

FINAL REPORT

Summary of 2015 Acoustic Bat Population Monitoring Data for Select Great Lakes Inventory and Monitoring Network Parks



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INTRODUCTION

The Great Lakes Inventory and Monitoring Network (GLKN) goal is developing an acoustic monitoring program for bats to track populations through time given populations are already stressed from WNS at regional and national scales. In 2015, four Parks of the GLKN implemented the first year of acoustic monitoring: Apostle Islands (APIS), Isle Royale (ISRO), Sleeping Bear Dunes (SLBE) and Voyageurs (VOYA). We will refer to these Parks by 4-letter code throughout this report, and as “the Parks” when referring to them collectively. Full spectrum acoustic detectors were deployed during 2015 at the Parks to monitor bat activity, bat species presence, and seasonal activity patterns.

The GLKN has requested that Western EcoSystems Technology, Inc. (WEST) manually review, identify and summarize bat calls recorded within the Parks in 2015. This document is intended to meet the following objectives: 1) manually review and identify to species (when possible) all bat call recordings; 2) summarize acoustic recording metadata (number of survey nights, number of recordings, etc.); 3) summarize species presence and relative activity, and; 4) provide individual Park summaries. This is the second revision of the report. This revision was conducted to correct internal inconsistencies within the call identification dataset, correct misidentifications of tri-colored bat calls, include missing identifications, remove duplicate identifications and accurately reflect identifications of call files that contain multiple call sequences.

METHODS

Acoustic data were collected during summer of 2015 by National Park Service (NPS) personnel using Wildlife Acoustics SM2Bat and SM3Bat (Wildlife Acoustics, Maynard, MA) full-spectrum acoustic detectors and data loggers. Deployments of detectors at the Parks generally followed SOPs outlined in Solick et al. (2015). During the summer (defined as June 1-July 31) and fall (August 1-October 15) of 2015, acoustic data were recorded and compiled individually by the Parks. In March 2016, GLKN provided copies of data from the Parks to WEST for organization, QAQC, and automated and manual species identification.

After receiving the acoustic data and associated documents from GLKN on a hard drive, WEST made a working copy of the contents and did not alter the original files. This was done primarily to ensure that original data would be available in the event of accidental data loss. Acoustic data that were received from GLKN included files in WAC format, WAV format and zero-crossing (ZC) format. WEST converted WAC or WAV files to ZC files using Kaleidoscope Pro v. 3.1.5 (Wildlife Acoustics, Maynard, MA). WEST converted to ZC files for two primary reasons: 1) ZC files are smaller and easier to work with than WAV files, and 2) ZC files facilitate faster and more efficient manual review of the bat call files by WEST biologists. Conversion of WAC or WAV files to ZC occurred simultaneously with automated species identification by the software (described in detail below). During conversion, a Division Ratio of 8 for the output ZC files was selected and no filename changes were specified. Thus, output ZC files retained the same filename as the original WAV file. Under the Filter tab, we selected the option to “*Filter noise files*” and to “*Keep noise files*”. Selecting these options meant that files determined by Kaleidoscope to contain only noise (i.e., no bat calls) were filtered out and placed in a separate folder. After converting files, WEST reviewed the available data logs, call data and datasheets to determine the dates that detectors

were deployed at particular locations, and if detectors had operated properly during the recording sessions. WEST defined non-operational nights as nights with no recorded files that occurred during and usually at the end of a recording period. Generally, files were recorded normally on the night preceding the non-operational night and all recording stopped and did not continue for the rest of the recording period. The recording period encompasses the multiple nights between the detector being deployed and then being serviced or removed from the field by the technician. Datasheets generally indicated that power failure due to battery drain was the cause of most non-operational nights. Nights with corrupt data files were also considered non-operational. When it was determined that a detector had not operated on a night, that detector-night was assigned a zero. Operation of a detector for a full or partial night at a station received a 1 for that detector-night. In this way, WEST developed a detector-night matrix for all stations that included a 1 for operating and a 0 for not operating.

WEST submitted all available acoustic data to Kaleidoscope Pro v. 3.1.5 for automated species identification, and final species determinations involved a combination of the species identification software and qualitative review by an acoustic expert. Kaleidoscope probabilistically identifies echolocation calls to species based on statistical comparison of the unknown calls to a suite of known calls that are proprietary within the software. WEST used default settings in the Signal Detection Parameters Tab within Kaleidoscope: 1) Minimum and Maximum Frequency Range set to 8 to 120 kHz, 2) Minimum and Maximum Length of Detected Pulses set to 2 to 500 ms, 3) Maximum inter-syllable gap set to 500 ms, 4) Minimum number of pulses set to 2, and 5) advanced signal processing toggled on. Under the Classifiers tab in Kaleidoscope we included the species likely to occur at a site by selecting the Bats of North America 3.1.0 classifier and selecting only the species appropriate for the site. For all Parks included in this report, the following species were included: EPFU (big brown bat), LABO (eastern red bat), LACI (hoary bat), LANO (silver-haired bat), MYLU (little brown bat), MYSE (northern long-eared bat) and PESU (tri-colored bat). In addition, we included MYSO (Indiana bat) for data collected at SLBE, given the potential for this species to occur at that Park. We selected the *-1 More Sensitive (Liberal)* option for the classifier. Of the 3 options (*-1, 0, and +1*) for sensitivity of the classifier engine, the *-1* setting will attempt to identify the greatest number of call files, but will also result in the greatest number of misclassifications (i.e. false positives). This is an inherent trade-off in automated species identification. During species classification, Kaleidoscope inserts its species classification into the Species field of each ZC file. Files that the Kaleidoscope cannot identify are labeled as NoID and files that are unlikely to contain bat calls are labeled as Noise. Kaleidoscope produces two summary output files that provide nightly classification summaries and a complete list of species classifications for all files.

Qualitative review was performed on all calls identified to species by Kaleidoscope. Calls were manually vetted by WEST bat biologists with extensive acoustic analysis experience. Originally, Jeff Gruver reviewed calls identified as little brown bat or northern long-eared bat; Donald Solick, Larisa Bishop-Boros and Kristina Hammond-Rendon reviewed calls identified as non-Myotis species (i.e., big brown, eastern red, hoary, silver-haired bats); and Dr. Kevin Murray reviewed calls identified as Indiana bat. For the second revision of the report Dr. Murray reviewed calls identified as little brown bat and tri-colored bat and D. Solick reviewed calls identified as little brown bat. Due to the number of calls recorded, particularly at APIS, WEST did not intend to

conduct qualitative review of files identified as NoID by Kaleidoscope at APIS. However, qualitative review actually was conducted on all NoID files from SLBE and VOYA and on a portion of NoID files from ISRO. The NoID files from APIS were not reviewed.

In performing the qualitative review of the calls recorded at the Parks and identified to a particular species, we relied on comparison to a known call library of the species. In addition, we relied on an understanding of the location of the microphone collecting the calls relative to vegetation, and the echolocation behavior of other species recorded at the location. This provided the context to understand how to interpret the recorded calls, as bats alter their echolocation in the presence of dense vegetation, which represents “acoustic clutter” (Britzke et al. 2002, Broders et al. 2004, Wund 2006). During qualitative review we relabeled bat call files (e.g., from MYLU to MYSE, from MYSO to MYLU, etc.) if there was sufficient evidence to suggest that a different species had produced the call. In instances where it was clear that the software should not have made a species determination (typically short fragmented call sequences), we generally were unable to make a definitive species determination and changed the label to reflect that the call was not identifiable to species. Unknown calls with a minimum frequency greater than or equal to 30 kHz were assigned to the high-frequency (HIFQ) species group. Unknown calls with a minimum frequency less than or equal to 30 kHz were assigned to the low-frequency (LOFQ) species group. Files that contained only non-bat sounds or did not contain at least two echolocation pulses within one second (White and Gehrt 2001, Gannon et al. 2003) were deemed to be noise and labeled as such. In all other instances, Kaleidoscope species labels were retained. Species codes are listed in Appendix 1.

RESULTS

Here we provide summaries and descriptive statistics for the acoustic surveys performed and data collected in 2015 at the Parks. Not all Parks collected data during the same period, so some of the summaries are broken out by Park and some of the summaries represent data from all Parks. Summaries presented represent those requested in the scope of work and/or those deemed by WEST to be beneficial for evaluating the effectiveness of the bat acoustic monitoring effort.

Summary of Acoustic Survey Effort and Kaleidoscope Analysis

In 2015, a total of 186,059 files were recorded at the Parks on 857 operational detector-nights. Of these files, Kaleidoscope classified 161,319 to species (Table 1). Although level of effort varied across the Parks, the greatest number of files with identifiable bat calls were recorded at APIS (111,156), followed by VOYA (23,820), SLBE (19,452) and ISRO (6,891). Kaleidoscope identified a total of 8,586 files as Noise and 16,154 files as NoID (Table 1). NoID files are either noise files or bat call files that the software did not identify to species due to low statistical confidence. Survey effort for each Park and station is summarized by season in Table 2. The results of Kaleidoscope Pro analysis for each Park and station are summarized in Table 3.

Table 1. Summary of 2015 acoustic bat survey effort by Park and number of files classified to species by Kaleidoscope Pro software.

Park	Survey Dates	# Stations	Detector-Nights	Total Files Recorded	Files Classified by Kaleidoscope as:		
					Noise	NoID	Bats
APIS	June 4 to Oct 15	24	348	120,266	3,002	6,108	111,156
ISRO	July 10 to Aug 26	10	94	10,311	1,396	2,024	6,891
SLBE	June 25 to Sept 11	18	259	28,091	3,054	5,585	19,452
VOYA	July 6 to Sept 15	12	156	27,391	1,134	2,437	23,820
Totals		64	857	186,059	8,586	16,154	161,319

Table 2. Summary of acoustic survey effort (detector-nights) by Park and season. Park abbreviations are provided in Appendix 1. Summer included data collected June 1 to July 31. Fall included data collected August 1 to October 15.

Park/Station	Detector-Nights			Percentage		Park Survey Effort
	Summer	Fall	Total	Summer	Fall	
APIS	158	190	348	48.12%	51.88%	100.00%
<i>Fixed</i>	42	96	138	30.4%	69.6%	39.7%
MD01	40	29	69	58.0%	42.0%	19.8%
MD02	2	67	69	2.9%	97.1%	19.8%
<i>Roaming</i>	116	94	210	55.2%	44.8%	60.3%
BA01	0	7	7	0.0%	100.0%	2.0%
BE01	8	0	8	100.0%	0.0%	2.3%
CA01	2	0	2	100.0%	0.0%	0.6%
DE01	0	11	11	0.0%	100.0%	3.2%
DE02	0	9	9	0.0%	100.0%	2.6%
EA01	0	11	11	0.0%	100.0%	3.2%
HE01	0	11	11	0.0%	100.0%	3.2%
IR01	11	0	11	100.0%	0.0%	3.2%
LO01	0	7	7	0.0%	100.0%	2.0%
MA01	10	0	10	100.0%	0.0%	2.9%
MI01	13	0	13	100.0%	0.0%	3.7%
NO01	0	13	13	0.0%	100.0%	3.7%

Park/Station	Detector-Nights			Percentage		Park Survey Effort
	Summer	Fall	Total	Summer	Fall	
OA01	10	0	10	100.0%	0.0%	2.9%
OT01	8	0	8	100.0%	0.0%	2.3%
OU01	7	0	7	100.0%	0.0%	2.0%
OU02	1	11	12	8.3%	91.7%	3.4%
RA01	11	0	11	100.0%	0.0%	3.2%
RO01	12	0	12	100.0%	0.0%	3.4%
SA01	0	5	5	0.0%	100.0%	1.4%
SO01	11	0	11	100.0%	0.0%	3.2%
ST01	12	0	12	100.0%	0.0%	3.4%
YO01	0	9	9	0.0%	100.0%	2.6%
ISRO	21	73	94	22.3%	77.7%	100.0%
Fixed	9	48	57	15.8%	84.2%	60.6%
DFP1	1	0	1	100.0%	0.0%	1.1%
FS1	4	24	28	14.3%	85.7%	29.8%
FS2	4	24	28	14.3%	85.7%	29.8%
Roaming	12	25	37	32.4%	67.6%	39.4%
BAT517	0	5	5	0.0%	100.0%	5.3%
BAT605	0	7	7	0.0%	100.0%	7.4%
BAT85	0	8	8	0.0%	100.0%	8.5%
DAVI1	0	5	5	0.0%	100.0%	5.3%
MPL1	4	0	4	100.0%	0.0%	4.3%
MSF1	4	0	4	100.0%	0.0%	4.3%
PIBH1	4	0	4	100.0%	0.0%	4.3%
SLBE	133	126	259	51.4%	48.6%	100.0%
Fixed	60	71	131	45.8%	54.2%	50.6%
GTFS	31	37	68	45.6%	54.4%	26.3%
PVFS	29	34	63	46.0%	54.0%	24.3%
Roaming	73	55	128	57.0%	43.0%	49.4%
AROC	4	2	6	66.7%	33.3%	2.3%
BLKT	12	0	12	100.0%	0.0%	4.6%
BSCR	4	8	12	33.3%	66.7%	4.6%
CDRS	0	5	5	0.0%	100.0%	1.9%
DELA	11	0	11	100.0%	0.0%	4.2%
DHDG	10	0	10	100.0%	0.0%	3.9%
DRWR	11	0	11	100.0%	0.0%	4.2%
FMLP	0	0	0	0.0%	0.0%	0.0%
GURA	11	0	11	100.0%	0.0%	4.2%

Park/Station	Detector-Nights			Percentage		Park Survey Effort
	Summer	Fall	Total	Summer	Fall	
KTSH	0	0	0	0.0%	0.0%	0.0%
LKMN	0	12	12	0.0%	100.0%	4.6%
PSFL	0	10	10	0.0%	100.0%	3.9%
SHCR	4	7	11	36.4%	63.6%	4.2%
SHRL	0	11	11	0.0%	100.0%	4.2%
TRFM	6	0	6	100.0%	0.0%	2.3%
WLCR	0	0	0	0.0%	0.0%	0.0%
VOYA	56	100	156	35.9%	64.1%	100.0%
Fixed	16	43	59	27.1%	72.9%	37.8%
FS02	12	39	51	23.5%	76.5%	32.7%
FS30	4	4	8	50.0%	50.0%	5.1%
Roaming	40	57	97	41.2%	58.8%	62.2%
15-237	0	12	12	0.0%	100.0%	7.7%
15-243	10	1	11	90.9%	9.1%	7.1%
15-269	10	1	11	90.9%	9.1%	7.1%
15-295	0	11	11	0.0%	100.0%	7.1%
15-347	10	0	10	100.0%	0.0%	6.4%
15-416	10	0	10	100.0%	0.0%	6.4%
15-452	0	10	10	0.0%	100.0%	6.4%
15-455	0	10	10	0.0%	100.0%	6.4%
15-472	0	10	10	0.0%	100.0%	6.4%
15-482	0	2	2	0.0%	100.0%	1.3%

Table 3. Summary of Kaleidoscope analysis by Park and station. Park abbreviations and species code descriptions are provided in Appendix 1.

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	MYSO†	PESU	NOID	NOISE	Total
APIS	2,713 (2.3%)	17,463 (14.5%)	4,498 (3.7%)	15,240 (12.7%)	61,397 (51.1%)	5,278 (4.4%)	----	4,567 (3.8%)	6,108 (5.1%)	3,002 (2.5%)	120,266
Fixed	1,170	10,269	3,657	12,634	8,511	746	----	1,838	2,400	1,416	42,641
MD01	346	6,902	2,714	8,324	6,065	531	----	939	1,011	619	27,451
MD02	824	3,367	943	4,310	2,446	215	----	899	1,389	797	15,190
Roaming	1,543	7,194	841	2,606	52,886	4,532	----	2,729	3,708	1,586	77,625
BA01	25	107	7	76	1,128	113	----	201	137	76	1,870
BE01	94	914	16	90	10,101	1,811	----	44	162	30	13,262
CA01	0	47	2	1	63	1	----	7	5	5	131
DE01	0	0	0	0	0	0	----	0	0	67	67
DE02	0	0	0	0	0	0	----	0	0	60	60
EA01	13	57	30	81	1,218	31	----	128	113	58	1,729
HE01	0	9	0	3	31	19	----	15	29	13	119
IR01	18	118	47	144	782	15	----	24	395	277	1,820
LO01	11	121	12	64	1,131	109	----	115	94	36	1,693
MA01	106	310	16	54	2,440	112	----	169	84	22	3,313
MI01	6	371	160	156	17,780	617	----	72	186	69	19,417
NO01	7	96	3	64	846	127	----	44	73	29	1,289
OA01	133	264	11	325	1,864	509	----	201	303	74	3,684
OT01	33	36	16	101	315	55	----	6	179	58	799
OU01	1	37	0	3	221	0	----	1	70	46	379
OU02	87	1,547	50	174	1,732	152	----	679	528	150	5,099
RA01	13	460	307	170	3,428	265	----	438	536	236	5,853
RO01	373	529	60	473	1,130	170	----	76	177	36	3,024
SA01	8	541	30	121	301	20	----	145	128	62	1,356
SO01	86	1,338	27	41	5,608	102	----	271	163	42	7,678
ST01	511	137	25	303	1,646	189	----	30	172	54	3,067

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	MYSO†	PESU	NOID	NOISE	Total
YO01	18	155	22	162	1,121	115	----	63	174	86	1,916
ISRO	44 (0.4%)	888 (8.6%)	147 (1.4%)	516 (5.0%)	4,100 (39.8%)	936 (9.1%)	----	260 (2.5%)	2,024 (19.6%)	1,396 (13.5%)	10,311
Fixed	29	450	123	334	1,536	479	----	167	1,159	844	5,121
DFP1	0	1	0	0	0	0	----	0	0	0	1
FS1	22	388	101	282	812	222	----	101	624	430	2,982
FS2	7	61	22	52	724	257	----	66	535	414	2,138
Roaming	15	438	24	182	2,564	457	----	93	865	552	5,190
BAT517	3	45	1	16	98	27	----	30	49	42	311
BAT605	3	25	7	32	79	27	----	5	43	39	260
BAT85	6	163	7	47	381	109	----	27	113	122	975
DAVI1	1	38	4	11	169	85	----	4	130	47	489
MPL1	1	36	0	34	190	50	----	3	85	74	473
MSF1	0	103	4	41	1,263	127	----	8	204	85	1,835
PIBH1	1	28	1	1	384	32	----	16	241	143	847
SLBE	1,675 (6.0%)	3,014 (10.7%)	2,997 (10.7%)	2,705 (9.6%)	5,637 (20.1%)	946 (3.4%)	1,129 (4.0%)	1,349 (4.8%)	5,585 (19.9%)	3,054 (10.9%)	28,091
Fixed	125	440	1,174	143	674	66	137	93	642	436	3,930
GTFS	27	91	325	94	440	18	51	23	352	264	1,685
PVFS	98	349	849	49	234	48	86	70	290	172	2,245
Roaming	1,550	2,574	1,823	2,562	4,963	880	992	1,256	4,943	2,618	24,161
AROC	210	1	44	31	3	67	15	0	583	147	1,101
BLKT	210	608	156	415	6	6	1	13	938	439	2,792
BSCR	101	497	44	40	855	70	255	414	644	123	3,043
CDRS	0	4	4	1	28	5	22	2	13	8	87

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	MYSO†	PESU	NOID	NOISE	Total
DELA	17	6	31	77	5	1	34	10	15	16	212
DHDG	312	305	36	161	147	32	47	122	957	912	3,031
DRWR	171	843	237	29	555	127	87	588	177	39	2,853
FMLP	0	0	0	0	0	0	0	0	0	0	0
GURA	210	20	180	685	29	3	1	3	47	29	1,207
KTSH	0	0	0	0	0	0	0	0	9	4	13
LKMN	30	37	160	271	5	2	10	4	97	70	686
PSFL	1	4	9	20	1	2	0	1	23	28	89
SHCR	54	70	817	163	2,881	413	295	34	266	126	5,119
SHRL	165	31	84	600	43	3	32	59	404	309	1,730
TRFM	69	148	21	69	405	149	193	6	770	368	2,198
WLCR	0	0	0	0	0	0	0	0	0	0	0
VOYA	669 (2.4%)	1,714 (6.3%)	1,339 (4.9%)	2,200 (8.0%)	14,821 (54.1%)	2,339 (8.5%)	----	738 (2.7%)	2,437 (8.9%)	1,134 (4.1%)	27,391
Fixed	276	420	303	939	1,763	270	----	113	619	308	5,011
FS02	140	266	276	692	1,130	219	----	70	519	212	3,524
FS30	136	154	27	247	633	51	----	43	100	96	1,487
Roaming	393	1,294	1,036	1,261	13,058	2,069	----	625	1,818	826	22,380
15-237	23	27	62	58	185	82	----	8	217	80	742
15-243	230	234	86	477	3,337	358	----	121	93	36	4,972
15-269	77	785	175	353	6,401	775	----	382	566	271	9,785
15-295	7	33	344	82	296	58	----	9	435	116	1,380
15-347	3	75	85	43	276	90	----	26	135	64	797
15-416	42	76	94	53	2,048	613	----	49	187	66	3,228
15-452	5	6	132	29	21	16	----	0	63	71	343
15-455	1	36	43	105	329	45	----	20	76	39	694
15-472	5	22	15	61	165	31	----	10	40	49	398

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	MYSO†	PESU	NOID	NOISE	Total
15-482	0	0	0	0	0	1	----	0	6	34	41
All Parks Total	5,101 (2.7%)	23,079 (12.4%)	8,981 (4.8%)	20,661 (11.1%)	85,955 (46.2%)	9,499 (5.1%)	1,129 (0.6%)	6,914 (3.7%)	16,154 (8.7%)	8,586 (4.6%)	186,059

† Indiana bats were included in the Kaleidoscope identification model for SLBE only.

Results of Qualitative Analysis

Species identifications resulting from qualitative analysis are summarized in Table 4. Number of bat calls identified at fixed and roaming stations by season for all Parks and survey stations are summarized in Table 5. Based on the acoustic data collected in 2015, big brown, eastern red, hoary, silver-haired, little brown, and northern long-eared bat were determined to be present at all four Parks (Table 4). All six species were detected at both fixed and roaming stations except for the northern long-eared bat, which was not detected at fixed stations at SLBE (Tables 5 and 6). Tricolored bats were only identified at APIS (Tables 4-6). The Indiana bat has the potential to occur at SLBE, but has never been captured or documented at the Park. We did identify 171 calls as *potential* Indiana bats at SLBE. While the characteristics of these calls do match Indiana bats, given the location of the project outside the known range of the species and the negative results of previous bat surveys, the most likely interpretation of these call files is that they are actually little brown bat calls. There were 4,293 little brown bat calls identified at SLBE. Given the number of little brown bat calls identified and assuming a very conservative false positive rate of five percent then approximately 215 little brown bat calls are expected to be misidentified as Indiana bats.

Table 4. Bat call identifications resulting from qualitative call analysis by Park. HIFQ and LOFQ represent calls that could not be reliably assigned to a species. See Appendix 1 for species code descriptions.

Species	APIS	ISRO	SLBE	VOYA	Total
EPFU	2,336 (1.9%)	37 (0.4%)	1,335 (4.7%)	617 (2.2%)	4,325 (2.3%)
LABO	22,141 (17.9%)	697 (6.8%)	5,324 (18.7%)	1,570 (5.6%)	29,732 (15.6%)
LACI	3,571 (2.9%)	102 (1.0%)	750 (2.6%)	349 (1.2%)	4,772 (2.5%)
LANO	13,616 (11.0%)	329 (3.2%)	1,656 (5.8%)	1,586 (5.7%)	17,187 (9.0%)
MYLU	54,699 (44.2%)	2,853 (27.7%)	4,293 (15.1%)	15,660 (55.8%)	77,505 (40.7%)
MYSE	142 (0.1%)	74 (0.7%)	17 (0.1%)	48 (0.2%)	281 (0.1%)
pMYSO [†]	----	----	171 (0.6%)	----	171 (0.1%)
PESU	89 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	89 (< 0.1%)
LOFQ	2,668 (2.2%)	143 (1.4%)	1,236 (4.3%)	891 (3.2%)	4,938 (2.6%)
HIFQ	14,263 (11.5%)	2,467 (23.9%)	3,953 (13.9%)	4,389 (15.6%)	25,072 (13.2%)
NoID	6,426 (5.2%)	1,140 (11.1%)	0 (0.0%)	0 (0.0%)	7,566 (4.0%)
Noise	3,924 (3.2%)	2,473 (24.0%)	9,679 (34.1%)	2,942 (10.5%)	19,018 (10.0%)
Total	123,875	10,315	28,414	28,052	190,656

[†] pMYSO = potential Indiana bat call

Table 5. Summary of number of bat calls identified by qualitative review by Park and season. Park abbreviations are provided in Appendix 1. Summer included data collected June 1 to July 31. Fall included data collected August 1 to October 15.

Park/Station	Bat Calls			Percentage		Park Activity
	Summer	Fall	Total	Summer	Fall	
APIS	77,575	35,950	113,525	68.3%	31.7%	100.0%
Fixed						
MD01 (6m)	16,307	11,266	27,573	59.1%	40.9%	24.3%
MD02 (2m)	1,124	12,070	13,194	8.5%	91.5%	11.6%
Roaming						
BA01	0	1,641	1,641	0.0%	100.0%	1.4%
BE01	13,226	0	13,226	100.0%	0.0%	11.7%
CA01	124	0	124	100.0%	0.0%	0.1%
DE01	0	0	0	0.0%	0.0%	0.0%
DE02	0	0	0	0.0%	0.0%	0.0%
EA01	0	1,491	1,491	0.0%	100.0%	1.3%
HE01	0	96	96	0.0%	100.0%	0.1%
IR01	1,094	0	1,094	100.0%	0.0%	1.0%
LO01	0	1,496	1,496	0.0%	100.0%	1.3%
MA01	3,206	0	3,206	100.0%	0.0%	2.8%
MI01	19,531	0	19,531	100.0%	0.0%	17.2%
NO01	0	1,177	1,177	0.0%	100.0%	1.0%
OA01	3,380	0	3,380	100.0%	0.0%	3.0%
OT01	559	0	559	100.0%	0.0%	0.5%
OU01	265	0	265	100.0%	0.0%	0.2%
OU02	486	3,923	4,409	11.0%	89.0%	3.9%
RA01	4,983	0	4,983	100.0%	0.0%	4.4%
RO01	2,917	0	2,917	100.0%	0.0%	2.6%
SA01	0	1,166	1,166	0.0%	100.0%	1.0%
SO01	7,501	0	7,501	100.0%	0.0%	6.6%
ST01	2,872	0	2,872	100.0%	0.0%	2.5%
YO01	0	1,624	1,624	0.0%	100.0%	1.4%
ISRO						
ISRO	2,978	3,724	6,702	44.4%	55.6%	100.0%
Fixed						
DFP1 (10m)	1	0	1	100.0%	0.0%	0.0%
FS1	631	1,456	2,087	30.2%	69.8%	31.1%
FS2	291	786	1,077	27.0%	73.0%	16.1%
Roaming						
BAT517	0	234	234	0.0%	100.0%	3.5%

Park/Station	Bat Calls			Percentage		Park Activity
	Summer	Fall	Total	Summer	Fall	
BAT605	0	168	168	0.0%	100.0%	2.5%
BAT85	0	772	772	0.0%	100.0%	11.5%
DAVI1	0	308	308	0.0%	100.0%	4.6%
MPL1	279	0	279	100.0%	0.0%	4.2%
MSF1	1,389	0	1,389	100.0%	0.0%	20.7%
PIBH1	387	0	387	100.0%	0.0%	5.8%

SLBE	12,500	6,235	18,735	66.7%	33.3%	100.0%
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Fixed

GTFS (10m)	104	715	819	12.7%	87.3%	4.4%
PVFS (2m)	470	593	1,063	44.2%	55.8%	5.7%

Roaming

AROC	262	48	310	84.5%	15.5%	1.7%
BLKT	1,657	0	1,657	100.0%	0.0%	8.8%
BSCR	1,202	1,680	2,882	41.7%	58.3%	15.4%
CDRS	0	72	72	0.0%	100.0%	0.4%
DELA	178	0	178	100.0%	0.0%	1.0%
DHDG	1,313	0	1,313	100.0%	0.0%	7.0%
DRWR	2,557	0	2,557	100.0%	0.0%	13.6%
FMLP	0	0	0	0.0%	0.0%	0.0%
GURA	1,091	0	1,091	100.0%	0.0%	5.8%
KTSH	0	0	0	0.0%	0.0%	0.0%
LKMN	0	445	445	0.0%	100.0%	2.4%
PSFL	0	29	29	0.0%	100.0%	0.2%
SHCR	2,578	1,727	4,305	59.9%	40.1%	23.0%
SHRL	0	926	926	0.0%	100.0%	4.9%
TRFM	1,088	0	1,088	100.0%	0.0%	5.8%
WLCR	0	0	0	0.0%	0.0%	0.0%

VOYA	20,059	5,051	25,110	79.9%	20.1%	100.0%
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Fixed

FS02	1,266	1,533	2,799	45.2%	54.8%	11.1%
FS30	670	694	1,364	49.1%	50.9%	5.4%

Roaming

15-237	0	588	588	0.0%	100.0%	2.3%
15-243	4,984	94	5,078	98.1%	1.9%	20.2%
15-269	9,419	209	9,628	97.8%	2.2%	38.3%
15-295	0	887	887	0.0%	100.0%	3.5%

Park/Station	Bat Calls			Percentage		Park Activity
	Summer	Fall	Total	Summer	Fall	
15-347	634	0	634	100.0%	0.0%	2.5%
15-416	3,086	0	3,086	100.0%	0.0%	12.3%
15-452	0	120	120	0.0%	100.0%	0.5%
15-455	0	594	594	0.0%	100.0%	2.4%
15-472	0	322	322	0.0%	100.0%	1.3%
15-482	0	10	10	0.0%	100.0%	0.0%

Table 6. Summary of bat call species identifications resulting from qualitative review by Park and station. Park abbreviations are provided in Appendix 1. Numbers in parentheses indicate the percentage of identified bat calls attributed to that species or group. Files identified as Noise and NoID are not included in the table.

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO†	PESU	LOFQ	HIFQ	Total
APIS	2,336 (2.1%)	22,141 (19.5%)	3,571 (3.1%)	13,616 (12.0%)	54,699 (48.2%)	142 (0.1%)	----	89 (0.1%)	2,668 (2.4%)	14,263 (12.6%)	113,525
Fixed	872	11,497	2,998	11,374	8,870	71	----	46	1,916	3,123	40,767
MD01	278	7,658	2,409	7,932	6,292	3	----	7	825	2,169	27,573
MD02	594	3,839	589	3,442	2,578	68	----	39	1,091	954	13,194
Roaming	1,464	10,644	573	2,242	45,829	71	----	43	752	11,140	72,758
BA01	22	100	4	59	1,114	2	----	22	15	303	1,641
BE01	79	3,393	7	87	9,227	6	----	9	72	346	13,226
CA01	0	48	2	1	65	0	----	0	0	8	124
DE01	0	0	0	0	0	0	----	0	0	0	0
DE02	0	0	0	0	0	0	----	0	0	0	0
EA01	13	62	0	66	186	0	----	1	4	1,159	1,491
HE01	0	8	0	3	1	2	----	2	0	80	96
IR01	4	266	20	64	524	1	----	0	50	165	1,094
LO01	8	130	0	53	337	0	----	1	9	958	1,496
MA01	104	320	11	49	1,946	4	----	1	12	759	3,206
MI01	38	314	190	257	17,777	2	----	0	137	816	19,531
NO01	7	115	1	62	485	33	----	0	1	473	1,177
OA01	133	352	12	258	630	7	----	0	86	1,902	3,380
OT01	22	1	7	66	35	0	----	0	41	387	559
OU01	0	17	1	3	193	0	----	0	1	50	265
OU02	17	2,169	25	144	1,220	1	----	0	23	810	4,409
RA01	9	479	175	131	3,593	0	----	0	83	513	4,983
RO01	361	501	48	419	540	0	----	0	102	946	2,917

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO†	PESU	LOFQ	HIFQ	Total
SA01	5	734	15	96	67	0	----	5	30	214	1,166
SO01	104	1,346	29	34	5,687	1	----	0	18	282	7,501
ST01	525	144	15	280	1,788	8	----	0	30	82	2,872
YO01	13	145	11	110	414	4	----	2	38	887	1,624
ISRO	37 (0.6%)	697 (10.4%)	102 (1.5%)	329 (4.9%)	2,853 (42.6%)	74 (1.1%)	----	0 (0.0%)	143 (2.1%)	2,467 (36.8%)	6,702
Fixed	18	364	76	230	933	69	----	0	99	1,376	3,165
DFP1	0	0	0	0	0	0	----	0	0	1	1
FS1	12	310	69	172	429	13	----	0	90	992	2,087
FS2	6	54	7	58	504	56	----	0	9	383	1,077
Roaming	19	333	26	99	1,920	5	----	0	44	1,091	3,537
BAT517	1	51	6	9	71	1	----	0	8	87	234
BAT605	2	21	9	20	61	0	----	0	9	46	168
BAT85	9	129	8	26	331	2	----	0	16	251	772
DAVI1	1	30	2	9	84	2	----	0	4	176	308
MPL1	4	21	0	17	124	0	----	0	4	109	279
MSF1	1	57	1	18	1,156	0	----	0	2	154	1,389
PIBH1	1	24	0	0	93	0	----	0	1	268	387
SLBE	1,335 (7.1%)	5,324 (28.4%)	750 (4.0%)	1,656 (8.8%)	4,293 (22.9%)	17 (0.1%)	171 (0.9%)	0 (0.0%)	1,236 (6.6%)	3,953 (21.1%)	18,735
Fixed	111	643	2	46	249	0	17	0	54	760	1,882
GTFS	18	149	2	14	35	0	9	0	37	555	819
PVFS	93	494	0	32	214	0	8	0	17	205	1,063
Roaming	1,224	4,681	748	1,610	4,044	17	154	0	1,182	3,193	16,853
AROC	77	8	14	24	6	1	0	0	15	165	310

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO†	PESU	LOFQ	HIFQ	Total
BLKT	163	639	309	358	2	0	0	0	111	75	1,657
BSCR	98	1,419	8	18	186	0	35	0	15	1,103	2,882
CDRS	0	11	0	0	31	0	2	0	2	26	72
DELA	15	16	17	60	11	3	14	0	28	14	178
DHDG	304	470	20	136	98	0	3	0	31	251	1,313
DRWR	163	1,646	3	15	328	0	15	0	12	375	2,557
FMLP	0	0	0	0	0	0	0	0	0	0	0
GURA	199	27	74	584	26	0	0	0	159	22	1,091
KTSH	0	0	0	0	0	0	0	0	0	0	0
LKMN	17	28	67	152	2	1	3	0	130	45	445
PSFL	1	2	0	2	0	0	0	0	12	12	29
SHCR	50	133	206	107	2,864	0	64	0	124	757	4,305
SHRL	72	95	26	103	35	0	7	0	513	75	926
TRFM	65	187	4	51	455	12	11	0	30	273	1,088
WLCR	0	0	0	0	0	0	0	0	0	0	0
VOYA	617 (2.5%)	1,570 (6.3%)	349 (1.4%)	1,586 (6.3%)	15,660 (62.4%)	48 (0.2%)	----	0 (0.0%)	891 (3.5%)	4,389 (17.5%)	25,110
Fixed	218	372	66	594	1,490	18	----	0	301	1,104	4,163
FS02	97	225	41	385	881	18	----	0	260	892	2,799
FS30	121	147	25	209	609	0	----	0	41	212	1,364
Roaming	399	1,198	283	992	14,170	30	----	0	590	3,285	20,947
15-237	13	26	4	29	164	7	----	0	32	313	588
15-243	232	292	67	397	3,658	2	----	0	188	242	5,078
15-269	70	667	139	304	7,005	6	----	0	276	1,161	9,628
15-295	7	41	12	82	207	0	----	0	3	535	887
15-347	3	56	19	18	203	0	----	0	19	316	634
15-416	65	58	24	23	2,520	13	----	0	31	352	3,086

Park/ Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO†	PESU	LOFQ	HIFQ	Total
15-452	3	0	4	10	6	0	----	0	13	84	120
15-455	1	39	12	79	244	0	----	0	14	205	594
15-472	5	19	2	50	161	0	----	0	14	71	322
15-482	0	0	0	0	2	2	----	0	0	6	10
All Parks Total	4,325 (2.6%)	29,732 (18.1%)	4,772 (2.9%)	17,187 (10.5%)	77,505 (47.2%)	281 (0.2%)	171 (0.1%)	89 (0.1%)	4,938 (3.0%)	25,072 (15.3%)	164,072

† pMYSO = potential Indiana bat call

While most species were detected at all station types (Table 7), not all species were detected at every station (Table 8). On average across Parks, the little brown bat (MYLU) was detected at the highest percentage of stations (89.1%), followed by eastern red bat (LABO; 87.5%), silver-haired bat (LANO; 85.9%), big brown bat (EPFU; 82.8%), hoary bat (LACI; 76.6%) and northern long-eared bat (MYSE; 45.3%). Potential Indiana bat calls (MYSO) were detected at 61.1% of the stations at SLBE, and tri-colored bats (PESU) were detected at 41.7% of the stations at APIS (Table 8). Neither of these species was detected at the other Parks.

Species detections on a given night varied by Park and species. On average across Parks, the little brown bat (MYLU) was detected on the highest percentage of survey nights (95.8%), followed by eastern red-bat (LABO; 89.9%), and silver-haired bat (LANO; 83.8%) (Table 9). The northern long-eared bat (MYSE) was detected on 35.1% of survey nights across all Parks (Table 9). The tri-colored bat (PESU) was detected on 18.0% of survey nights at APIS and potential Indiana bat calls were detected on 61.3% of survey nights at SLBE (Table 9).

Table 7. Acoustic detections by species across Parks and Station types. Species codes are presented in Appendix 1.

Park/Station	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO[†]	PESU
APIS								
Fixed	Yes	Yes	Yes	Yes	Yes	Yes	----	Yes
Roaming	Yes	Yes	Yes	Yes	Yes	Yes	----	Yes
ISRO								
Fixed	Yes	Yes	Yes	Yes	Yes	Yes	----	No
Roaming	Yes	Yes	Yes	Yes	Yes	Yes	----	No
SLBE								
Fixed	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Roaming	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
VOYA								
Fixed	Yes	Yes	Yes	Yes	Yes	Yes	----	No
Roaming	Yes	Yes	Yes	Yes	Yes	Yes	----	No

[†] pMYSO = potential Indiana bat calls

Table 8. Number and percentage of survey stations where species were detected acoustically.

	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO [†]	PESU
APIS (n = 24)	19 (79.2%)	22 (91.7%)	19 (79.2%)	22 (91.7%)	22 (91.7%)	14 (58.3%)	----	10 (41.7%)
ISRO (n = 10)	9 (90.0%)	9 (90.0%)	7 (70.0%)	8 (80.0%)	9 (90.0%)	5 (50.0%)	----	0 (0.0%)
SLBE (n = 18)	14 (77.8%)	15 (83.3%)	12 (66.7%)	14 (77.8%)	14 (77.8%)	4 (22.2%)	11 (61.1%)	0 (0.0%)
VOYA (n = 12)	11 (91.7%)	10 (83.3%)	11 (91.7%)	11 (91.7%)	12 (100.0%)	6 (50.0%)	----	0 (0.0%)
Average	82.8%	87.5%	76.6%	85.9%	89.1%	45.3%	17.2%	15.6%

[†] pMYSO = potential Indiana bat call

Table 9. Number and percentage of survey nights with species detected acoustically.

	EPFU	LABO	LACI	LANO	MYLU	MYSE	pMYSO [†]	PESU
APIS (n = 128)	97 (75.8%)	121 (94.5%)	88 (68.8%)	114 (89.1%)	126 (98.4%)	56 (43.8%)	----	23 (18.0%)
ISRO (n = 39)	14 (35.9%)	36 (92.3%)	23 (59.0%)	33 (84.6%)	39 (100.0%)	18 (46.2%)	----	0 (0.0%)
SLBE (n = 75)	53 (70.7%)	66 (88.0%)	42 (56.0%)	56 (74.7%)	68 (90.7%)	8 (10.7%) (61.3%)	46 (61.3%)	0 (0.0%)
VOYA (n = 66)	40 (60.6%)	54 (81.8%)	42 (63.6%)	55 (83.3%)	62 (93.9%)	26 (39.4%)	----	0 (0.0%)
Total	204	277	195	258	295	108	46	23
Average	66.2%	89.9%	63.3%	83.8%	95.8%	35.1%	14.9%	7.5%

[†] pMYSO = potential Indiana bat call

Based on percent of stations and survey nights detected, most species appear to be relatively common and widespread at the four Parks, with the exception of the northern long-eared bat, Indiana bat, and tri-colored bat. Northern long-eared bats appeared to be most widespread at APIS, being detected at 58.3% of stations (Table 8), but were detected most frequently at ISRO, on 46.2% of nights (Table 9). This species appeared to be least common at SLBE, being detected at only four stations (22.2%) and only eight nights (10.7%) (Tables 8 and 9). Potential Indiana bat calls were identified at 11 of 18 stations (61.1%) and on 46 survey nights (61.3%) at SLBE. Although, these calls appear to be common within the Park, they may be false positives, and reflect the commonness of little brown bats, rather than Indiana bats, at the Park. Tri-colored bat calls were only identified at APIS, detected at 41.7% of stations and on 18.0% of survey nights. Relative percentage of bat calls identified at each Park is shown in Figure 1.

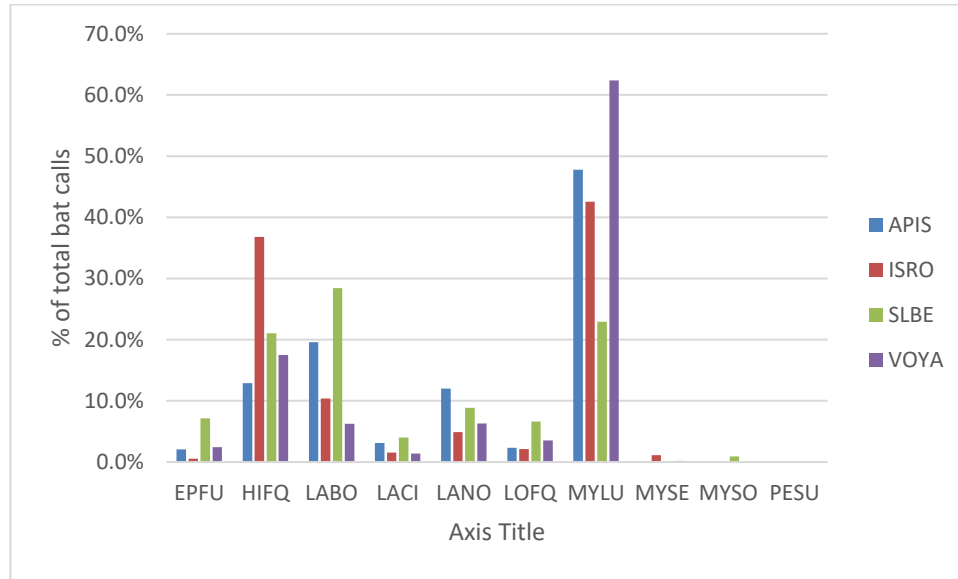


Figure 1. Relative number of bat call files per species or group by Park.

Temporal Patterns of Bat Activity for All Parks

Collated across Parks and seasons, bat activity (percent of call files) within a night increased until 2100 hours and then remained relatively constant until 0400 hours, with 10-12% of all call files recorded each hour (Figure 2). Activity then decreased in the hours approaching dawn. This pattern is consistent with nightly bat activity observed elsewhere (Hayes 1997). Considering all Parks together, nightly bat activity was variable across the study period (Figure 3) with a general trend of peak activity occurring in late July, a pattern that is congruous with patterns of bat activity measured elsewhere in the Midwest (Redell et al. 2006) and across North America (Johnson, et al. 2011). Within Parks, the timing of peak activity varies (Figure 4), but is generally consistent with the more regional pattern. An investigation of the temporal pattern of bat activity recorded at eight fixed stations (i.e., recording stations that remained in the same location during the study period) at four Parks (Figure 5) suggests that the overall temporal variability observed likely reflects typical night-to-night variability at a given location, as has been noted elsewhere (Hayes 1997).

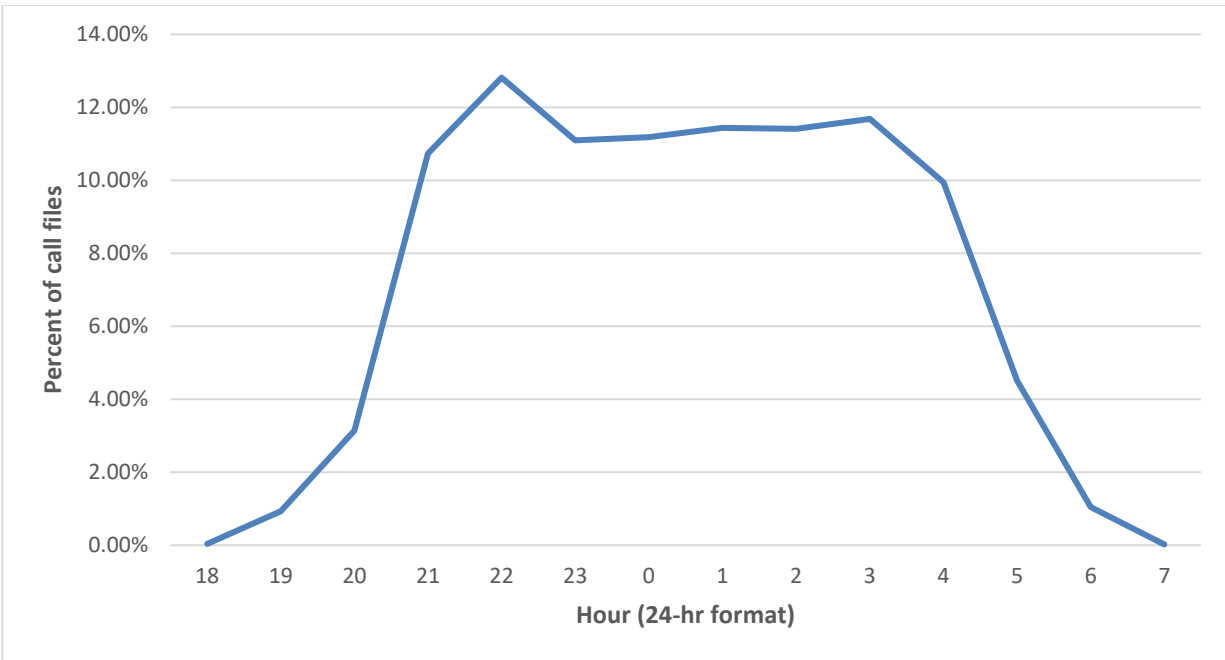


Figure 2. Hourly pattern of bat activity recorded across all Parks.

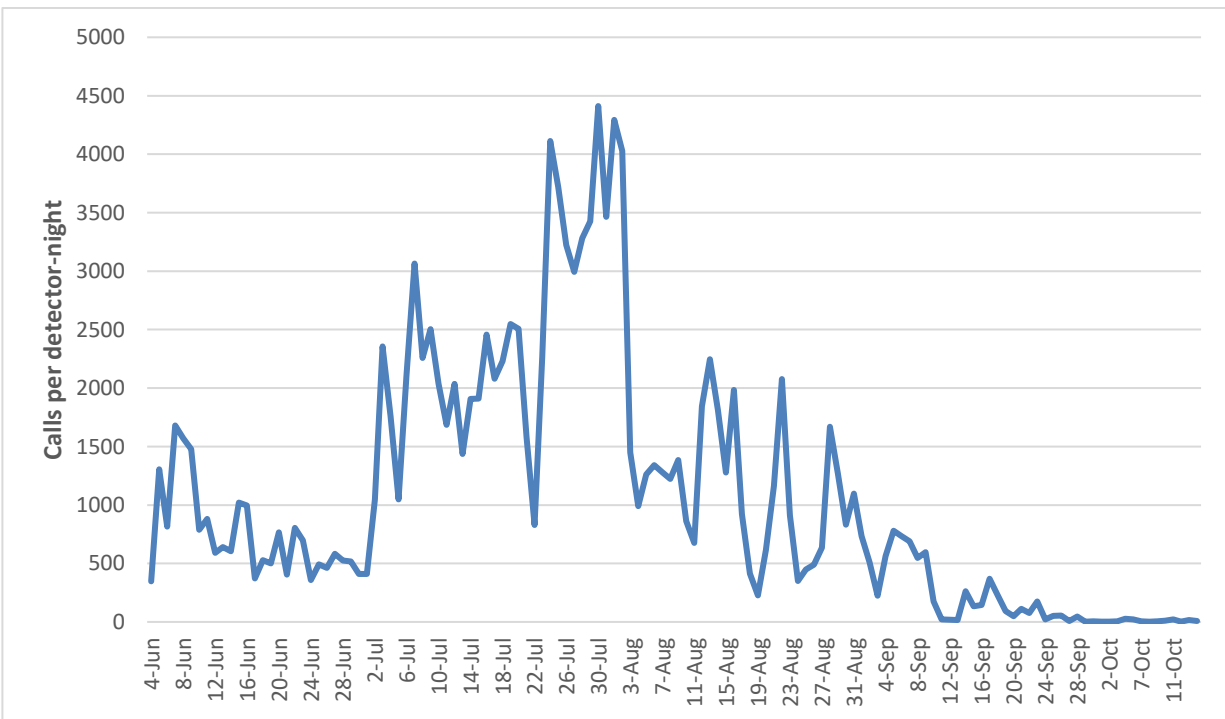


Figure 3. Nightly pattern of bat activity recorded across all Parks.

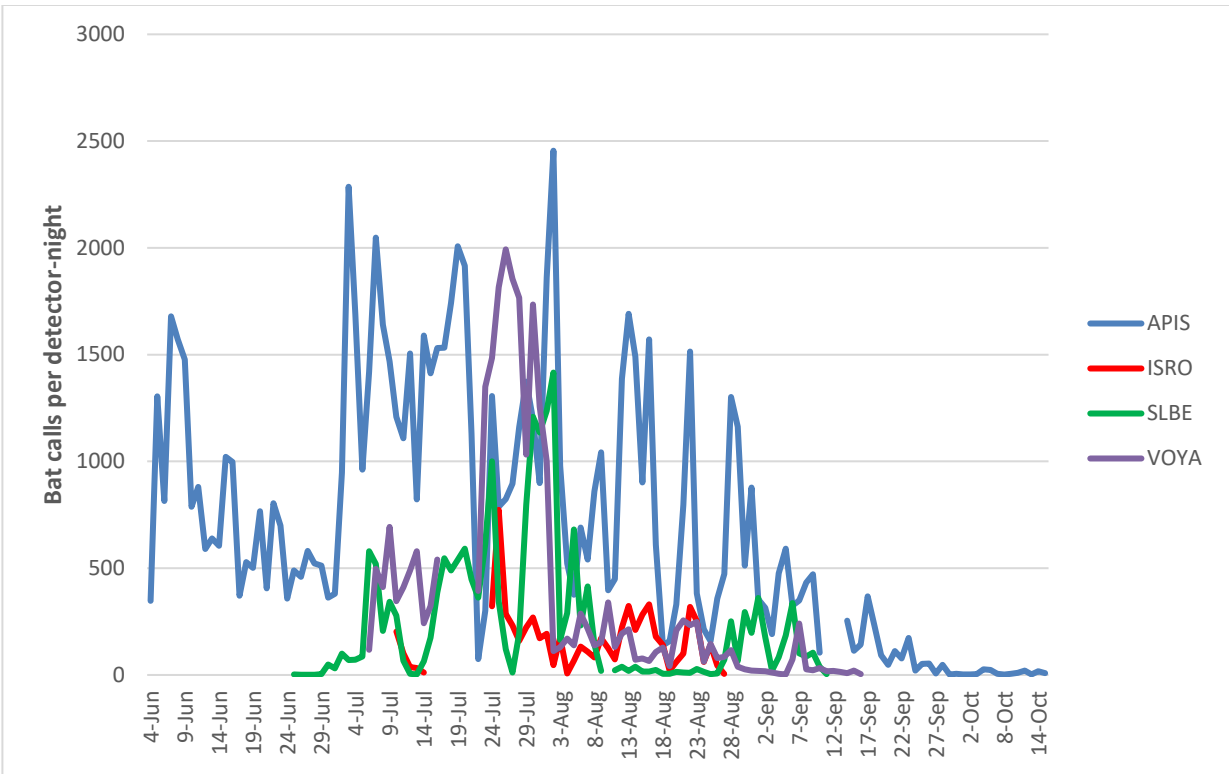


Figure 4. Nightly pattern of bat activity by Park

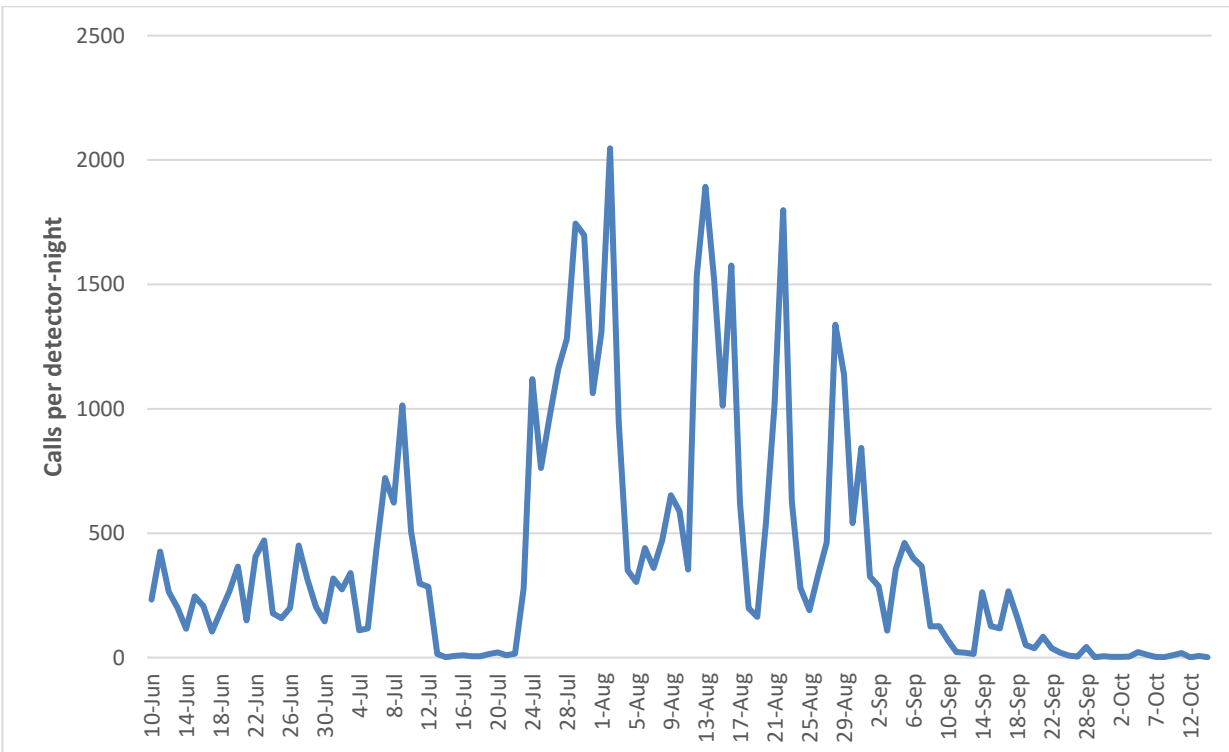


Figure 5. Nightly pattern of bat activity at fixed stations.

DISCUSSION

Species Detections and Presence

We have presented the raw acoustic data along with the percentage of nights or stations at which a species was detected, rather than focusing on only the absolute or relative number of call files attributable to a given species. This is primarily because, acoustic recordings of bats represent an index of bat activity, rather than an enumeration of bats themselves. It is not possible to determine based on passive acoustic recordings, whether 100 little brown bat calls detected at a station represents 100 little brown bats being detected once, 1 little brown bat being detected 100 times, or any combination in between. Thus, acoustic bat recordings do not allow a count of the number of individual bats present in an area at a given time. Acoustic data are better suited to provide an indication of the relative levels of bat activity in general or by species at a given time and place, and are often used to compare habitat use by species (Loeb and O'Keefe 2006) as well as to determine presence or probable absence of species (USFWS 2016).

In addition to uncertainty regarding the absolute number of bats that acoustic data represent, there is also inherent uncertainty in the ability to accurately assign echolocation calls to particular species. While the ability to reliably and accurately distinguish among bat species is desirable it remains a difficult problem for some species because bat echolocation is intrinsically plastic and can vary depending on task and context (Barclay 1999, Schnitzler and Kalko 2001). This plasticity results from individual and behavioral variability (Faure and Barclay 1994), as well as variability introduced by the presence of conspecifics (i.e., other individuals of the same species) (Obrist 1995) and by habitat differences (Arlettaz et al. 2001, Britzke et al. 2002, Broders et al. 2004, Wund 2006). The effects of all of these sources of variability on accurate species identification are exacerbated for species whose echolocation structure is inherently similar, as with many species in the genus *Myotis*. Among eastern forest-dwelling *Myotis* bats, the Indiana bat (*M. sodalis*) shows considerable overlap in range, habitat characteristics, morphology, and echolocation characteristics with two common conspecifics, the little brown (*M. lucifugus*) and northern long-eared (*M. septentrionalis*) bat. In addition, echolocation calls of the eastern red bat often closely resemble those of eastern *Myotis* bats, especially when recordings are made near acoustic clutter. One of the most common automated acoustic software classification errors is identification of eastern red bat calls as a *Myotis* species.

With these caveats in mind, based on acoustic data collected at the four Parks in 2015 there is moderate to robust evidence for the presence of all species whose ranges overlap the Parks, or whose known range limits are close to one or more Parks. For relatively common species whose ranges clearly overlap with the Parks (i.e., big brown bat, eastern red bat, hoary bat, silver-haired bat, northern long-eared bat, little brown bat), there is fairly definitive evidence for presence given the expectation (or existing knowledge) of presence, as well as the relative frequency that the species were detected. In addition to these results, we also identified calls attributable to Indiana bat at SLBE and tri-colored bat at APIS. For Indiana bats at SLBE, we determined that 171 echolocation call files were potentially produced by Indiana bats. Currently outside the delineated range of the Indiana bat, SLBE is located only about 30 miles north of a known Priority 4 Indiana bat hibernaculum (Tippy Dam) in Manistee County (Kurta 2008). The maximum estimate of hibernating Indiana bats at Tippy Dam is 20. It is certainly possible that Indiana bats may use

SLBE during the non-hibernation season. However, we caution against relying solely on acoustic data to establish presence of Indiana bats at SLBE. Prior capture surveys at the Park have failed to confirm the presence of Indiana bats and the echolocation calls of Indiana bats can be difficult to distinguish from other *Myotis* species (Murray et al. 1999, O'Farrell et al. 1999, Britzke et al. 2002, Ford et al. 2005, Yates and Muzika 2006, Britzke et al. 2011). Given the number of little brown bat calls identified at SLBE, it is most likely that the calls identified as potential Indiana bats were actually produced by little brown bats. We recommend that further capture surveys be conducted to confirm the presence or absence of this species.

We also detected calls a relatively small number of calls (n=89) attributable to the tri-colored bat at APIS, which is on the northern edge of the range for this species (Kurta 2017). The calls were recorded at ten different stations on 23 nights between June 28 and October 6, with 39 of the calls (43.8%) recorded at station MD02, a fixed station in a forest clearing above Little Sand Bay. Given the existence of suitable summer habitat at APIS and the other Parks, their proximity to the currently delineated range, and the documented range expansion for this species (Kurta 2017), future surveys should continue to look for evidence of use of the Parks by this species.

RECOMMENDATIONS

Acoustic Data Management

To make the bat acoustic survey data as useful as possible and to execute the monitoring program as efficiently as possible, we provide the following recommendations. These recommendations are interrelated and are based on the premise that collecting the highest quality data in the field will result in the most efficient use of time and resources during and after the survey season and will result in the best input data for modeling trends.

In general, having someone that is dedicated primarily to coordinating the acoustic monitoring effort each season will greatly improve the amount and quality of the data being collected. At WEST, the acoustic liaison is responsible for communicating directly with technicians about detector operation, set-up, placement in the field, etc. The liaison is also responsible for receiving, organizing, and reviewing the acoustic data as it is collected in the field. This provides a number of advantages, including the opportunity to identify and remedy errors while data collection is ongoing, which generally yields better quality data overall and less lost data. The liaison would also be on the lookout for data that should have but has not arrived and can then contact the technician and inquire about it. The liaison could ensure that standardized naming and labeling conventions (e.g., for station names and detectors) are adhered to across Parks, as well as ensure good record-keeping (such as start and end times and dates, detector serial numbers, etc.) for QAQC purposes. The liaison would do this while reviewing the incoming data to check that the quality of recoded data is sufficient.

Vetting Recommendations

In general, vetting should be restricted to only the most complete high quality call sequences. A good rule of thumb is to have a *minimum* of 5 high quality call pulses to attempt species identification, but sometimes ≥ 10 high quality call pulses in a sequence are necessary. The

reliability of species identification (both automated and human-vetted) will depend on the location of acoustic detectors. For example, detectors placed under the tree canopy of acoustically cluttered environments will record bat echolocation that may not be typical of various species. In these situations, bat echolocation tends to converge on a similar “clutter call” type of echolocation which greatly reduces the ability to distinguish between species (see Discussion above for more on this topic). Regardless, with passively collected data it is typical to have a large percentage of call files that are not suitable for species-level identification because they are short and/or fragmented and/or not typical search-phase calls. During vetting we often find that the software has identified call files to species that are not suitable for species identification. Software settings to determine what is suitable for automated identification vary by software program. To increase the threshold for Kaleidoscope to identify a call sequence, NPS should consider using the Classifier setting *+1 More Accurate (Conservative)*. Other identification software programs suitable for this work have different approaches to filtering lower quality call sequences, but those are not addressed here.

It will be very time-consuming to manually review all the acoustic data that are collected, and it may not be necessary, depending on your objectives and goals. Another idea for reducing the time and expense associated with manual vetting of a large number of call files is to focus on the period of interest. It may be more efficient to manually vet only those calls collected during the two-week peak for each season that will be used as inputs into the trend model. However, to get a sense of how species are distributed through time and space within the Parks, it may still be necessary to vet some or all of the acoustic data outside of the two-week peaks.

Detector Settings

Adjusting some of the detector settings can result in higher quality data, better QAQC, and/or longer battery life for detectors in the field. Below are some suggested settings based on our experience and/or recommendations from Wildlife Acoustics.

- Do not record in Stereo. In the SM2 settings, select the right-side port for the microphone. On the body of the SM2 device itself, mark the right-side port using a Sharpie or by affixing a label to it to let biologists know which port to plug the microphone into. WEST has learned that if Stereo is selected, extraneous files will sometimes be generated from the port without a microphone.
- Record in WAV not WAC for less battery drain and higher resolution. WAV uses more storage space, but storage limitations should not be an issue.
- Include the Settings file with each data download. This is necessary for effective QAQC and troubleshooting.

Detector Placement

It is very important to improve microphone placement so that the microphone is sampling non-cluttered habitats. Figure 6 shows examples of cluttered and open habitats at SLBE stations, and the associated calls that were recorded at these stations. The top left image shows the direction the microphone was pointing at the Aral Rd station. This is highly “cluttered” habitat, with respect

to the amount of background information that a bat has to interpret, and as a result, most of the calls recorded at this station were less than ideal for making species classifications. In situations with a high degree of acoustic clutter, bats tend to increase the minimum frequency of their calls, reduce call duration, and increase bandwidth (i.e. more vertical). Classification software (and the human eye) will struggle to correctly distinguish these types of calls from other species. In the bottom image, the microphone at the Bow Lake station was pointed out into an open field. As such, bats flying by this microphone were produced longer duration search-phase echolocation calls. Training datasets for classification programs usually consist of reference calls that were recorded in more open habitat situations, such as these, making automated classification more reliable.

Many of the stations at SLBE recorded call sequences that contained artificial sounds caused by oversampling (Figure 7). In these cases, either the bat passed too close to the microphone, or the internal gain of the detector was set too high. In either case, it is likely that these artificial bat pulses are confusing to classification software, making species classifications less reliable.

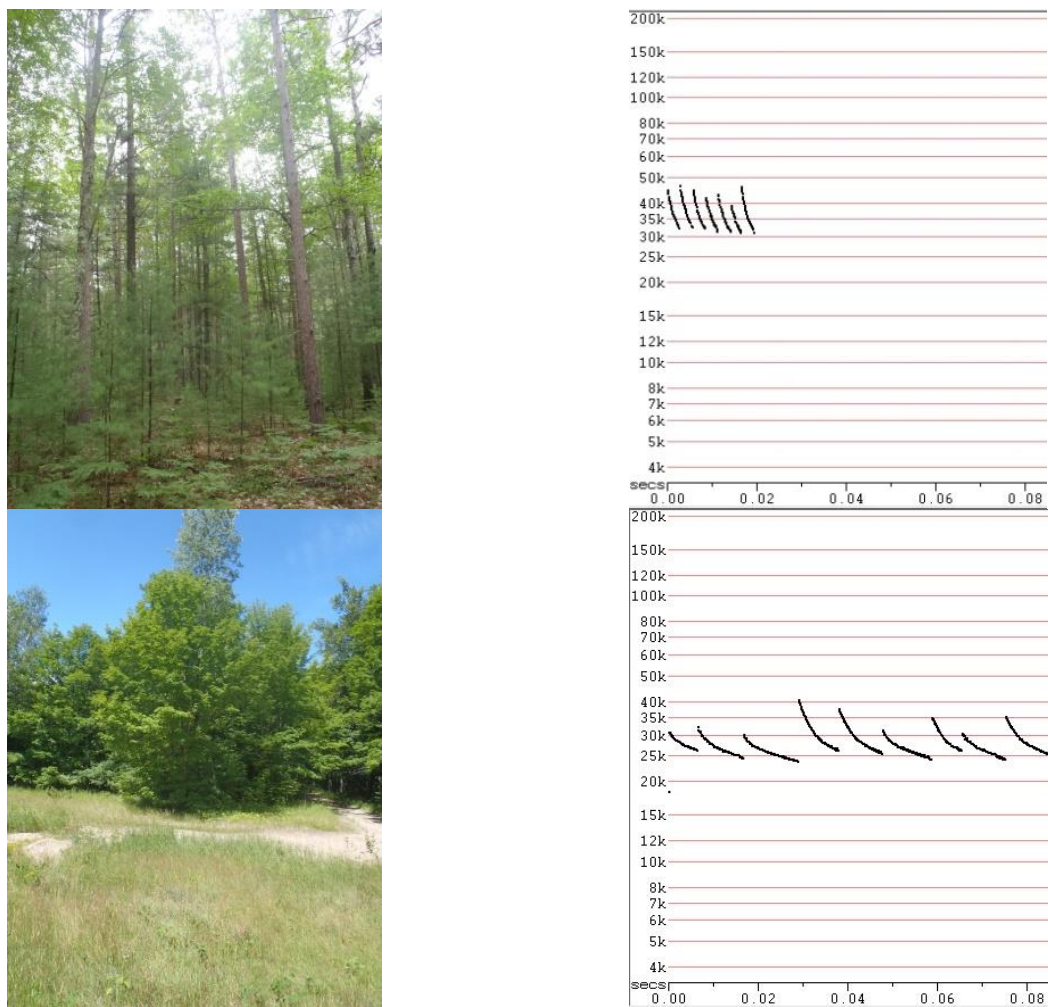


Figure 6. Microphone pointing into cluttered habitat (Aral Rd, SLBE), and call recorded in this habitat (top). Microphone pointing into open habitat (Bow Lake, SLBE) and call recorded in this habitat (bottom).

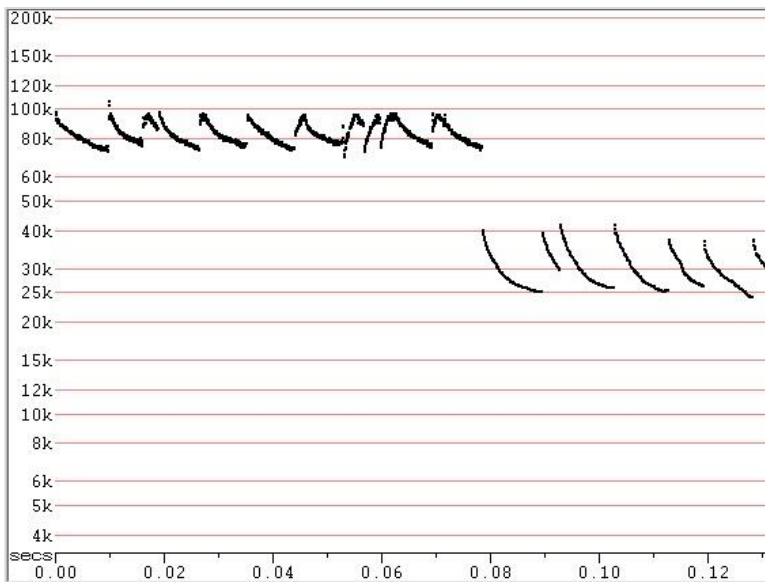


Figure 7. Example of an aliased call. The first 10 pulses in this sequence are not real. No bat species in the temperate zone produces calls like this around 80 kHz. These artificial pulses may have been caused by the bat passing too close to the microphone, or because the internal gain was set too high, but was more likely a result of the sampling rate being set too low (e.g., at 196 kHz). In any case, these artificial pulses tend to confuse automated classification software, making classifications less reliable.

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Appendix 1. Species and Station Codes

Appendix Table 1.1. Species code descriptions.

Species Code	Scientific Name	Common Name	Freq. Group
EPFU	<i>Eptesicus fuscus</i>	Big brown bat	LOFQ
LABO	<i>Lasiurus borealis</i>	Eastern red bat	HIFQ
LACI	<i>Lasiurus cinereus</i>	Hoary bat	LOFQ
LANO	<i>Lasionycteris noctivagans</i>	Silver-haired bat	LOFQ
MYLU	<i>Myotis lucifugus</i>	Little brown bat	HIFQ
MYSE	<i>M. septentrionalis</i>	Northern long-eared bat	HIFQ
MYSO	<i>M. sodalis</i>	Indiana bat	HIFQ
PESU	<i>Perimyotis subflavus</i>	Tri-colored bat	HIFQ
HIFQ	Unknown High-frequency (min. freq. of call > 30 kHz)		HIFQ
LOFQ	Unknown Low-frequency (min. freq of call < 30 kHz)		LOFQ

Appendix Table 1.2. Station information

Park	Station ID	Station Type	Location	CoorX	CoorY	Device
APIS	BA01	Roaming	Basswood Island, old quarry	46.83251	90.75577	SM3
APIS	BE01	Roaming	Bear Island, Near cabins	47.00100	90.74914	SM3
APIS	CA01	Roaming	Cat Island, lagoon	47.02552	90.56015	SM3
APIS	DE01	Roaming	Devil's Island	47.07159	90.72761	SM3
APIS	DE02	Roaming	Devil's Island, Lighthouse Station	47.07855	90.72781	SM3
APIS	EA01	Roaming	Eagle Island	46.94154	91.03711	SM3
APIS	HE01	Roaming	Hermit	47.07491	90.58712	SM3
APIS	IR01	Roaming	Ironwood Island	46.99024	90.61758	SM3
APIS	LO01	Roaming	Long Island, LaPointe Lighthouse Station	46.72867	90.78495	SM3
APIS	MA01	Roaming	Manitou Island, Fishing Camp	46.95565	90.67661	SM3
APIS	MD01	Fixed	LSB Permanent Site, Guyed tower	46.94327	90.89292	SM3
APIS	MD02	Fixed	LSB Permanent Site, Ground	46.94352	90.89215	SM3
APIS	MI01	Roaming	Michigan Island Lighthouse	46.87112	90.49686	SM3
APIS	NO01	Roaming	North Twin	47.07491	90.58712	SM3
APIS	OA01	Roaming	Oak Island, Ranger Residence	46.92996	90.75336	SM3
APIS	OT01	Roaming	Otter Island, near dock	46.98431	90.69519	SM3
APIS	OU01	Roaming	Outer Island Light Station	47.07672	90.41698	SM3
APIS	OU02	Roaming	Outer Island, pond	47.07402	90.41677	SM3
APIS	RA01	Roaming	Raspberry Island Light Station	46.97068	90.80439	SM3
APIS	RO01	Roaming	Behind Rocky Island Ranger Residence	47.03028	90.67641	SM3
APIS	SA01	Roaming	Sand Island	46.98267	90.94315	SM3
APIS	SO01	Roaming	South Twin, Near Dock and Beach	47.03312	90.65087	SM3
APIS	ST01	Roaming	Stockton Island, Presque Isle near Ranger House	46.91141	90.54991	SM3
APIS	YO01	Roaming	York Island	46.98641	90.87342	SM3
ISRO	BAT517	Roaming	W517 (BAT517)	376296	5324771	SM3

Park	Station ID	Station Type	Location	CoorX	CoorY	Device
ISRO	BAT605	Roaming	W605 (BAT605)	385385	5331092	SM3
ISRO	BAT85	Roaming	W85 (BAT85)	377886	5325799	SM3
ISRO	DAVI1	Roaming	Davidson Island	387354	5331116	SM2
ISRO	DFP1	Fixed	Daisy Farm Pond Fixed	379331	5328471	SM3
ISRO	FS1	Fixed	Daisy Farm Fixed1	379315	5328476	SM3
ISRO	FS2	Fixed	Daisy Farm Fixed2	379276	5328504	SM3
ISRO	MPL1	Roaming	Mott Power Line	385007	5329394	SM3
ISRO	MSF1	Roaming	Mott Septic Field	385009	5329355	SM3
ISRO	PIBH1	Roaming	Passage Island	399299	5342887	SM2
SLBE	GTFS	Fixed	Pierce Stocking Scenic Drive	44°51'42"	86°02'42"	SM3
SLBE	PVFS	Fixed	Pierce Stocking Scenic Drive	44°51'44"	86°02'41"	SM3
SLBE	AROC	Roaming	Aral Rd., Otter Creek	44°44'52"	86°04'03"	SM2+
SLBE	BLKT	Roaming	Bow Lake, Kettles Trail	44°50'08"	85°54'55"	SM2+
SLBE	BSCR	Roaming	Basch Road, Pyramid Point	44°57'43"	85°55'37"	SM3
SLBE	CDRS	Roaming	SMI Cedars	45°00'15"	86°08'53"	SM3
SLBE	DELA	Roaming	Deer Lake	44°43'32"	86°04'09"	SM3
SLBE	DHDG	Roaming	DH Day Group	44°53'27"	86°02'23"	SM3
SLBE	DRWR	Roaming	Darwin Rd	44°54'53"	85°56'18"	SM3
SLBE	FMLP	Roaming	SMI Farm Loop	45°01'38"	86°07'35"	SM2+
SLBE	GURA	Roaming	Gun Range	44°42'37"	86°05'54"	SM3
SLBE	KTSH	Roaming	NMI Katie Shepard	580215	4996607	SM2+
SLBE	LKMN	Roaming	NMI Lake Manitou	577193	4996534	SM3
SLBE	PSFL	Roaming	SMI School House and Flo Lake Path	45°01'03"	86°07'05"	SM3
SLBE	SHCR	Roaming	Shalda Creek_Non Random	44°56'48"	85°53'07"	SM3
SLBE	SHRL	Roaming	NMI Shoreline	579932	4999228	SM3
SLBE	TRFM	Roaming	Treat Farm	44°47'27"	86°04'05"	SM2+
SLBE	WLCR	Roaming	Wilco Road	44°48'23"	86°03'48"	SM2+
VOYA	15-237	Roaming		513180	5369761	SM3
VOYA	15-243	Roaming		494154	5368864	SM3

Park	Station ID	Station Type	Location	CoorX	CoorY	Device
VOYA	15-269	Roaming		495795	5366595	SM3
VOYA	15-295	Roaming		510545	5366681	SM3
VOYA	15-347	Roaming		505438	5364277	SM3
VOYA	15-416	Roaming		516256	5362374	SM3
VOYA	15-452	Roaming		534679	5359971	SM3
VOYA	15-455	Roaming		538022	5360168	SM3
VOYA	15-472	Roaming		537105	5357075	SM3
VOYA	15-482	Roaming		534892	5355924	SM3
VOYA	FS30	Fixed	Sullivan Bay	511653	5363589	SM3
VOYA	FS02	Fixed	Sullivan Bay	511749	5363505	SM3