



Acoustic Amphibian Monitoring, 2019 Data Summary

Apostle Islands National Lakeshore

Natural Resource Data Series NPS/GLKN/NRDS—2022/1380



ON THE COVER

Eastern American Toad, Hermit Island, 2018.

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Contents

	Page
Figures.....	v
Tables.....	vii
Appendices.....	vii
Abstract.....	ix
Introduction.....	1
Methods.....	3
2.1 Site Selection.....	3
2.2 Data Collection.....	5
2.2.1 Temperature Logs.....	5
2.2.2 Automated Recording Systems	5
2.3 Data Analysis Methods.....	6
Results.....	9
3.1 Phenology.....	9
3.2 Call Index Values (CIV).....	12
3.3 Automated Detection Rates.....	12
Discussion.....	17
Literature Cited	19

Figures

	Page
Figure 1. Monitoring site locations at Apostle Islands National Lakeshore.	4
Figure 2. Example of automated recording system (ARS) deployed in the field.	5
Figure 3. Dates of first confirmed automated detections for Eastern American Toad (ANAM), Treefrog spp. (HYSP), and Green Frog (LICL) at Apostle Islands National Lakeshore, 2019.	10
Figure 4. First detection dates of three species for all parks conducting monitoring in 2019 (parks ordered north to south).	11
Figure 5. Call Index Value (CIV) distribution for each species at each site, Apostle Islands National Lakeshore, 2019.	13
Figure 6. Estimated percent of samples with detections by species at each site at Apostle Islands National Lakeshore in 2019.	15
Figure 7. Percent of samples with detections by species across parks monitored in 2019 (parks ordered south to north).	16
Figure A1. Successful recording periods for Apostle Islands National Lakeshore, 2019.	21
Figure B1. Sampling success for Apostle Islands National Lakeshore, 2019.	23
Figure C1. Temperature logs for each APIS site in 2019.	25
Figure E1. Successful data collection periods for each site at Apostle Islands National Lakeshore, 2014–2019.	29
Figure F1. Cumulative occupancy record for each species and site at APIS, 2014–2019.	32

Tables

	Page
Table 1. Species monitored by the program and their current status at Apostle Islands National Lakeshore.	1
Table 2. Automated detection error rates for samples where manual verification identified a species in the sample.....	14
Table D1. Error counts for 30 samples per site (N=270 in 2019) for four conditions.	27
Table D2. Percent error for automated detection results from 30 samples proofed manually at each site.	28

Appendices

	Page
Appendix A. Acoustic Recorder Deployment Success.....	21
Appendix B. ARS Samples.....	23
Appendix C. Temperature Logs.....	25
Appendix D. Automated Detection Error Analysis.	27
Appendix E. Cumulative Data Collection Results.....	29
Appendix F. Cumulative Occupancy Record.	31

Abstract

Amphibians are a Vital Sign indicator for monitoring long-term ecosystem health in seven national park units that comprise the Great Lakes Network. We present here the results for 2019 amphibian monitoring at Apostle Islands National Lakeshore (APIS). Appendices contain tabular summaries for six years of cumulative results.

The National Park Service Great Lakes Inventory and Monitoring Network established 10 permanent acoustic amphibian monitoring sites at APIS in 2014. Acoustic samples are collected by placing automated recorders with omnidirectional stereo microphones at each of the 10 sample sites. Temperature loggers co-located with the recorders also collect air temperature during the sampling period.

The monitoring program detected six species of frogs and toads in 2019, with Green Frog and Spring Peeper occurring at every site sampled. Eastern American Toad was found at eight sites, Mink Frog at two sites, Gray Treefrog at six sites, and Wood Frog at four sites. An additional five species surveyed for were not detected: American Bullfrog, Boreal Chorus Frog, Cope's Gray Treefrog, Northern Leopard Frog, and Pickerel Frog. Of these latter species, only Cope's Gray Treefrog and Northern Leopard Frog are currently known to occur within the Apostle Islands National Lakeshore. Data were successfully collected from all sites in 2019 except APIS06 (due to equipment failure). Combining manual and automated surveys with large sample sizes continues to return reliable results, providing a confident record of site occupancy for most species.

We recommend continuing to deploy island equipment in the fall, programmed for a delayed start, to better sample early calling species. However, we now recommend a start date of 10 March rather than 1 April based on the temperature logs showing that the threshold of $\geq 40^{\circ}\text{F}$ was exceeded in mid-March in 2019. Loggers were programmed to start on 22 March in 2020 and on 15 March in 2021.

Introduction

The National Park Service Great Lakes Inventory and Monitoring Network (GLKN) established 10 permanent amphibian monitoring sites at Apostle Islands National Lakeshore (APIS) in 2014. Acoustic recordings are collected and analyzed to determine the species of frogs and toads calling at each location and their calling intensity. Both metrics are used to track trends in species richness and calling intensity across years.

The program monitors for all fourteen anuran species found within the western Great Lakes region. Raw data and confirmed acoustic detections are archived at the Great Lakes Network office. This annual summary report presents results for 2019. Six years of cumulative results for APIS are summarized in Appendices E and F. In automated analysis, current recognizers do not distinguish between the two treefrog species (HYCH, HYVE). Subsequently, discussion of automated detection for these species combines them as *Hyla* species (HYSP).

Eight frog and toad species are known to occur at APIS (Table 1). Two additional species are known from its surrounding region (American Bullfrog, Boreal Chorus Frog) but are currently not documented within park boundaries. There are a few unverified reports of calling American Bullfrog and Boreal Chorus Frog within the national lakeshore, but no empirical evidence (i.e., photos, recordings, specimens) has been presented, and it is not uncommon for calls from large Green Frogs or the trill calls of Spring Peepers to be misidentified as American Bullfrog or Boreal Chorus Frog, respectively.

Table 1. Species monitored by the program and their current status at Apostle Islands National Lakeshore.

Common name	Scientific name	Code	Status
Blanchard's Cricket Frog	<i>Acris blanchardi</i>	ACBL	Absent
Eastern American Toad	<i>Anaxyrus americanus americanus</i>	ANAM	Present
Fowler's Toad	<i>Anaxyrus fowleri</i>	ANFO	Absent
Cope's Gray Treefrog	<i>Hyla chrysoscelis</i>	HYCH	Present
Gray Treefrog	<i>Hyla versicolor</i>	HYVE	Present
American Bullfrog	<i>Lithobates catesbeianus</i>	LICA	Unconfirmed
Green Frog	<i>Lithobates clamitans</i>	LICL	Present
Pickereel Frog	<i>Lithobates palustris</i>	LICL	Absent
Northern Leopard Frog	<i>Lithobates pipiens</i>	LIPI	Present
Mink Frog	<i>Lithobates septentrionalis</i>	LISE	Present
Wood Frog	<i>Lithobates sylvaticus</i>	LISY	Present
Spring Peeper	<i>Pseudacris crucifer</i>	PSCR	Present
Boreal Chorus Frog	<i>Pseudacris maculata</i>	PSMA	Present
Western Chorus Frog	<i>Pseudacris triseriata</i>	PSMA	Absent

Methods

2.1 Site Selection

Candidate monitoring sites were initially selected based on a stratified random study design (Route et al. 2014). A pool of 30–40 points were selected from GIS environmental data for the park using a Generalized Random Tesselation Stratified (GRTS) process, with selections at least 1 km apart. The objective was to ensure an adequate pool of candidate wetlands for selecting 3–4 permanent monitoring sites that represent each of three wetland types: permanent, semi-permanent, and ephemeral, for a total of 10 sites. The candidate sites were unbiased and spatially balanced (spread relatively evenly across the park). Candidate sites were then visited in an iterative fashion to verify that suitable breeding habitat was present and to confirm the wetland classification type (permanent, semi-permanent, and ephemeral). We used this process to select or reject sites until 3–4 sites of each wetland type were verified (Figure 1). Park personnel were also consulted on final site selections to ensure logistical feasibility for annual visits.

Isolated, perched, ephemeral wetlands typical of the mainland are uncommon in the Apostle Islands and found mostly in island interiors. However, site selection in the islands was limited to shoreline areas accessible by boat and relatively short hikes. Amphibian species that use ephemeral wetlands also use semi-permanent wetlands, such as impounded beaver ponds, depressional bogs, and wetlands on the inland side of beaches that often have groundwater connections through porous sand and hydroperiods that vary with lake levels. Therefore, while no island-interior ephemeral wetlands were selected for monitoring, the species most closely associated with ephemeral wetlands (Boreal Chorus Frog, Spring Peeper, Wood Frog) are adequately monitored at the four semi-permanent wetland sites we selected. Occasional supplemental amphibian surveys that sampled interior wetlands and additional islands and sites have not revealed any additional anuran species that are being missed by this program (Casper 2018).

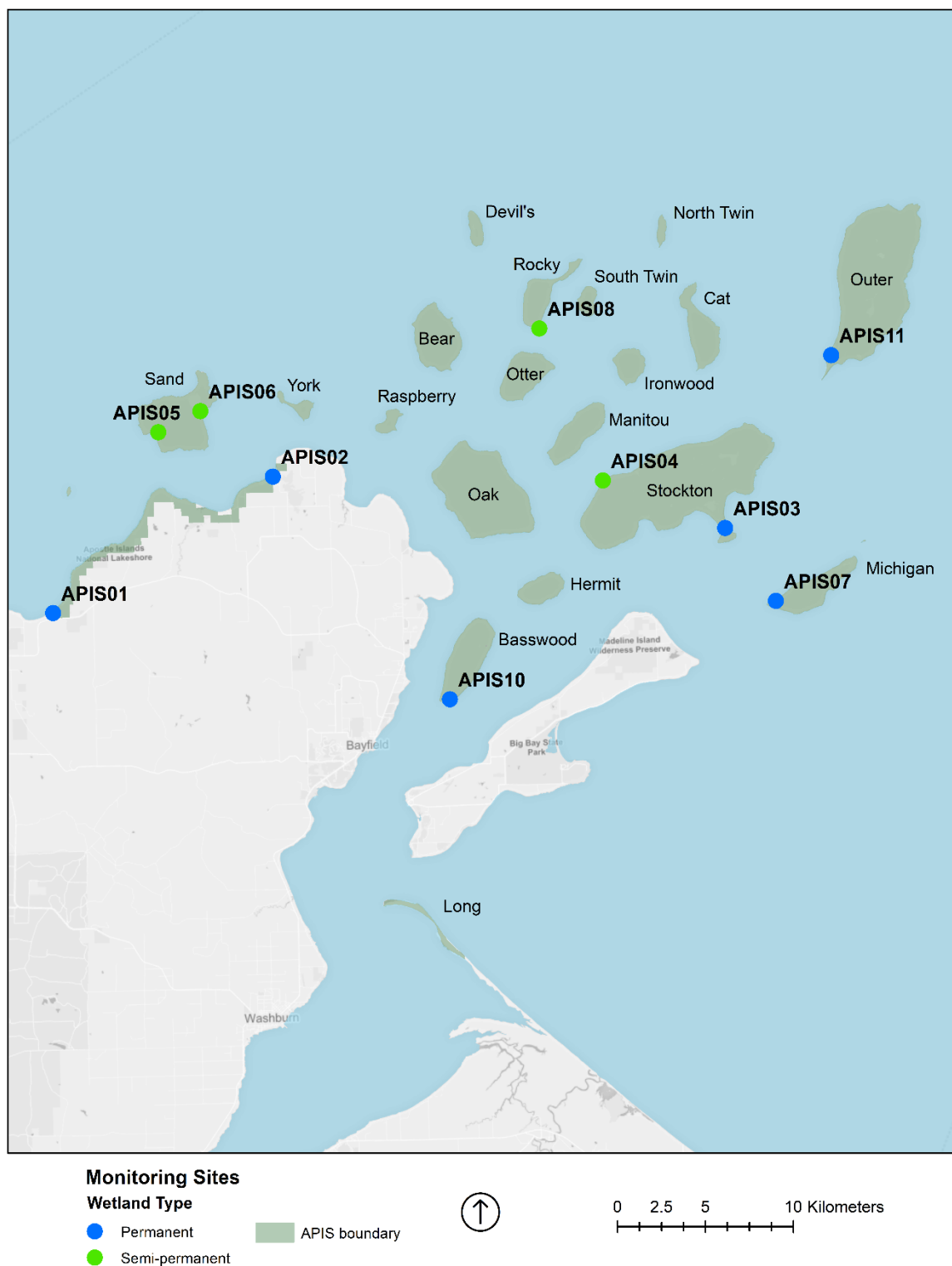


Figure 1. Monitoring site locations at Apostle Islands National Lakeshore.

2.2 Data Collection

2.2.1 Temperature Logs

Temperature logs are recorded at each site and used for filtering samples for data analyses, where only samples with an ambient air temperature of $\geq 40^{\circ}\text{F}$ are used for manual surveys. In 2019, loggers (HOBO MX2202, Onset Computer Corporation, Bourne, Massachusetts, USA) were programmed to record temperature every hour. Loggers are deployed with the Automated Recording Systems (ARS) mounted underneath the roof of the ARS mounting backboard (Figure 2). In all instances, loggers are shaded from overhead sunlight. ARS and loggers are photographed in the field each year to document placement and habitat.



Figure 2. Example of automated recording system (ARS) deployed in the field. This device is attached to a backer board with a strap around the tree. The temperature logger is attached under the roof of the backer board (*upper right*).

2.2.2 Automated Recording Systems

Automated recording systems with omnidirectional stereo microphones (Song Meter model SM4; Wildlife Acoustics, Inc., Concord, Massachusetts, USA) were co-located with temperature loggers. Beginning on 1 April 2019, one 5-minute sample (.wav file) was collected each day at the top of each hour and four extra samples were collected on the half-hour mark from 19:30 to 22:30 h. ARS are

programmed at a 16000 Hz sample rate, and in 2019 a high pass filter excluded frequencies below 220 Hz. Data are collected on SD cards.

ARS are deployed as soon as possible after ice-out, or in the previous autumn on a delayed start, for 1 April of the following year. Earlier start dates are being considered as climate change progresses. Data cards are retrieved after 31 July each year. Units often record beyond 31 July until batteries fail. Data collected after 31 July is archived but not used in our analyses.

2.3 Data Analysis Methods

Please see Casper and Nadeau (2019) for detailed analysis steps. A simplified workflow is outlined below. Digital acoustic data, scanned data forms, temperature logs, and digital photographs are archived at the network office.

In sum, the protocol steps are:

- 1) Obtain recordings and temperature logs (field component).
- 2) Filter recordings to a subset of those collected after sunset and run recordings through the automated recognition procedure (automated survey).
- 3) Proof automated output by manually confirming at least one auto-detection at each site in each year, thereby eliminating false presences for occupancy in this data set. Manual confirmation involves an experienced surveyor visually examining the place in the spectrogram where the algorithm reports a detection, then playing it back to confirm a correct species identification. Both first and last auto-detections are confirmed at each site, with proofing limited to within the calling periods determined from Appendix A. Note that false presences still persist on an individual sample level (between the first and last confirmed detections), but not on a site occupancy level (additional false presences do not matter if the site is already confirmed to be occupied). False absences for site occupancy also occur for most species (although mostly at low rates), but site occupancy can nevertheless be modeled with high confidence due to the large sample size. The next step eliminates most false absences.
- 4) Perform a manual scan of the same data and assign a Call Index Value (CIV) for each acoustic file. For this survey, 30 samples are equally distributed from the first auto-detection date for any early calling frog species at the site, through 31 July, and where air temperature is $\geq 40^{\circ}\text{F}$. An additional six morning samples are scanned for Mink Frog, selecting one sample each week from 15 June through 31 July. CIV is scored for each species detected in each sample, and annotations are made for sample quality (i.e., noise) and any CIV or identification uncertainties. These survey results are then checked by a second observer, and if concurrence is not reached re-checked by a third observer. This survey detects all species, including species with low auto-detection rates (i.e., Northern Leopard Frog). It also identifies to species pairs that are not separated by auto-detection (Cope's vs. Gray treefrogs; Western vs. Boreal Chorus frogs) and surveys for species for which no auto-detection algorithm is currently available (i.e., Mink Frog).

- 5) Report on combined results. The auto-detection analysis scores species site occupancy as 0 or 1; the manual scan analysis scores Call Index Values for each species. Results are combined in a cumulative master site occupancy table. Very few species escape detection by this dual survey approach.
- 6) Periodically model occupancy and CIV trends (ca. every five years). This analysis tracks frog occupancy trends and allows for early warnings of declines by tracking changes in Call Index Values.

Results

3.1 Phenology

Phenology tracking assesses the trends in annual first calling dates over time. Initially we are restricting analyses to three species common to all parks in the network: Eastern American Toad, Treefrog spp. (aggregating data for both treefrog species), and Green Frog. Eastern American Toad and Treefrog spp. typically begin calling in early to mid-May, and Green Frog represents a late season species with calling typically beginning in late May to early June. Three species were chosen for tracking mid-season phenology because Treefrog spp. are very rare at two network parks (Isle Royale National Park and Grand Portage National Monument). Note that auto-detections do not distinguish between the closely related Gray Treefrog and Cope's Gray Treefrog owing to the similarity of their calls. Manual scans however do attempt to distinguish between these species. For phenology purposes, we treat these as a species pair, as calling periods do not differ between species (Mossman et al. 1998, Dodd 2013).

Calling is influenced by temperature and possibly day length. Water temperature in turn is influenced by sun and wind exposure of the surface water layer occupied by frogs, and, at APIS, by proximity to or connection with the cold waters of Lake Superior. Typically, frogs are expected to call earlier from sunny wetlands away from Lake Superior and later from shaded wetlands close to or connected with Lake Superior (i.e., river mouths, lagoons).

At APIS in 2019, Eastern American Toad began calling earlier at mainland sites APIS01 and APIS02, and then calling commenced at occupied island sites fairly synchronized in time at APIS03, APIS04, APIS08 and APIS11, and somewhat later at APIS07 and APIS05 (Figure 3). Treefrog spp. (all were Gray Treefrog) initial calling was clustered in the second week of June at mainland sites (APIS01, APIS02), Presque Isle lagoon (APIS03), and at Sand Island west (APIS05). Gray Treefrog began calling in late June at APIS04 (Stockton Island NW) and APIS07 (Michigan Island lagoon). At APIS04 however Gray Treefrog was detected only as a single male calling on a single date (27 June), and therefore is interpreted as a non-breeding individual which should not be used for phenology analyses. Commencement of calling for Green Frog was biphasic, with an earlier cluster around 1 June at APIS03, APIS04, APIS05, and APIS10, and then a week later at all remaining sites.

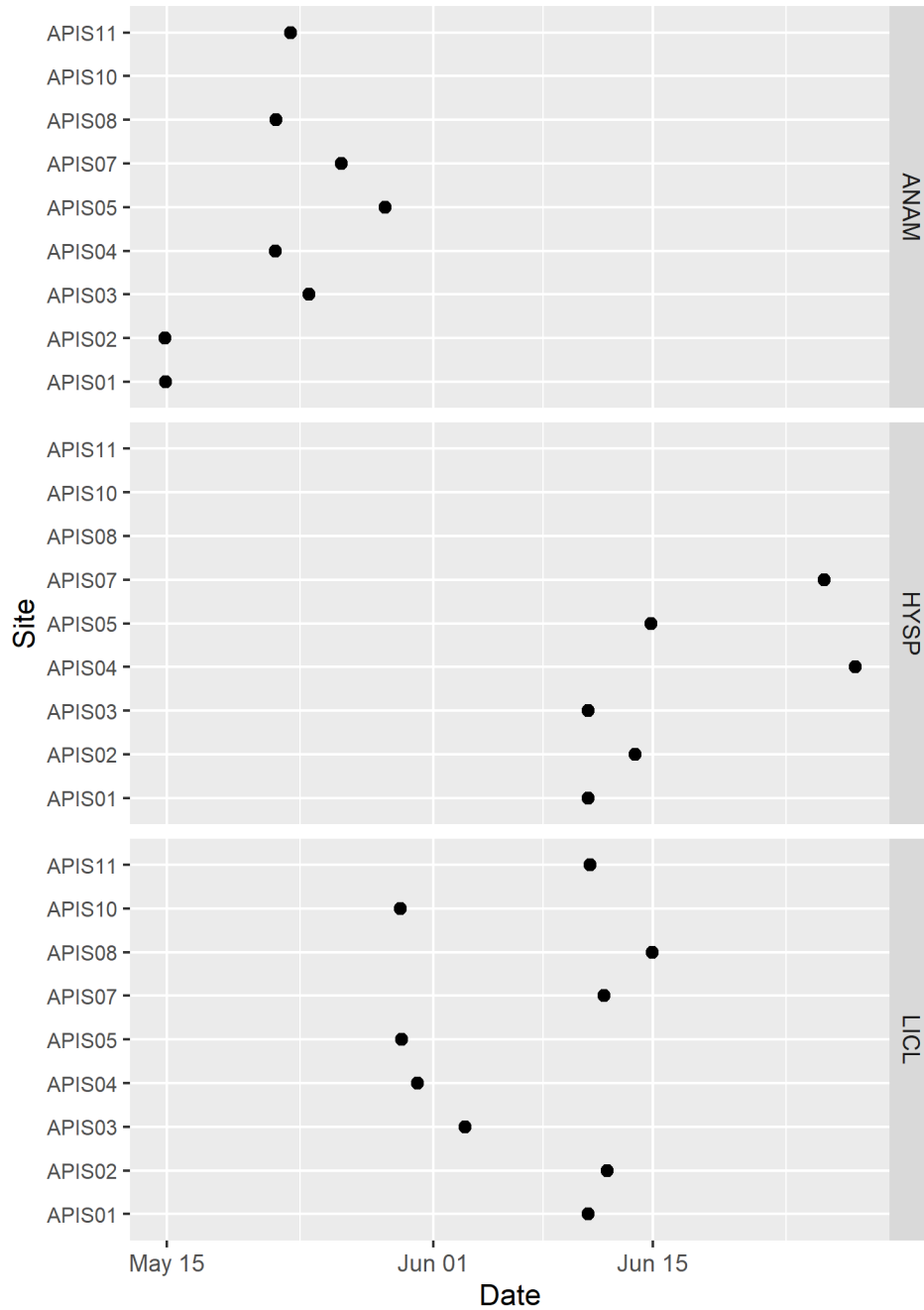


Figure 3. Dates of first confirmed automated detections for Eastern American Toad (ANAM), Treefrog spp. (HYSP), and Green Frog (LICL) at Apostle Islands National Lakeshore, 2019.

As expected from climate differences, frogs begin calling earlier at more southerly parks and later at more northern parks, with APIS start dates falling in the middle (Figure 4). Late first-calling dates typically represent lone frogs at sites where no breeding population is established.

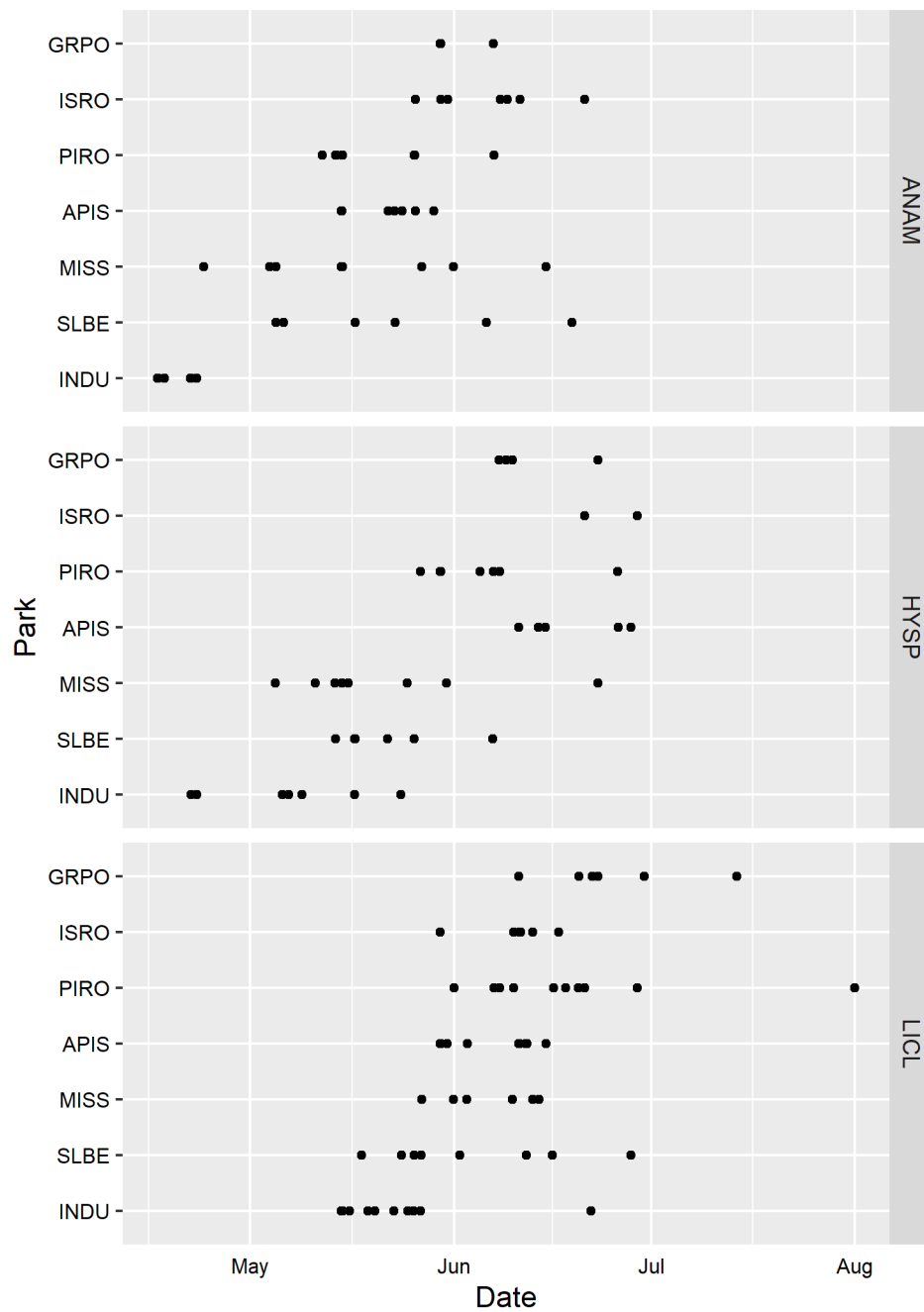


Figure 4. First detection dates of three species for all parks conducting monitoring in 2019 (parks ordered north to south). ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog. GRPO = Grand Portage, ISRO = Isle Royale, PIRO = Pictured Rocks, APIS = Apostle Islands, MISS = Mississippi National River, SLBE = Sleeping Bear Dunes, INDU = Indiana Dunes.

3.2 Call Index Values (CIV)

We also tracked calling intensity among the 36 samples manually scanned at each site as the proportion of samples falling within each of three call intensity rank values (Figure 5). CIV is scored in manual surveys, where Cope's Gray Treefrog and Gray Treefrog are identified to species and are reported on separately. For example, Eastern American Toad (ANAM) at APIS03 and APIS04 had 100% of samples scored as CIV=1 (non-overlapping calls indicating few singing males) in 2019, and the maximum CIV of 3 (calls too numerous to count individuals) was scored at the three other occupied sites. Over time, we will track whether the proportion of samples with a CIV of 3 is increasing or decreasing, which will reveal whether the number of calling males is increasing or decreasing at a site.

Several sites/species never exceeded a CIV of 1 in 2019, indicating that few males were present and calling (e.g., Eastern American Toad and Gray Treefrog at APIS03 and APIS04). Conversely, a maximum CIV of 3 indicates that large populations are present (e.g., Green Frog at APIS11 and Spring Peeper at most sites).

3.3 Automated Detection Rates

Before calculating automated detection rates for each species, we first assessed error rates in automated detection by comparing results from automated detections and manual scans on the same 300 samples (30 samples per site), where manual scan results are assumed to be correct (at least two observers agree on the determination). Note that this process evaluates filtered automated scan results rather than raw results, and at the sample occupancy level rather than the individual call level. We then calculated the proportion of the 300 samples where automated detection returned a species when there was not a species present (commission error or false presence). Automated detection results were then corrected using these species-specific commission error rates to obtain final automated detection results for each species (Error rate multiplied by number automated detections = corrected N). See Appendix D for more details regarding detection error analyses. Overall agreement rates between manual and automated detections range from 21% to 98% (Table 2). Note that agreement rates between manual and automated surveys for site occupancy are much higher (see Casper and Nadeau 2018).

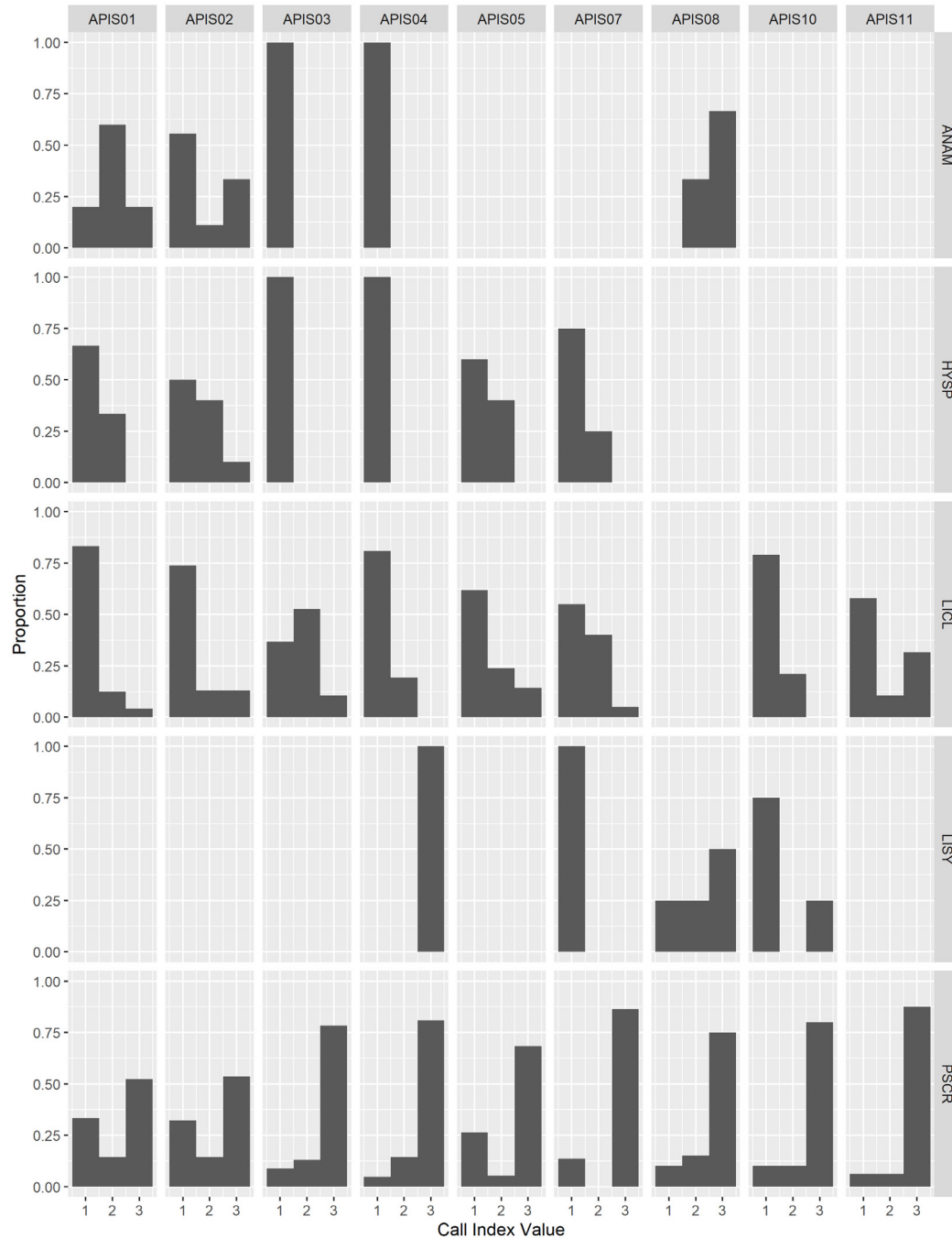


Figure 5. Call Index Value (CIV) distribution for each species at each site, Apostle Islands National Lakeshore, 2019. Only species detected on at least one site are displayed. ANAM = Eastern American Toad, HYVE = Gray Treefrog, LICL = Green Frog, LISE = Mink Frog, LISY = Wood Frog, PSCR = Spring Peeper. Call Index Values: 0 = No calls detected; 1 = Individuals of the species can be counted, there is silence between calls; 2 = Calls of individuals can be distinguished, but there is some overlapping of calls; 3 = Full chorus for the species, calls are constant, continuous, and overlapping.

Table 2. Automated detection error rates for samples where manual verification identified a species in the sample. For example, for ANAM, of the 270 nighttime samples that were manually checked, 23 had ANAM present. Of these 23 samples, the automated method identified ANAM in 12 of these, giving an overall agreement rate of 52.17%.

Species *	Number of samples with species detected manually	Number of matches on automated detection	Agreement
ANAM	23	12	52.17%
HYSP	38	10	26.63%
LICL	125	95	76.00%
LISY	14	3	21.43%
PSCR	177	174	98.31%

* ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog, LISY = Wood Frog, PSCR = Spring Peeper

Eastern American Toad (ANAM) automated detection rates were variable across sites at APIS in 2019, with fewer detections at APIS05 and APIS07 (Figure 6). This same pattern applied in 2018. Gray Treefrog (HYSP) detections were fairly consistent at approximately 20% of samples from four sites and lower rates at APIS04 and APIS07 (neither of which were occupied in 2018). Green Frog (LICL) detections were evenly distributed among all APIS sites at consistent detection rates but were absent from the semi-permanent wetland APIS08 (Rocky Island) in 2019. No Northern Leopard Frog (LIPI) or Boreal Chorus Frog (PSMA) were detected in 2019. Wood Frog (LISY) detection rates were consistent at APIS04, APIS08, and APIS10, and lower at APIS07. Spring Peeper (PSCR) detection rates were the highest for any species and constant across all sites.

Compared to other parks, 2019 detection rates at APIS were similar for Eastern American Toad (ANAM), Green Frog (LICL), Wood Frog (LISY), and Spring Peeper (PSCR); and lower for Treefrog spp. (HYSP) (Figure 7). American Bullfrog (LICA) and Boreal Chorus Frog (PSMA) remain undetected by any method, and APIS is out of range for Blanchard's Cricket Frog (ACBL), Fowler's Toad (ANFO), and Pickerel Frog (LIPA).

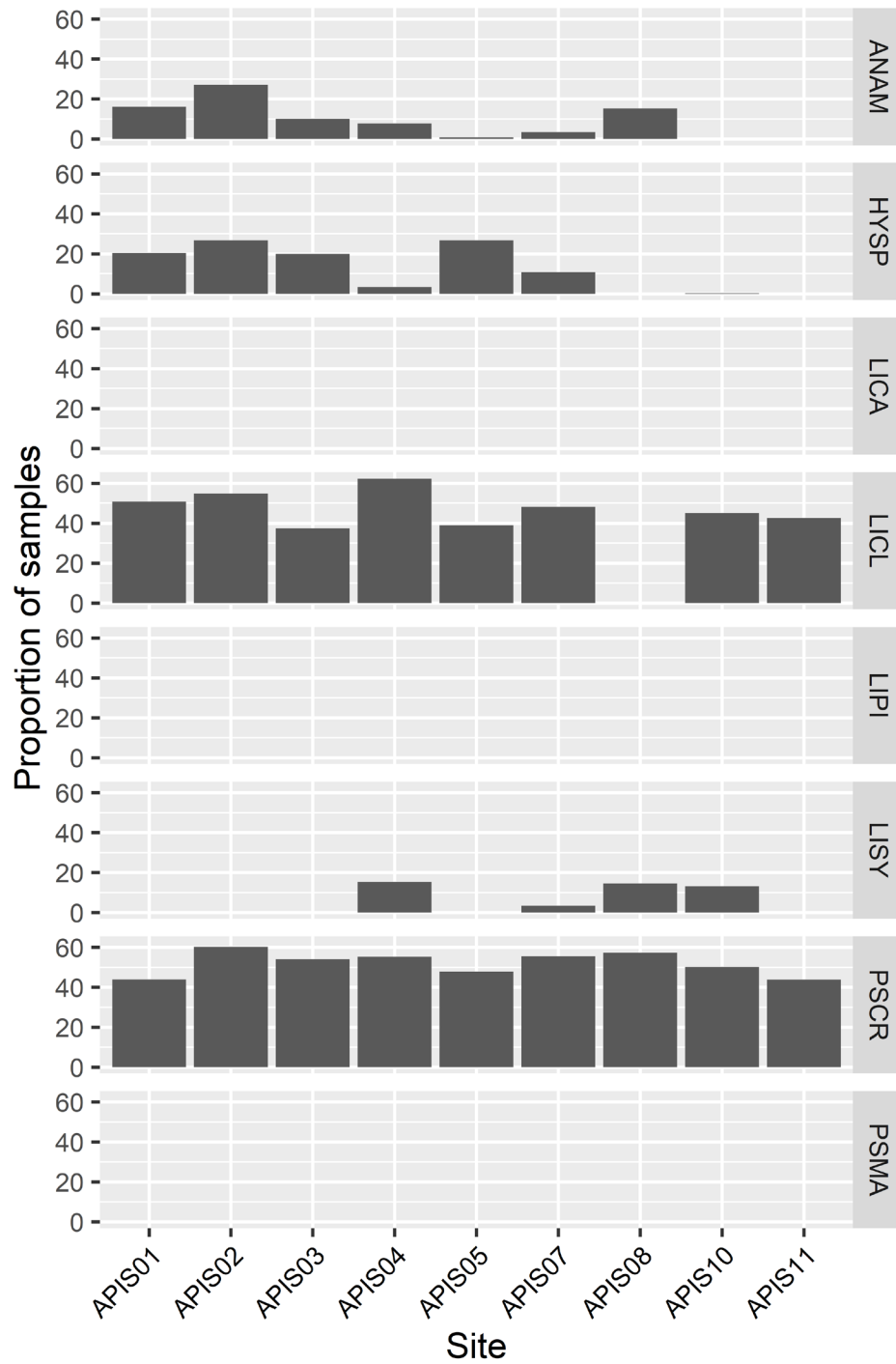


Figure 6. Estimated percent of samples with detections by species at each site at Apostle Islands National Lakeshore in 2019. From top, Eastern American Toad (ANAM), Treefrog spp. (HYSP), Green Frog (LICL), Wood Frog (LISY), and Spring Peeper (PSCR).

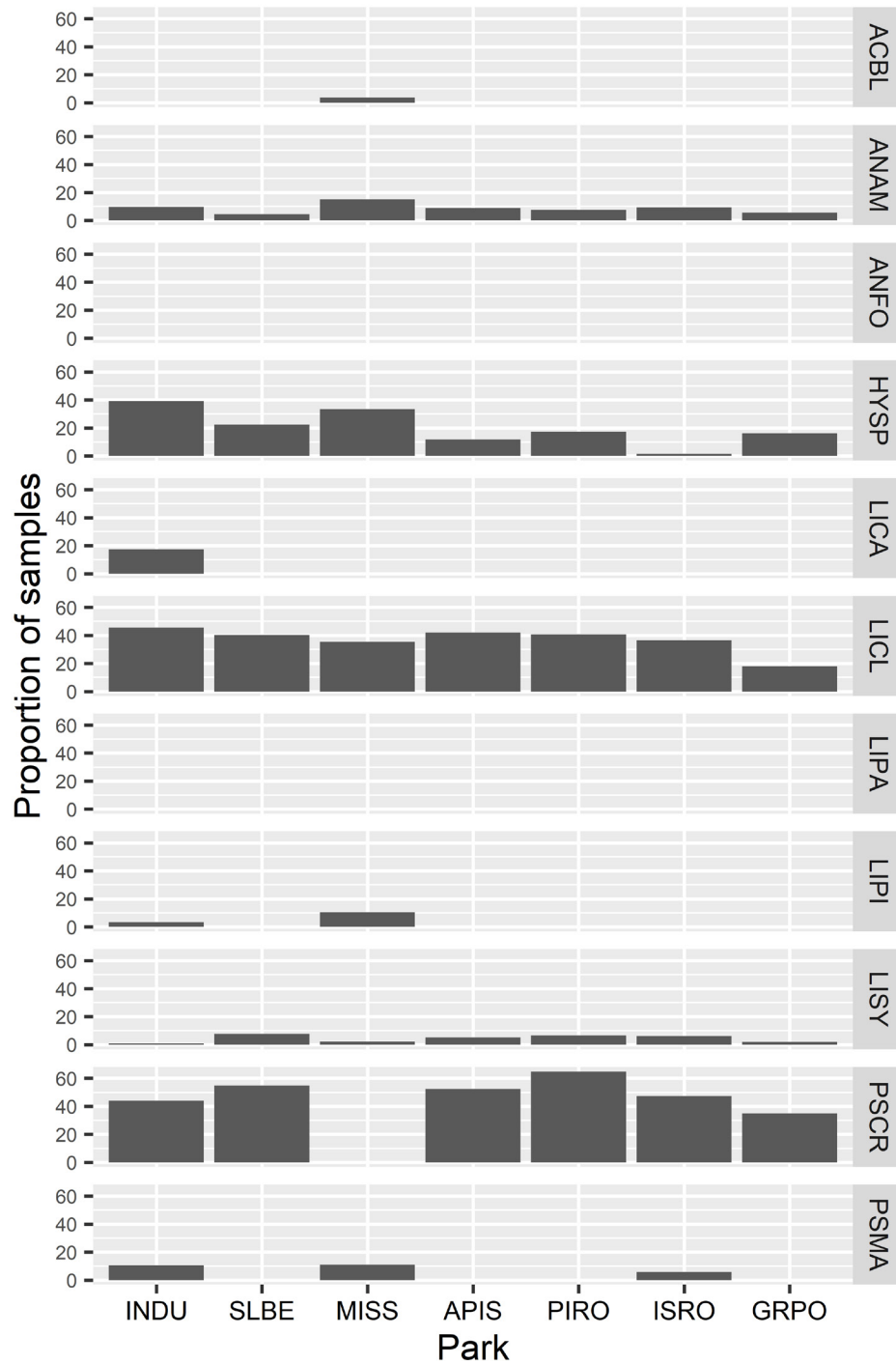


Figure 7. Percent of samples with detections by species across parks monitored in 2019 (parks ordered south to north). From top, Blanchard's Cricket Frog (ACBL), Eastern American Toad (ANAM), Fowler's Toad (ANFO), Treefrog spp. (HYSP), American Bullfrog (LICA), Green Frog (LICL), Pickerel Frog (LIPA), Northern Leopard Frog (LIPI), Wood Frog (LISY), Spring Peeper (PSCR), Boreal Chorus Frog (PSMA). INDU = Indiana Dunes, SLBE = Sleeping Bear Dunes, MISS = Mississippi National River, APIS = Apostle Islands, PIRO = Pictured Rocks, ISRO = Isle Royale, GRPO = Grand Portage.

Discussion

The monitoring program detected six of eight species of frog and toad known to occur at APIS in 2019 (Appendix F), with Green Frog and Spring Peeper occurring at every site sampled, Eastern American Toad at eight sites, Gray Treefrog at six sites, and Wood Frog at four sites. Mink Frog was found at only two sites in 2019 (Stockton and Michigan Island lagoons, APIS03 and APIS07, respectively), although they are also known from Long Island and the Sand River Estuary (Casper 2018). Northern Leopard Frog was not detected at any monitored sites in 2019 but has been confirmed outside the GLKN program on Long Island, and there are unconfirmed reports from Bear, Devils, Stockton, and York islands (Casper 2018). Likewise, American Bullfrog, Boreal Chorus Frog, and Pickerel Frog were not detected and are not known to occur at APIS despite several unconfirmed reports (Casper 2018).

We expanded analyses and reporting in 2018 to address calling phenology and to provide a second metric for tracking changes in abundance (as opposed to occupancy) across years. Occupancy analyses track whether or not a site was occupied by a species. Abundance is tracked by assessing how the maximum call intensity changes on sites across years, and by how many automated detections are reported from sites across years.

Using two independent survey methods, manual and automated, with large sample sizes continues to return reliable results, providing a confident record of site occupancy for most species. False absences are mostly attributable to weak signals (distant calls), obscuring noise (both natural and anthropogenic), and in some cases the rareness of a species calling. False absences are accounted for in periodic occupancy modeling. False positives for site occupancy are eliminated by dual observer proofing, although it is possible some could remain due to human error. More details regarding false absences (omission) can be found in Appendix D.

The most difficult species to confirm are American Bullfrog, Cope's Gray Treefrog, Mink Frog, and Northern Leopard Frog. American Bullfrog calls are often obscured by anthropogenic or natural noise sharing its low frequency band. Cope's Gray Treefrog calls can be distinguished from Gray Treefrog calls by pulse rates (Jaslow and Vogt 1977), but we find that counting pulses is not always possible unless a very clear recording with little background noise is obtained. In these cases, we still rely on qualitative call interpretation. Mink Frog calls are quiet, often obscured by noise or the calls of Green Frog, and they are often hard to distinguish from truncated Green Frog calls and natural or electronic interference sounds. The addition of early morning samples in our protocol, when Mink Frog tends to call more, has improved detection rates. Northern Leopard Frog calls are low frequency and low volume, a combination that results in little carrying power and calls often being masked by other natural and anthropogenic sounds. Moreover, Northern Leopard Frog calls sporadically and often from only a few small areas within larger wetlands; therefore, it is more often missed by chance (where selected samples are not at the times of peak calling) or because calling is too distant from the ARS. While these difficult species are adequately monitored by the dual survey approach, they do have higher false absence rates than other species (see Appendix D, Table D1).

The only data collection issue in 2019 was the lack of acoustic data from APIS06 due to equipment failure. All temperature loggers succeeded. Cumulative data collection result summaries are provided in Appendix E, and 2019 summaries in Appendices A, B, and C. We recommend continuing to deploy island ARS in the fall, programmed for a delayed start, to better sample early calling species. However, we now recommend a start date of 10 March rather than 1 April based on the temperature logs showing that the threshold of $\geq 40^{\circ}\text{F}$ was exceeded in mid-March in 2019 (Appendix C). Clipping (overwhelming of frequency bands into undifferentiated noise that cannot be resolved to species) and presumed static discharge (sharp clicks of high volume), also persist in the data and can make samples impossible to analyze when very loud Spring Peeper choruses obscure everything else. We recommend investigating possible solutions to these issues.

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Appendix A. Acoustic Recorder Deployment Success.

In 2019, all recorders collected data as programmed except APIS06 (Figure A1).

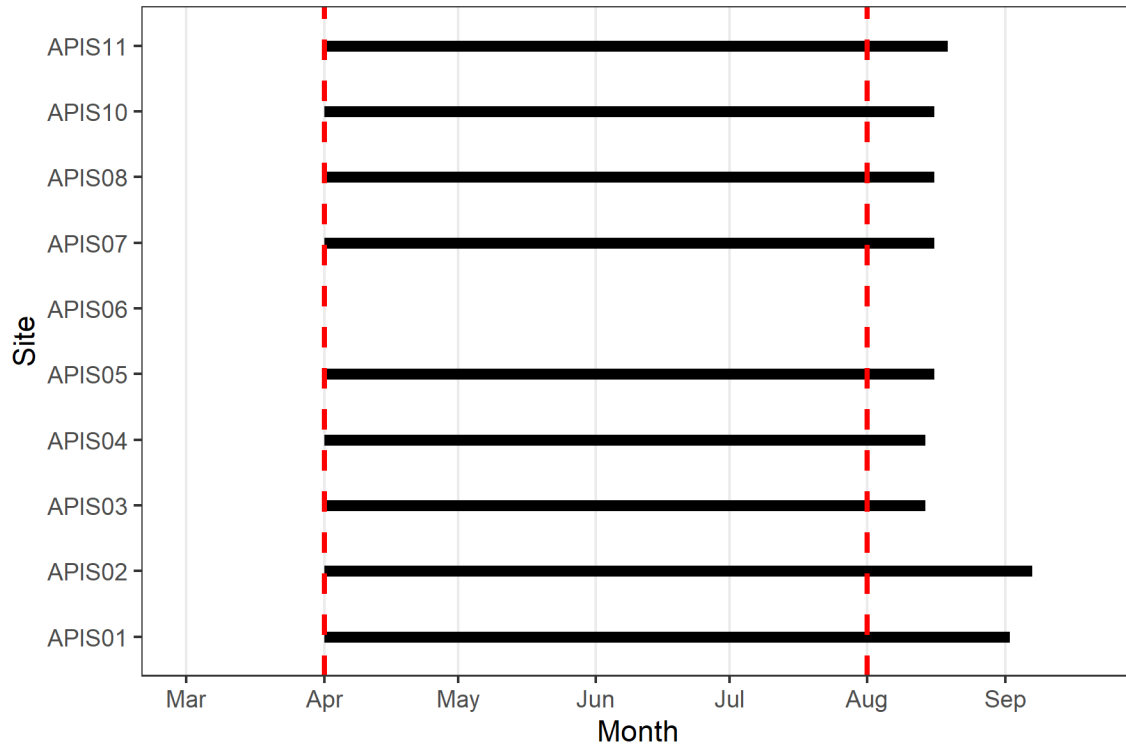


Figure A1. Successful recording periods for Apostle Islands National Lakeshore, 2019.

Appendix B. ARS Samples.

No ARS programming errors occurred in 2019. All programmed samples were successfully recorded on the days that the recording devices were operational (Figure B1), except for APIS06, which failed to record data in 2019.

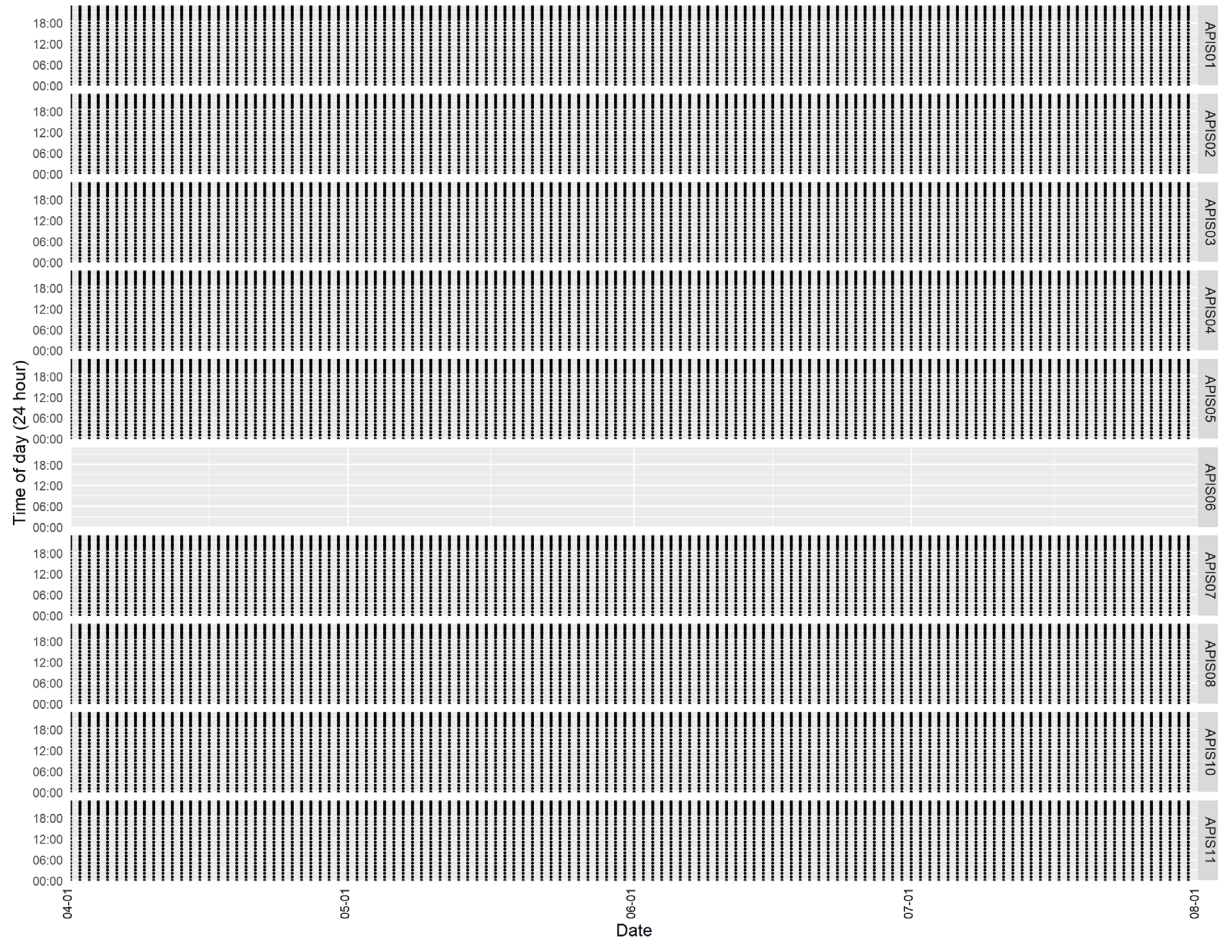


Figure B1. Sampling success for Apostle Islands National Lakeshore, 2019. Each dot represents a recording. Figure shows the entire recording periods for each ARS, from 1 April through the night of 31 July.

Appendix C. Temperature Logs.

Temperature logs were successfully collected for all sites (Figure C1). Mainland site logs did not begin until 1 April, but island site logs, where loggers were in place the previous September, show that the $\geq 40^{\circ}\text{F}$ temperature threshold was met in mid-March, hence frogs may have started calling before units were programmed to start recording. We recommend starting sampling earlier.

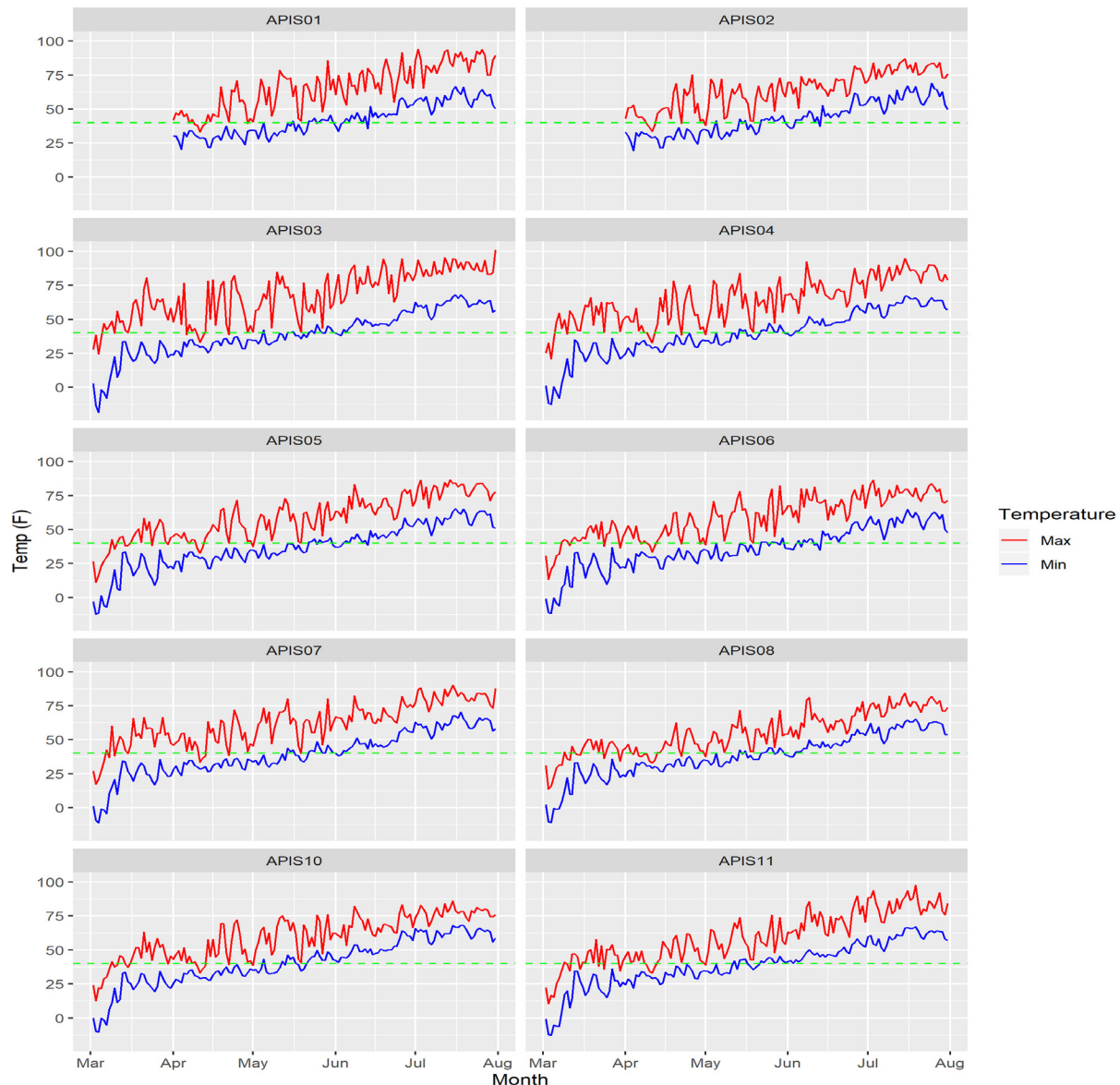


Figure C1. Temperature logs for each APIS site in 2019. The red line depicts daily maximum temperature, the blue line daily minimum temperature. The dashed green line is the 40°F minimum temperature threshold for selection of samples for manual scanning. This figure only shows data through the night of 31 July (when data analyses end).

Appendix D. Automated Detection Error Analysis.

Automated survey error counts for each species in 2019 are presented in Table D1. For example, Eastern American Toad (ANAM) was detected in 33 of 270 samples by manual scans (Agree Present plus Omission), with automated detections agreeing in 12 of these and returning false absences in 11. Manual surveys concluded ANAM was absent from 247 samples (Agree Absent plus Commission), and automated surveys returned false positives in seven of those. Note that false presences (Commission error) do not affect occupancy conclusions, but rather are used for estimating automated detection rates.

Table D1. Error counts for 30 samples per site (N=270 in 2019) for four conditions. Agree Absent = automated and manual results agree on species absent. Commission = automated survey falsely detected a species. Agree Present = automated and manual results agree on species present. Omission = automated survey missed a species that was present.

Species *	Agree Absent	Commission	Agree Present	Omission
ANAM	240	7	12	11
HYSP	233	0	10	27
LICA	259	11	0	0
LICL	133	12	95	30
LIPI	168	102	0	0
LISY	183	73	3	11
PSCR	71	22	174	3
PSMA	162	108	0	0

* ANAM = Eastern American Toad, HYSP = Treefrog spp., LICA = American Bullfrog, LICL = Green Frog, LIPI = Northern Leopard Frog, LISY = Wood Frog, PSCR = Spring Peeper, PSMA = Boreal Chorus Frog.

We assessed automated detection rates by correcting results obtained by running acoustic samples through the automated detection process (in which algorithms are used to identify call patterns assigned to specific species) for commission errors (i.e., false presences). Correction factors are calculated by comparing results from automated and manual surveys on the same 30 samples (Table D2). These correction factors are then applied to all samples run through the automated detection procedures (typically 100 to 200 samples per site per year) to estimate the number of samples with automated detections for each species at each site in each year as a metric for tracking trends in abundance.

Error rates for automated detection algorithms are variable, however all false presences for site occupancy are rejected by the proofing process.

Table D2. Percent error for automated detection results from 30 samples proofed manually at each site. Commission = automated survey falsely detected a species. Agree Present = automated and manual results agree on species present. Omission = automated survey missed a species that was present.

Species *	Agree Absent	Commission	Agree Present	Omission
ANAM	97.17	2.83	52.17	47.83
HYSP	100.00	0.00	27.03	72.97
LICA	95.93	4.07	NA	NA
LICL	91.72	8.28	76.00	24.00
LIPI	62.22	37.78	NA	NA
LISY	71.48	28.52	21.43	78.57
PSCR	76.34	23.66	98.31	1.69
PSMA	60.00	40.00	NA	NA

* ANAM = Eastern American Toad, HYSP = Treefrog spp., LICA = American Bullfrog, LICL = Green Frog, LIPI = Northern Leopard Frog, LISY = Wood Frog, PSCR = Spring Peeper, PSMA = Boreal Chorus Frog.

Appendix E. Cumulative Data Collection Results.

Data collection was successful at each site in each year (Figure E1). Our goal is to consistently collect data from ice-out through the end of July in each year.

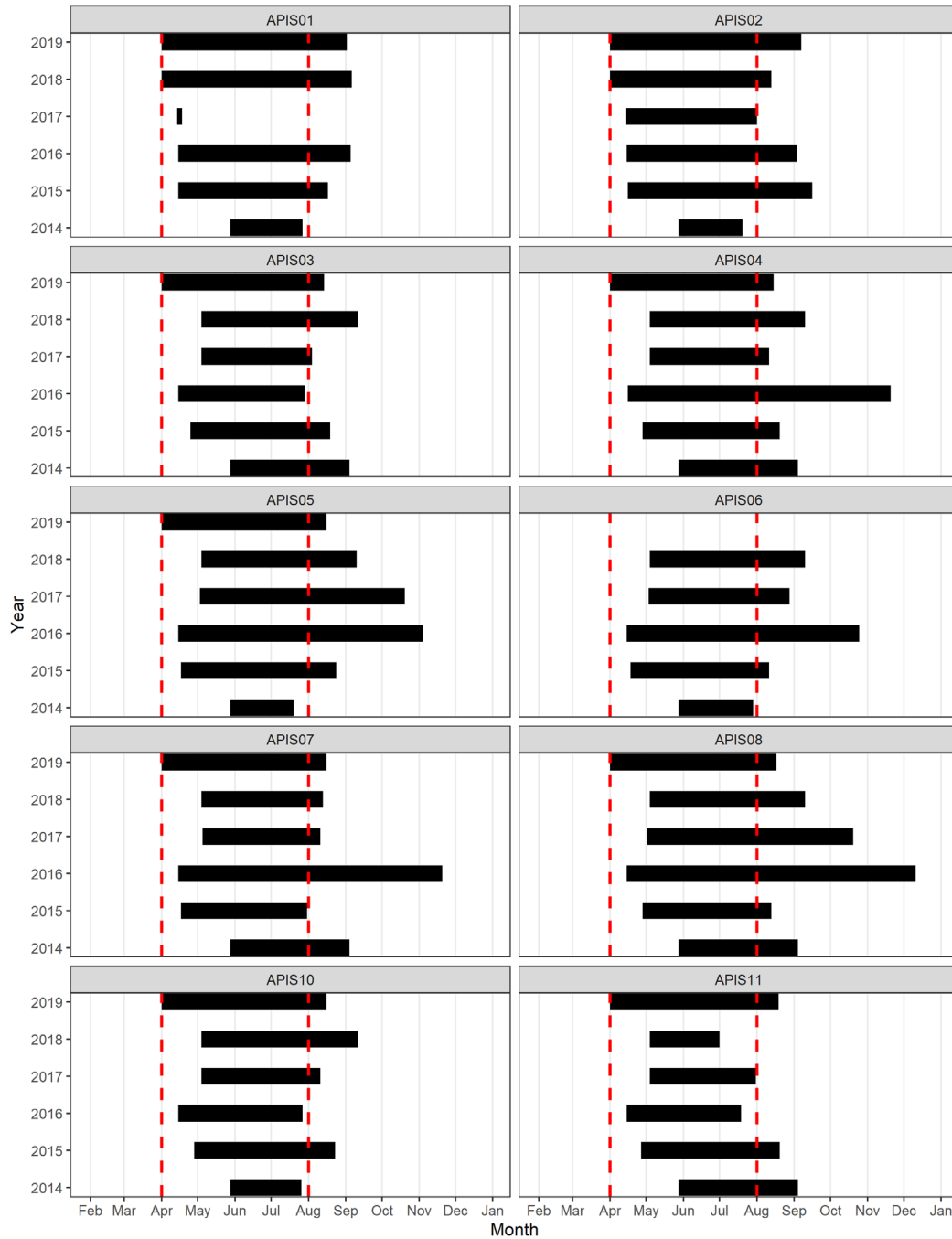


Figure E1. Successful data collection periods for each site at Apostle Islands National Lakeshore, 2014–2019. Dotted lines bound 1 April through 1 August.

Appendix F. Cumulative Occupancy Record.

The multi-year occupancy record (Figure F1) provides preliminary site occupancy trends. Solid dots indicate confirmed presence, while open dots indicate an absence conclusion (not detected by any method). Putative absences will be transformed to probabilities of absence when multi-year occupancy modeling is performed, but naïve absence data presented here are usually reliable due to large sample sizes. Red dots (NA) indicate that sampling was insufficient for reaching any conclusion on presence or absence, because too few or no samples were taken during the prime calling period for the species.

Eastern American Toad, Green Frog, and Spring Peeper are present at every site in most years. Gray Treefrog and Wood Frog are present at fewer sites. All HYSF detections in 2019 were for Gray Treefrog (*Hyla versicolor*).

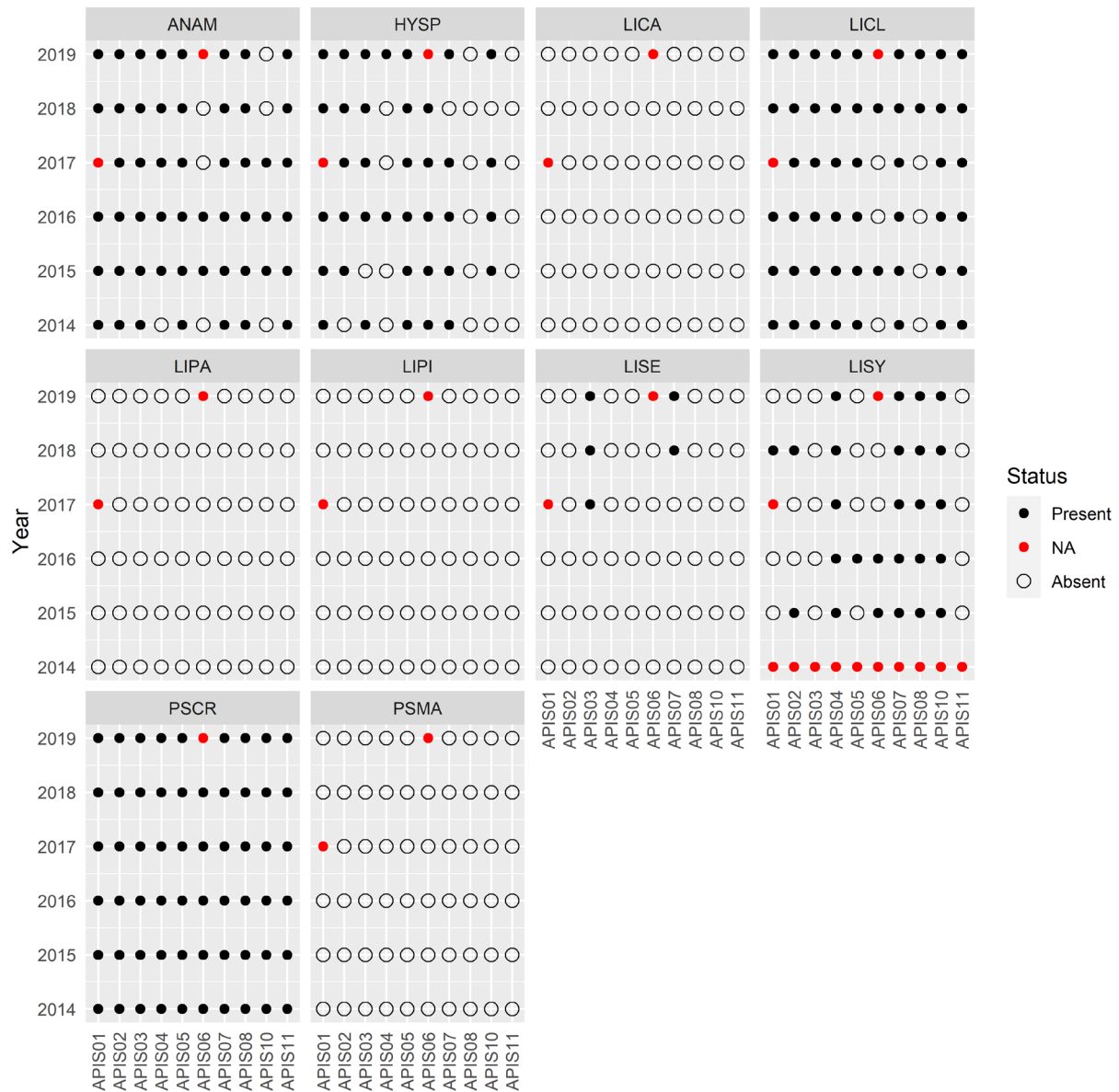


Figure F1. Cumulative occupancy record for each species and site at APIS, 2014–2019. An 'NA' value (red dot) indicates that there was insufficient sampling to determine occupancy. Black and clear dots indicate presence and absence, respectively. ANAM = Eastern American Toad, HYSP = Treefrog spp., LICA = American Bullfrog, LICL = Green Frog, LIPA = Pickerel Frog, LIPI = Northern Leopard Frog, LISE = Mink Frog, LISY = Wood Frog, PSCR = Spring Peeper, PSMA = Boreal Chorus Frog.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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