analysis	Total Sites	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	7	7	7	7	7	7	7	n/a
2015	expanded	7	7	7	7	7	7	7	4
2016	baseline	18	17	18	18	18	18	18	n/a
2016	expanded	18	17	18	18	18	18	18	11
2017	baseline	18	14	15	18	18	18	14	n/a
2017	expanded	18	14	15	18	18	18	14	8
2018	baseline	17	16	15	17	17	16	11	n/a
2018	expanded	17	16	15	17	17	16	11	4
2019	baseline	18	18	16	18	18	18	14	n/a
2019	expanded	18	18	16	18	18	18	14	7

Table E5. Total number of monitoring sites, and percent of sites where each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019. A species was considered to be detected at a site if at least one audio file was classified by Kaleidoscope Pro to that species. Tricolored bat was allowed as a possible species only during the expanded analysis. This table corresponds to Figure 8 in the main text.

Year	Analysis	Total Sites	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	7	100.00	100.00	100.00	100.00	100.00	100.00	n/a
2015	expanded	7	100.00	100.00	100.00	100.00	100.00	100.00	57.14
2016	baseline	18	94.44	100.00	100.00	100.00	100.00	100.00	n/a
2016	expanded	18	94.44	100.00	100.00	100.00	100.00	100.00	61.11
2017	baseline	18	77.78	83.33	100.00	100.00	100.00	77.78	n/a
2017	expanded	18	77.78	83.33	100.00	100.00	100.00	77.78	44.44
2018	baseline	17	94.12	88.24	100.00	100.00	94.12	64.71	n/a
2018	expanded	17	94.12	88.24	100.00	100.00	94.12	64.71	23.53
2019	baseline	18	100.00	88.89	100.00	100.00	100.00	77.78	n/a
2019	expanded	18	100.00	88.89	100.00	100.00	100.00	77.78	38.89

Table E6. Total number of recording nights, and count of recording nights on which each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019. A species was considered to be detected on a night if at least one audio file was classified by Kaleidoscope Pro to that species. Tricolored bat was allowed as a possible species only during the expanded analysis.

Year	Analysis	Total Nights	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	67	51	63	64	67	67	65	n/a
2015	expanded	67	51	62	64	67	67	65	16
2016	baseline	180	85	131	146	147	173	137	n/a
2016	expanded	180	85	130	146	148	173	137	32
2017	baseline	193	68	94	127	161	161	69	n/a
2017	expanded	193	68	93	127	161	161	68	12
2018	baseline	200	85	74	135	183	136	45	n/a
2018	expanded	200	85	73	135	183	136	45	8
2019	baseline	261	100	109	209	233	196	83	n/a
2019	expanded	261	100	102	209	233	196	83	15

Table E7. Total number of recording nights, and percent of recording nights on which each species was detected for each year and analysis type, Voyageurs National Park, 2015–2019. A species was considered to be detected on a night if at least one audio file was classified by Kaleidoscope Pro to that species. Tricolored bat was allowed as a possible species only during the expanded analysis. This table corresponds to Figure 9 in the main text.

Year	Analysis	Total Nights	Big Brown Bat	Eastern Red Bat	Hoary Bat	Silver-haired Bat	Little Brown Bat	Northern Long-eared Bat	Tricolored Bat
2015	baseline	67	76.12	94.03	95.52	100.00	100.00	97.01	n/a
2015	expanded	67	76.12	92.54	95.52	100.00	100.00	97.01	23.88
2016	baseline	180	47.22	72.78	81.11	81.67	96.11	76.11	n/a
2016	expanded	180	47.22	72.22	81.11	82.22	96.11	76.11	17.78
2017	baseline	193	35.23	48.70	65.80	83.42	83.42	35.75	n/a
2017	expanded	193	35.23	48.19	65.80	83.42	83.42	35.23	6.22
2018	baseline	200	42.50	37.00	67.50	91.50	68.00	22.50	n/a
2018	expanded	200	42.50	36.50	67.50	91.50	68.00	22.50	4.00
2019	baseline	261	38.31	41.76	80.08	89.27	75.10	31.80	n/a
2019	expanded	261	38.31	39.08	80.08	89.27	75.10	31.80	5.75

Appendix F: Noise Assessment.

Figures F1 and F2 and Table F1 show the assessment of noise levels relative to detector model and survey site.

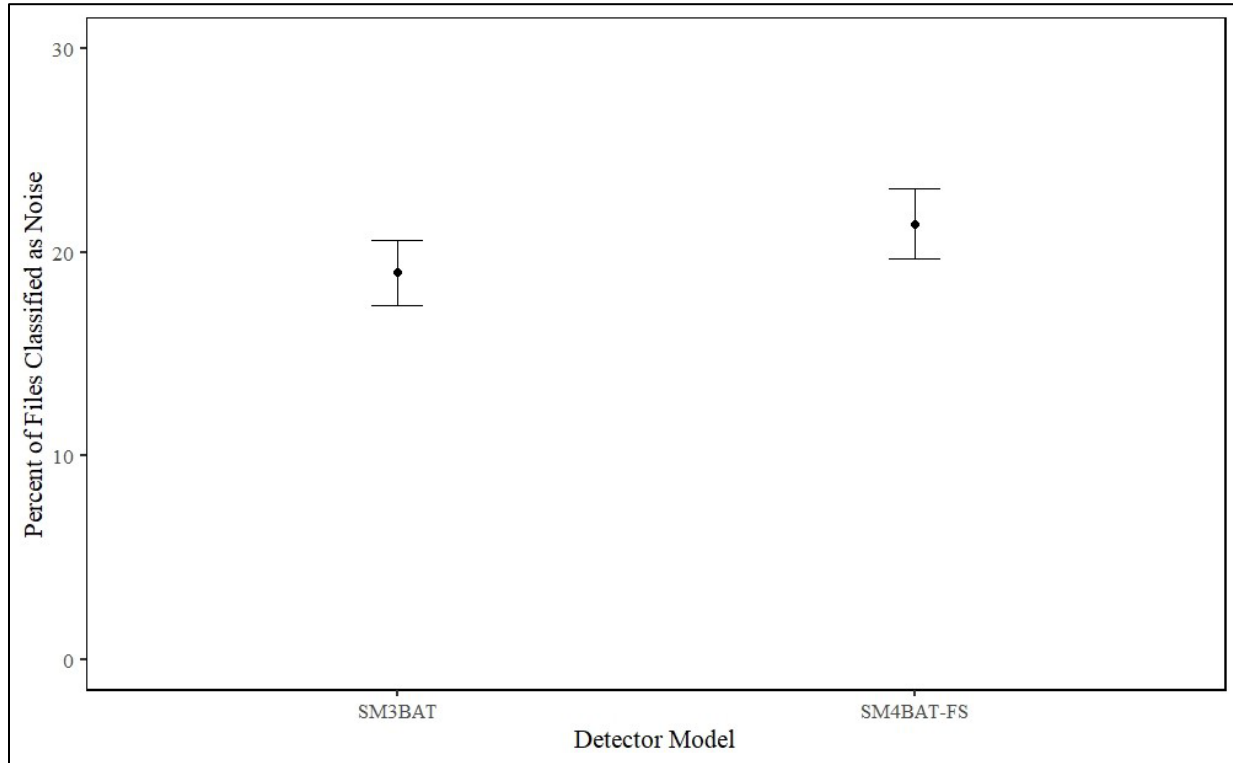


Figure F1. Percent of audio files classified as noise for each detector model (mean $\pm$ 95% confidence interval). Includes all Great Lakes Network parks in which bat monitoring occurred. Includes all deployments from 2015–2019 except failed deployments. Sample size = 442 for SM3BAT, 452 for SM4BAT-FS.

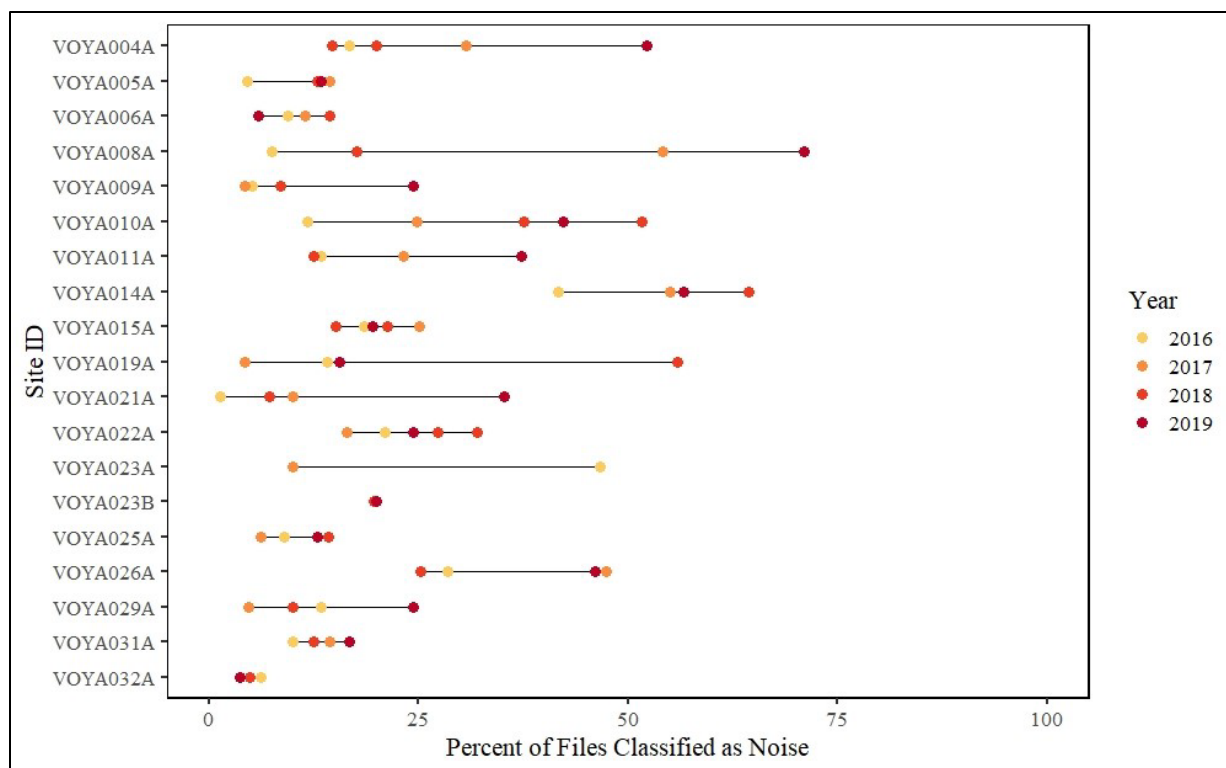


Figure F2. Percent of audio files classified as noise for each sampling site at Voyageurs National Park, 2016–2019. Each point represents the percent noise for one year’s deployment at that sampling site. Excludes failed deployments and all sites that were sampled only in 2015.

Table F1. Mean percent of audio files classified as noise for each sampling site at Voyageurs National Park, 2016–2019. Excludes failed deployments and all sites that were sampled only in 2015. Standard deviation, minimum percent noise, and maximum percent noise are given for each site. The last column indicates whether the site’s mean percent noise exceeded the parkwide mean percent noise, with asterisks indicating the top five sites with the highest mean percent noise.

Site ID	Mean % Noise	St. Dev.	Min. % Noise	Max. % Noise	Exceeds Parkwide Mean
VOYA004A	26.8	15.4	14.7	52.2	Yes
VOYA005A	11.3	4.5	4.6	14.4	–
VOYA006A	10.2	3.6	5.8	14.3	–
VOYA008A	37.5	30.0	7.4	71.0	Yes*
VOYA009A	10.5	9.4	4.2	24.4	–
VOYA010A	33.6	15.6	11.7	51.7	Yes*
VOYA011A	21.5	11.5	12.4	37.2	–
VOYA014A	54.4	9.5	41.6	64.4	Yes*
VOYA015A	19.9	3.7	15.1	25.1	–
VOYA019A	22.5	22.8	4.3	55.9	Yes
VOYA021A	13.4	15.0	1.3	35.2	–
VOYA022A	24.2	5.9	16.4	32.0	Yes
VOYA023A	28.3	26.0	9.9	46.7	Yes*
VOYA023B	19.8	0.3	19.6	20.0	–
VOYA025A	10.6	3.7	6.1	14.2	–
VOYA026A	36.8	11.6	25.2	47.4	Yes*
VOYA029A	13.1	8.3	4.7	24.4	–
VOYA031A	13.3	2.9	9.9	16.7	–
VOYA032A	4.6	1.2	3.6	6.2	–

Appendix G: Manual Vetting Results for Entire Park.

Manual vetting was performed on approximately 1% of call files classified to each species by Kaleidoscope Pro (or minimum of 10 files).

Table G1. Total number of files manually vetted, and the results of manual vetting for each year, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2015	baseline	Big Brown Bat	8	3	37.50
2015	baseline	Eastern Red Bat	13	1	7.69
2015	baseline	Hoary Bat	5	2	40.00
2015	baseline	Silver-haired Bat	10	3	30.00
2015	baseline	Little Brown Bat	149	105	70.47
2015	baseline	Northern Long-eared Bat	8	2	25.00
2015	expanded	Tricolored Bat	10	0	0.00
2016	baseline	Big Brown Bat	10	2	20.00
2016	baseline	Eastern Red Bat	18	5	27.78
2016	baseline	Hoary Bat	12	3	25.00
2016	baseline	Silver-haired Bat	21	16	76.19
2016	baseline	Little Brown Bat	191	171	89.53
2016	baseline	Northern Long-eared Bat	17	2	11.76
2016	expanded	Tricolored Bat	9	0	0.00
2017	baseline	Big Brown Bat	10	1	10.00
2017	baseline	Eastern Red Bat	10	2	20.00
2017	baseline	Hoary Bat	42	37	88.10
2017	baseline	Silver-haired Bat	15	9	60.00
2017	baseline	Little Brown Bat	101	95	94.06
2017	baseline	Northern Long-eared Bat	10	0	0.00
2017	expanded	Tricolored Bat	10	1	10.00
2018	baseline	Big Brown Bat	10	0	0.00
2018	baseline	Eastern Red Bat	10	8	80.00
2018	baseline	Hoary Bat	29	29	100.00

Table G1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2018	baseline	Silver-haired Bat	18	11	61.11
2018	baseline	Little Brown Bat	11	11	100.00
2018	baseline	Northern Long-eared Bat	10	0	0.00
2018	expanded	Tricolored Bat	10	0	0.00
2019	baseline	Big Brown Bat	10	1	10.00
2019	baseline	Eastern Red Bat	12	6	50.00
2019	baseline	Hoary Bat	55	51	92.73
2019	baseline	Silver-haired Bat	28	14	50.00
2019	baseline	Little Brown Bat	49	38	77.55
2019	baseline	Northern Long-eared Bat	10	1	10.00
2019	expanded	Tricolored Bat	10	0	0.00

Appendix H: Manual Vetting Results by Site.

Manual vetting was performed on approximately 1% of call files classified to each species by Kaleidoscope Pro (or minimum of 10 files). This was 1% parkwide, so not every combination of monitoring site/species had files vetted.

Table H1. Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2015	15-237_2015	baseline	Hoary Bat	1	0	0.0
2015	15-237_2015	baseline	Silver-haired Bat	1	1	100.0
2015	15-237_2015	baseline	Little Brown Bat	3	3	100.0
2015	15-237_2015	baseline	Northern Long-eared Bat	3	1	33.3
2015	15-243_2015	baseline	Big Brown Bat	5	2	40.0
2015	15-243_2015	baseline	Eastern Red Bat	2	1	50.0
2015	15-243_2015	baseline	Silver-haired Bat	6	1	16.7
2015	15-243_2015	baseline	Little Brown Bat	37	31	83.8
2015	15-243_2015	expanded	Tricolored Bat	4	0	0.0
2015	15-269_2015	baseline	Big Brown Bat	1	0	0.0
2015	15-269_2015	baseline	Eastern Red Bat	6	0	0.0
2015	15-269_2015	baseline	Hoary Bat	1	1	100.0
2015	15-269_2015	baseline	Silver-haired Bat	1	1	100.0
2015	15-269_2015	baseline	Little Brown Bat	68	48	70.6
2015	15-269_2015	baseline	Northern Long-eared Bat	1	0	0.0
2015	15-269_2015	expanded	Tricolored Bat	5	0	0.0
2015	15-295_2015	baseline	Big Brown Bat	1	0	0.0
2015	15-295_2015	baseline	Eastern Red Bat	1	0	0.0
2015	15-295_2015	baseline	Little Brown Bat	6	4	66.7
2015	15-295_2015	baseline	Northern Long-eared Bat	4	1	25.0
2015	15-347_2015	baseline	Eastern Red Bat	1	0	0.0
2015	15-347_2015	baseline	Hoary Bat	2	1	50.0
2015	15-347_2015	baseline	Little Brown Bat	5	3	60.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2015	15-416_2015	baseline	Big Brown Bat	1	1	100.0
2015	15-416_2015	baseline	Eastern Red Bat	2	0	0.0
2015	15-416_2015	baseline	Hoary Bat	1	0	0.0
2015	15-416_2015	baseline	Silver-haired Bat	1	0	0.0
2015	15-416_2015	baseline	Little Brown Bat	29	15	51.7
2015	15-416_2015	expanded	Tricolored Bat	1	0	0.0
2015	FS-2M_2015	baseline	Eastern Red Bat	1	0	0.0
2015	FS-2M_2015	baseline	Silver-haired Bat	1	0	0.0
2015	FS-2M_2015	baseline	Little Brown Bat	1	1	100.0
2016	VOYA004A_2016	baseline	Hoary Bat	1	0	0.0
2016	VOYA004A_2016	baseline	Little Brown Bat	8	7	87.5
2016	VOYA005A_2016	baseline	Big Brown Bat	2	1	50.0
2016	VOYA005A_2016	baseline	Eastern Red Bat	1	0	0.0
2016	VOYA005A_2016	baseline	Hoary Bat	4	3	75.0
2016	VOYA005A_2016	baseline	Silver-haired Bat	2	2	100.0
2016	VOYA005A_2016	baseline	Little Brown Bat	26	24	92.3
2016	VOYA005A_2016	expanded	Tricolored Bat	3	0	0.0
2016	VOYA006A_2016	baseline	Silver-haired Bat	1	1	100.0
2016	VOYA006A_2016	baseline	Little Brown Bat	5	5	100.0
2016	VOYA006A_2016	baseline	Northern Long-eared Bat	3	2	66.7
2016	VOYA008A_2016	baseline	Silver-haired Bat	10	7	70.0
2016	VOYA008A_2016	baseline	Little Brown Bat	3	3	100.0
2016	VOYA009A_2016	baseline	Big Brown Bat	1	0	0.0
2016	VOYA009A_2016	baseline	Eastern Red Bat	4	2	50.0
2016	VOYA009A_2016	baseline	Hoary Bat	1	0	0.0
2016	VOYA009A_2016	baseline	Little Brown Bat	32	31	96.9
2016	VOYA009A_2016	baseline	Northern Long-eared Bat	2	0	0.0
2016	VOYA010A_2016	baseline	Big Brown Bat	1	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2016	VOYA010A_2016	baseline	Eastern Red Bat	1	0	0.0
2016	VOYA010A_2016	baseline	Silver-haired Bat	1	1	100.0
2016	VOYA010A_2016	baseline	Little Brown Bat	1	1	100.0
2016	VOYA011A_2016	baseline	Eastern Red Bat	1	0	0.0
2016	VOYA011A_2016	baseline	Silver-haired Bat	1	0	0.0
2016	VOYA011A_2016	baseline	Little Brown Bat	11	10	90.9
2016	VOYA011A_2016	baseline	Northern Long-eared Bat	2	0	0.0
2016	VOYA014A_2016	baseline	Little Brown Bat	3	3	100.0
2016	VOYA015A_2016	baseline	Big Brown Bat	1	0	0.0
2016	VOYA015A_2016	baseline	Little Brown Bat	1	1	100.0
2016	VOYA019A_2016	baseline	Little Brown Bat	14	14	100.0
2016	VOYA019A_2016	baseline	Northern Long-eared Bat	1	0	0.0
2016	VOYA021A_2016	baseline	Eastern Red Bat	1	0	0.0
2016	VOYA021A_2016	baseline	Little Brown Bat	22	19	86.4
2016	VOYA021A_2016	baseline	Northern Long-eared Bat	3	0	0.0
2016	VOYA022A_2016	baseline	Little Brown Bat	3	2	66.7
2016	VOYA023A_2016	baseline	Hoary Bat	4	0	0.0
2016	VOYA025A_2016	baseline	Big Brown Bat	1	0	0.0
2016	VOYA025A_2016	baseline	Eastern Red Bat	2	0	0.0
2016	VOYA025A_2016	baseline	Silver-haired Bat	1	1	100.0
2016	VOYA025A_2016	baseline	Little Brown Bat	18	16	88.9
2016	VOYA025A_2016	expanded	Tricolored Bat	3	0	0.0
2016	VOYA026A_2016	baseline	Eastern Red Bat	1	0	0.0
2016	VOYA026A_2016	baseline	Hoary Bat	1	0	0.0
2016	VOYA026A_2016	baseline	Silver-haired Bat	1	1	100.0
2016	VOYA026A_2016	baseline	Little Brown Bat	2	0	0.0
2016	VOYA029A_2016	baseline	Big Brown Bat	1	1	100.0
2016	VOYA029A_2016	baseline	Eastern Red Bat	1	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2016	VOYA029A_2016	baseline	Silver-haired Bat	3	2	66.7
2016	VOYA029A_2016	baseline	Little Brown Bat	12	8	66.7
2016	VOYA029A_2016	baseline	Northern Long-eared Bat	3	0	0.0
2016	VOYA029A_2016	expanded	Tricolored Bat	1	0	0.0
2016	VOYA031A_2016	baseline	Eastern Red Bat	2	0	0.0
2016	VOYA031A_2016	baseline	Silver-haired Bat	1	1	100.0
2016	VOYA031A_2016	baseline	Little Brown Bat	5	5	100.0
2016	VOYA031A_2016	baseline	Northern Long-eared Bat	1	0	0.0
2016	VOYA032A_2016	baseline	Big Brown Bat	3	0	0.0
2016	VOYA032A_2016	baseline	Eastern Red Bat	4	3	75.0
2016	VOYA032A_2016	baseline	Hoary Bat	1	0	0.0
2016	VOYA032A_2016	baseline	Little Brown Bat	25	22	88.0
2016	VOYA032A_2016	baseline	Northern Long-eared Bat	2	0	0.0
2016	VOYA032A_2016	expanded	Tricolored Bat	2	0	0.0
2017	VOYA004A_2017	baseline	Little Brown Bat	1	1	100.0
2017	VOYA005A_2017	baseline	Hoary Bat	2	2	100.0
2017	VOYA005A_2017	baseline	Silver-haired Bat	3	2	66.7
2017	VOYA005A_2017	baseline	Little Brown Bat	2	2	100.0
2017	VOYA005A_2017	expanded	Tricolored Bat	2	0	0.0
2017	VOYA006A_2017	baseline	Big Brown Bat	1	0	0.0
2017	VOYA006A_2017	baseline	Hoary Bat	1	1	100.0
2017	VOYA006A_2017	baseline	Silver-haired Bat	3	3	100.0
2017	VOYA009A_2017	baseline	Big Brown Bat	2	0	0.0
2017	VOYA009A_2017	baseline	Eastern Red Bat	3	0	0.0
2017	VOYA009A_2017	baseline	Hoary Bat	1	1	100.0
2017	VOYA009A_2017	baseline	Silver-haired Bat	2	2	100.0
2017	VOYA009A_2017	baseline	Little Brown Bat	9	9	100.0
2017	VOYA009A_2017	baseline	Northern Long-eared Bat	4	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2017	VOYA009A_2017	expanded	Tricolored Bat	3	1	33.3
2017	VOYA010A_2017	baseline	Little Brown Bat	1	1	100.0
2017	VOYA010A_2017	baseline	Northern Long-eared Bat	1	0	0.0
2017	VOYA011A_2017	baseline	Little Brown Bat	1	1	100.0
2017	VOYA014A_2017	baseline	Big Brown Bat	1	0	0.0
2017	VOYA014A_2017	baseline	Hoary Bat	1	0	0.0
2017	VOYA014A_2017	expanded	Tricolored Bat	1	0	0.0
2017	VOYA019A_2017	baseline	Big Brown Bat	1	1	100.0
2017	VOYA019A_2017	baseline	Little Brown Bat	10	10	100.0
2017	VOYA021A_2017	baseline	Eastern Red Bat	2	2	100.0
2017	VOYA021A_2017	baseline	Little Brown Bat	19	18	94.7
2017	VOYA021A_2017	baseline	Northern Long-eared Bat	1	0	0.0
2017	VOYA022A_2017	baseline	Eastern Red Bat	2	0	0.0
2017	VOYA022A_2017	baseline	Silver-haired Bat	3	2	66.7
2017	VOYA022A_2017	expanded	Tricolored Bat	1	0	0.0
2017	VOYA023A_2017	baseline	Big Brown Bat	2	0	0.0
2017	VOYA023A_2017	baseline	Little Brown Bat	1	0	0.0
2017	VOYA025A_2017	baseline	Eastern Red Bat	1	0	0.0
2017	VOYA025A_2017	baseline	Silver-haired Bat	3	0	0.0
2017	VOYA025A_2017	baseline	Little Brown Bat	9	9	100.0
2017	VOYA025A_2017	expanded	Tricolored Bat	1	0	0.0
2017	VOYA029A_2017	baseline	Big Brown Bat	2	0	0.0
2017	VOYA029A_2017	baseline	Eastern Red Bat	2	0	0.0
2017	VOYA029A_2017	baseline	Little Brown Bat	45	41	91.1
2017	VOYA029A_2017	baseline	Northern Long-eared Bat	4	0	0.0
2017	VOYA029A_2017	expanded	Tricolored Bat	1	0	0.0
2017	VOYA032A_2017	baseline	Big Brown Bat	1	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2017	VOYA032A_2017	baseline	Hoary Bat	37	33	89.2
2017	VOYA032A_2017	baseline	Silver-haired Bat	1	0	0.0
2017	VOYA032A_2017	baseline	Little Brown Bat	3	3	100.0
2017	VOYA032A_2017	expanded	Tricolored Bat	1	0	0.0
2018	VOYA005A_2018	baseline	Big Brown Bat	1	0	0.0
2018	VOYA005A_2018	baseline	Eastern Red Bat	1	1	100.0
2018	VOYA005A_2018	baseline	Hoary Bat	4	4	100.0
2018	VOYA005A_2018	baseline	Silver-haired Bat	7	5	71.4
2018	VOYA005A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA005A_2018	expanded	Tricolored Bat	3	0	0.0
2018	VOYA006A_2018	baseline	Big Brown Bat	1	0	0.0
2018	VOYA006A_2018	baseline	Little Brown Bat	3	3	100.0
2018	VOYA006A_2018	baseline	Northern Long-eared Bat	4	0	0.0
2018	VOYA008A_2018	baseline	Big Brown Bat	1	0	0.0
2018	VOYA008A_2018	baseline	Silver-haired Bat	1	1	100.0
2018	VOYA011A_2018	baseline	Eastern Red Bat	1	0	0.0
2018	VOYA011A_2018	baseline	Silver-haired Bat	1	0	0.0
2018	VOYA011A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA011A_2018	baseline	Northern Long-eared Bat	1	0	0.0
2018	VOYA014A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA014A_2018	baseline	Northern Long-eared Bat	1	0	0.0
2018	VOYA015A_2018	baseline	Big Brown Bat	3	0	0.0
2018	VOYA015A_2018	baseline	Silver-haired Bat	1	0	0.0
2018	VOYA021A_2018	baseline	Eastern Red Bat	6	6	100.0
2018	VOYA021A_2018	baseline	Silver-haired Bat	1	0	0.0
2018	VOYA021A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA021A_2018	baseline	Northern Long-eared Bat	1	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2018	VOYA021A_2018	expanded	Tricolored Bat	1	0	0.0
2018	VOYA023B_2018	baseline	Silver-haired Bat	3	2	66.7
2018	VOYA025A_2018	baseline	Big Brown Bat	2	0	0.0
2018	VOYA025A_2018	baseline	Hoary Bat	1	1	100.0
2018	VOYA025A_2018	baseline	Silver-haired Bat	1	0	0.0
2018	VOYA025A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA026A_2018	baseline	Silver-haired Bat	1	1	100.0
2018	VOYA029A_2018	baseline	Little Brown Bat	2	2	100.0
2018	VOYA029A_2018	baseline	Northern Long-eared Bat	2	0	0.0
2018	VOYA031A_2018	baseline	Eastern Red Bat	1	0	0.0
2018	VOYA031A_2018	baseline	Little Brown Bat	1	1	100.0
2018	VOYA031A_2018	baseline	Northern Long-eared Bat	1	0	0.0
2018	VOYA031A_2018	expanded	Tricolored Bat	1	0	0.0
2018	VOYA032A_2018	baseline	Big Brown Bat	2	0	0.0
2018	VOYA032A_2018	baseline	Eastern Red Bat	1	1	100.0
2018	VOYA032A_2018	baseline	Hoary Bat	24	24	100.0
2018	VOYA032A_2018	baseline	Silver-haired Bat	2	2	100.0
2018	VOYA032A_2018	expanded	Tricolored Bat	5	0	0.0
2019	VOYA004A_2019	baseline	Little Brown Bat	3	2	66.7
2019	VOYA005A_2019	baseline	Eastern Red Bat	1	1	100.0
2019	VOYA005A_2019	baseline	Hoary Bat	1	1	100.0
2019	VOYA005A_2019	baseline	Silver-haired Bat	3	2	66.7
2019	VOYA005A_2019	baseline	Little Brown Bat	1	1	100.0
2019	VOYA005A_2019	expanded	Tricolored Bat	3	0	0.0
2019	VOYA006A_2019	baseline	Big Brown Bat	1	1	100.0
2019	VOYA006A_2019	baseline	Silver-haired Bat	1	0	0.0
2019	VOYA006A_2019	baseline	Little Brown Bat	11	10	90.9
2019	VOYA006A_2019	baseline	Northern Long-eared Bat	7	0	0.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2019	VOYA008A_2019	baseline	Big Brown Bat	1	0	0.0
2019	VOYA008A_2019	baseline	Northern Long-eared Bat	1	1	100.0
2019	VOYA008A_2019	expanded	Tricolored Bat	1	0	0.0
2019	VOYA009A_2019	baseline	Eastern Red Bat	2	1	50.0
2019	VOYA009A_2019	baseline	Hoary Bat	2	1	50.0
2019	VOYA009A_2019	baseline	Little Brown Bat	2	2	100.0
2019	VOYA010A_2019	baseline	Big Brown Bat	1	0	0.0
2019	VOYA010A_2019	baseline	Hoary Bat	2	2	100.0
2019	VOYA011A_2019	baseline	Big Brown Bat	1	0	0.0
2019	VOYA011A_2019	baseline	Hoary Bat	1	1	100.0
2019	VOYA011A_2019	baseline	Silver-haired Bat	1	1	100.0
2019	VOYA014A_2019	baseline	Big Brown Bat	2	0	0.0
2019	VOYA014A_2019	baseline	Hoary Bat	2	2	100.0
2019	VOYA014A_2019	baseline	Silver-haired Bat	3	0	0.0
2019	VOYA015A_2019	baseline	Silver-haired Bat	3	3	100.0
2019	VOYA015A_2019	baseline	Little Brown Bat	1	1	100.0
2019	VOYA015A_2019	baseline	Northern Long-eared Bat	1	0	0.0
2019	VOYA019A_2019	baseline	Little Brown Bat	23	19	82.6
2019	VOYA021A_2019	baseline	Eastern Red Bat	5	3	60.0
2019	VOYA021A_2019	baseline	Little Brown Bat	4	0	0.0
2019	VOYA021A_2019	expanded	Tricolored Bat	3	0	0.0
2019	VOYA022A_2019	baseline	Eastern Red Bat	2	0	0.0
2019	VOYA022A_2019	baseline	Silver-haired Bat	1	0	0.0
2019	VOYA022A_2019	expanded	Tricolored Bat	1	0	0.0
2019	VOYA023B_2019	baseline	Big Brown Bat	2	0	0.0
2019	VOYA023B_2019	baseline	Eastern Red Bat	1	1	100.0
2019	VOYA023B_2019	baseline	Hoary Bat	1	0	0.0
2019	VOYA023B_2019	baseline	Silver-haired Bat	4	1	25.0

Table H1 (continued). Total number of files manually vetted, and the results of manual vetting for each year, site, analysis type, and species, Voyageurs National Park, 2015–2019. “Verified” indicates that the manual identification matched, and thus verified, the automated identification.

Year	Site ID	Analysis	Kaleidoscope Classification	Total Files Vetted	Number Files Verified	Percent Files Verified
2019	VOYA023B_2019	baseline	Little Brown Bat	3	3	100.0
2019	VOYA023B_2019	expanded	Tricolored Bat	2	0	0.0
2019	VOYA025A_2019	baseline	Big Brown Bat	2	0	0.0
2019	VOYA025A_2019	baseline	Eastern Red Bat	1	0	0.0
2019	VOYA025A_2019	baseline	Hoary Bat	1	1	100.0
2019	VOYA025A_2019	baseline	Silver-haired Bat	2	2	100.0
2019	VOYA025A_2019	baseline	Little Brown Bat	1	0	0.0
2019	VOYA025A_2019	baseline	Northern Long-eared Bat	1	0	0.0
2019	VOYA026A_2019	baseline	Silver-haired Bat	1	1	100.0
2019	VOYA029A_2019	baseline	Silver-haired Bat	3	1	33.3
2019	VOYA031A_2019	baseline	Silver-haired Bat	1	0	0.0
2019	VOYA032A_2019	baseline	Hoary Bat	45	43	95.6
2019	VOYA032A_2019	baseline	Silver-haired Bat	5	3	60.0

Appendix I: Species Composition Across Parks.

Figure I1 is for the baseline analysis only, and it includes all Great Lakes Network parks in which bat monitoring occurred.

APIS: Apostle Islands National Lakeshore (Wisconsin)

GRPO: Grand Portage National Monument (Minnesota)

INDU: Indiana Dunes National Park (Indiana)

ISRO: Isle Royale National Park (Michigan)

MISS: Mississippi National River and Recreation Area (Minnesota)

PIRO: Pictured Rocks National Lakeshore (Michigan)

SACN: St. Croix National Scenic Riverway (Wisconsin/Minnesota)

SLBE: Sleeping Bear Dunes National Lakeshore (Michigan)

VOYA: Voyageurs National Park (Minnesota)

The baseline analysis had Indiana bat and evening bat allowed as possible species only for INDU, and tricolored bat allowed as a possible species only for INDU, MISS, and SACN.

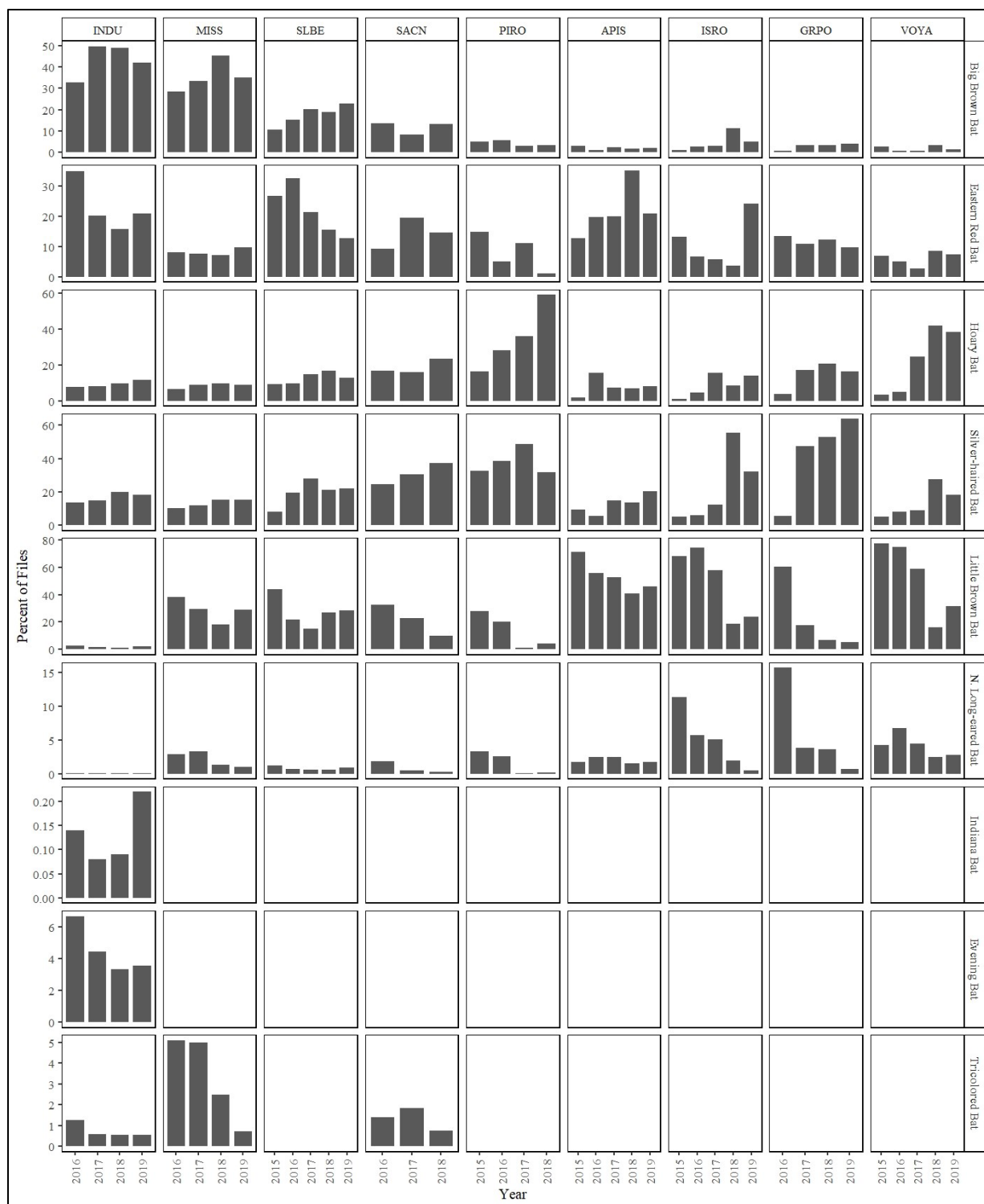


Figure 11. Percent of audio files classified as each bat species by Kaleidoscope Pro in the baseline analysis for each park and year. Note that the y-axis scale is different for each species and not all parks conducted surveys in all years. Only data from valid deployments are shown. Parks are ordered approximately by latitude, from INDU (southernmost) to VOYA (northernmost).

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National Park Service
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