



Acoustic Amphibian Monitoring Data Summary Report for Apostle Islands National Lakeshore *2018*

Natural Resource Data Series NPS/GLKN/NRDS—2020/1269



ON THE COVER

Mink Frog in Sand River Estuary.

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Acoustic Amphibian Monitoring Data Summary Report for Apostle Islands National Lakeshore 2018

Natural Resource Data Series NPS/GLKN/NRDS—2020/1269

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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).....	11
3.6 Automated Detection Rates	13
Discussion	17
Literature Cited	19

Figures

	Page
Figure 1. Monitoring site locations at Apostle Islands National Lakeshore.	4
Figure 2. Example of automated recording device (ARS) deployed in the field.	5
Figure 3. Dates of first confirmed detections for Eastern American Toad (ANAM), Treefrog spp. (HYSP), and Green Frog (LICL), Apostle Islands National Lakeshore, 2018.....	10
Figure 4. First detection dates of three species for all parks conducting monitoring (parks ordered north to south).....	11
Figure 5. Call Index Value (CIV) distribution for each species at each site, Apostle Islands National Lakeshore, 2018.	12
Figure 6. Percent of samples with detections by species at each site at Apostle Islands National Lakeshore in 2018.	14
Figure 7. Percent of samples with detections by species across parks monitored in 2018, for all species potentially occurring at APIS (parks ordered south to north). Only species detected at any park are shown. Blanchard’s Cricket Frog (ACBL) potentially occurs at only three parks (INDU, MISS, SLBE).	15
Figure A1. Successful recording periods for Apostle Islands National Lakeshore, 2018.	21
Figure B1. Sampling success for Apostle Islands National Lakeshore, 2018.....	23
Figure C1. Temperature logs for each APIS site in 2018.	25
Figure E1. Successful data collection periods are shown for each site in each year.	29
Figure F1. Cumulative occupancy record for each species and site at APIS since 2015.	32

Tables

	Page
Table 1. Species monitored 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.....	13
Table D1. Matrix of number of samples in which species' presence from automated detection algorithms (columns) was confirmed by manual scans (rows) for 30 samples at each of 10 sites.....	27
Table D2. Percent error for automated algorithm 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 nine national park units that comprise the Great Lakes Network. We present here the results for 2018 amphibian monitoring at one of those parks—Apostle Islands National Lakeshore. Appendices contain tabular summaries of four years of cumulative results.

The National Park Service Great Lakes Inventory and Monitoring Network (GLKN) established 10 permanent acoustic amphibian monitoring sites at Apostle Islands National Lakeshore (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 collect air temperature during the sample period.

Six species of frogs and toads were detected in 2018, with Green Frog and Spring Peeper occurring at each of the ten sites. Mink Frog was found at only two sites in 2018. Northern Leopard Frog, American Bullfrog, and Boreal Chorus Frog are found near or within the park but have not yet been detected at any network monitored sites; none were detected in 2018. Eastern American Toad, Gray Treefrog, and Wood Frog were not detected at some sites where they were detected in prior years.

We expanded analyses and reporting in 2018 to address calling phenology, and to provide a second metric for tracking changes in abundance (in addition to occupancy) across years. 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. We also added analysis of error rates for automated detection algorithms, most of which were less than 5%.

The dual survey approach with large sample sizes continues to return reliable results, providing a near-perfect record of site occupancy for most species. False absences are accounted for in periodic occupancy modeling. False positives for site occupancy are eliminated by dual observer proofing. Data collection issues in 2018 were minimal.

Introduction

The National Park Service Great Lakes Inventory and Monitoring Network (GLKN) established 10 permanent acoustic amphibian monitoring sites at Apostle Islands National Lakeshore (APIS) in 2014. Acoustic recordings are 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.

Eight frog and toad species are known to occur at APIS, but we also monitor for two additional species which occur near park boundaries (American Bullfrog and Boreal Chorus Frog) and may occupy park lands in the future as a result of range expansions (e.g., from climate change) (Table 1). 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 a American Bullfrog or Boreal Chorus Frog, respectively.

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

Common name	Scientific name	Code	Status
Eastern American Toad	<i>Anaxyrus americanus americanus</i>	ANAM	Present
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
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	Unconfirmed

Thus, in total, 10 species are monitored at APIS by this program, and confirmed acoustic detections are archived at the Great Lakes Network office. This annual summary report presents results for 2018. A summary of four years of cumulative results are presented in Appendices A and B.

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 Tessellation Stratified 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. Park personnel were also consulted on final site selections to ensure logistical feasibility for annual visits (Figure 1).

At APIS, logistic feasibility played an important role in limiting site selection to shoreline areas that are accessible by boat and relatively short hikes. Isolated perched ephemeral wetlands typical of the mainland are uncommon at APIS and found mostly in island interiors. The species that utilize ephemeral wetlands, however, also utilize semi-permanent wetlands, which at APIS mostly consist of 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 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).

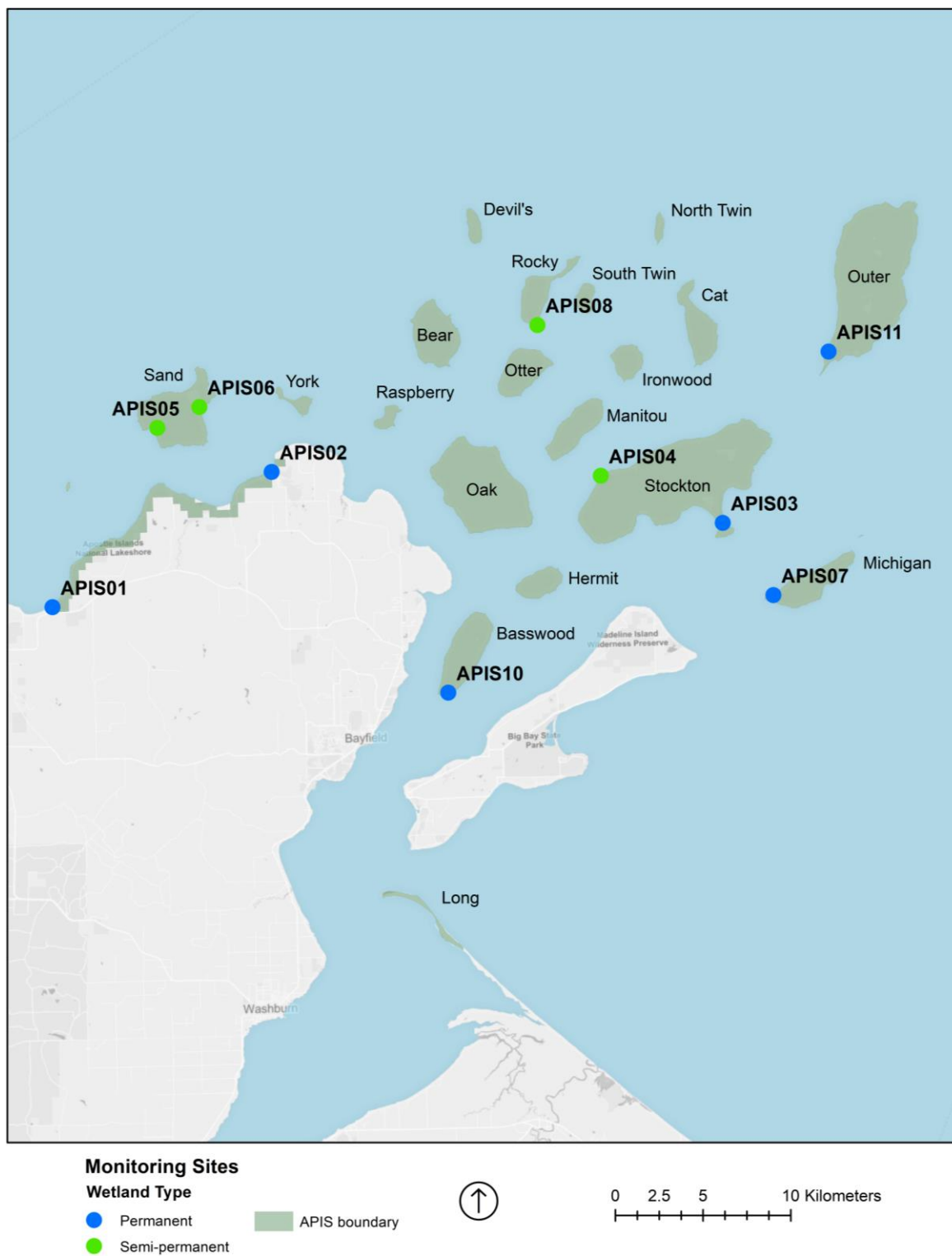


Figure 1. Monitoring site locations at Apostle Islands National Lakeshore.

2.2 Data Collection

2.2.1 Temperature Logs

Temperature logs are recorded at each site and used for filtering data analyses, where only samples with an ambient air temperature of $\geq 40^{\circ}\text{F}$ are used for manual surveys. Loggers (HOBO Pendant® model UA-002-08, Onset Computer Corporation, Bourne, Massachusetts, USA) are 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 device (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 (Wildlife Acoustics, Inc., Concord, MA, USA; Song Meter models SM3 and SM4) are co-located with temperature loggers. They are programmed to record seventeen 5-minute samples (.wav files) each day on the top of each hour from 1500h to 0300h (includes four extra samples immediately after sunset on the half-hour

mark). An additional three samples are taken at 0400h, 0500h, and 0600h for Mink Frog analysis, as this species is more detectable in the early morning hours. ARS are programmed at 16000 Hz sample rates, and 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. They 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

For detailed analysis steps, please see Casper and Nadeau (2019). 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 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, they are 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 Treefrog; Western vs. Boreal Chorus frog), 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 to detect declines before a site becomes completely unoccupied.

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 Gray Treefrog and Cope's Gray Treefrog, owing to the similarity of the calls of this diploid-tetraploid species pair. Manual scans do attempt to determine detections to species. For phenology we treat these as a species pair, as calling periods do not differ between species (Mossman et al. 1998, Dodd 2013).

We chose not to model the earlier calling species at this time (Boreal Chorus Frog, Northern Leopard Frog, Spring Peeper, Wood Frog), owing to often late deployment of ARS units missing their earliest calls. These species can be modeled if ARS deployment target dates improve through fall deployments and delayed starts. 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 2018, Treefrog spp. began calling later from sites APIS01 (Sand River mouth) and APIS03 (Stockton Island lagoon), both of which are connected to the cold waters of Lake Superior (Figure 3). They began calling earlier from sites APIS02 (Sand Bay), APIS05 (Sand Island west), and APIS06 (Sand Island east), which are sheltered surface water wetlands (Figure 3). Eastern American Toad began calling earlier at sites APIS04 (Stockton Island west), APIS02, and APIS01, respectively, and then calling commenced at remaining sites fairly synchronized in time (Figure 3).

Green Frog also began calling earlier at sites APIS05 and APIS06 (Sand Island), with remaining sites lagging about a week later (Figure 3). The very late start for Green Frog calling at APIS08 (Rocky Island; 5 July) is an outlier, and all samples examined had only a single male calling, which we interpret as a lone colonizer rather than a breeding population. The early outlier on 14 May at APIS11 (Outer Island lagoon) is a single male from a single sample (0900h CDT; APIS11_0+1_20180514_210000.wav) during an unusual warm period. Temperatures spiked to the mid-70s°F from 13 May through 16 May, with an 85°F maximum on 16 May, which apparently triggered this lone male to call. No additional calls were found in any other surrounding samples examined from 1900h to 2200h on 14 May, from 2000h to 2200h on 15 May, and 2100h on 16 May. This is interpreted as a lone male calling well before breeding activity began. The next detection was on 9 June with steady subsequent detections, indicating that breeding activity phenology was in accord with most other sites.

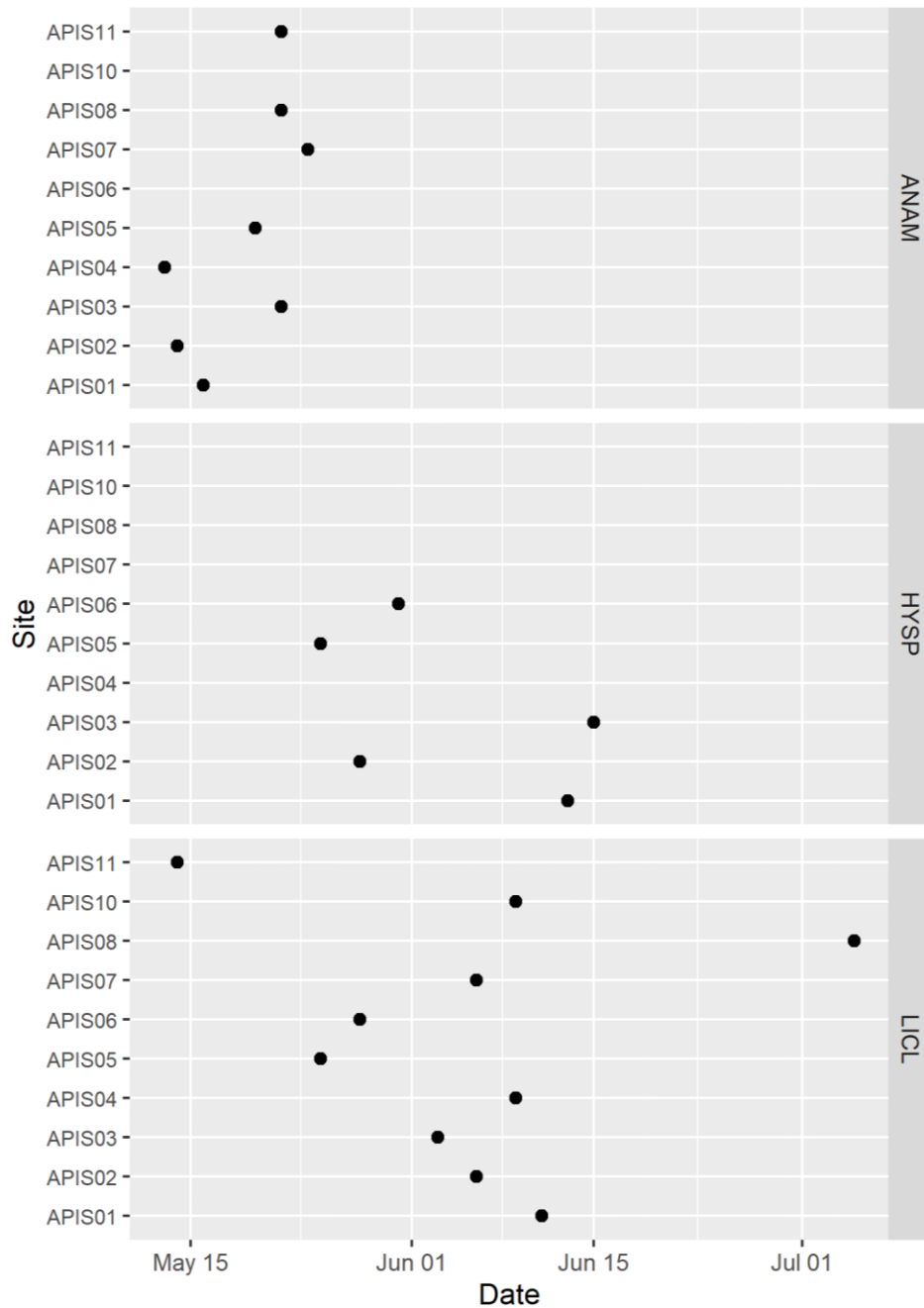


Figure 3. Dates of first confirmed detections for Eastern American Toad (ANAM), Treefrog spp. (HYSP), and Green Frog (LICL), Apostle Islands National Lakeshore, 2018.

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.

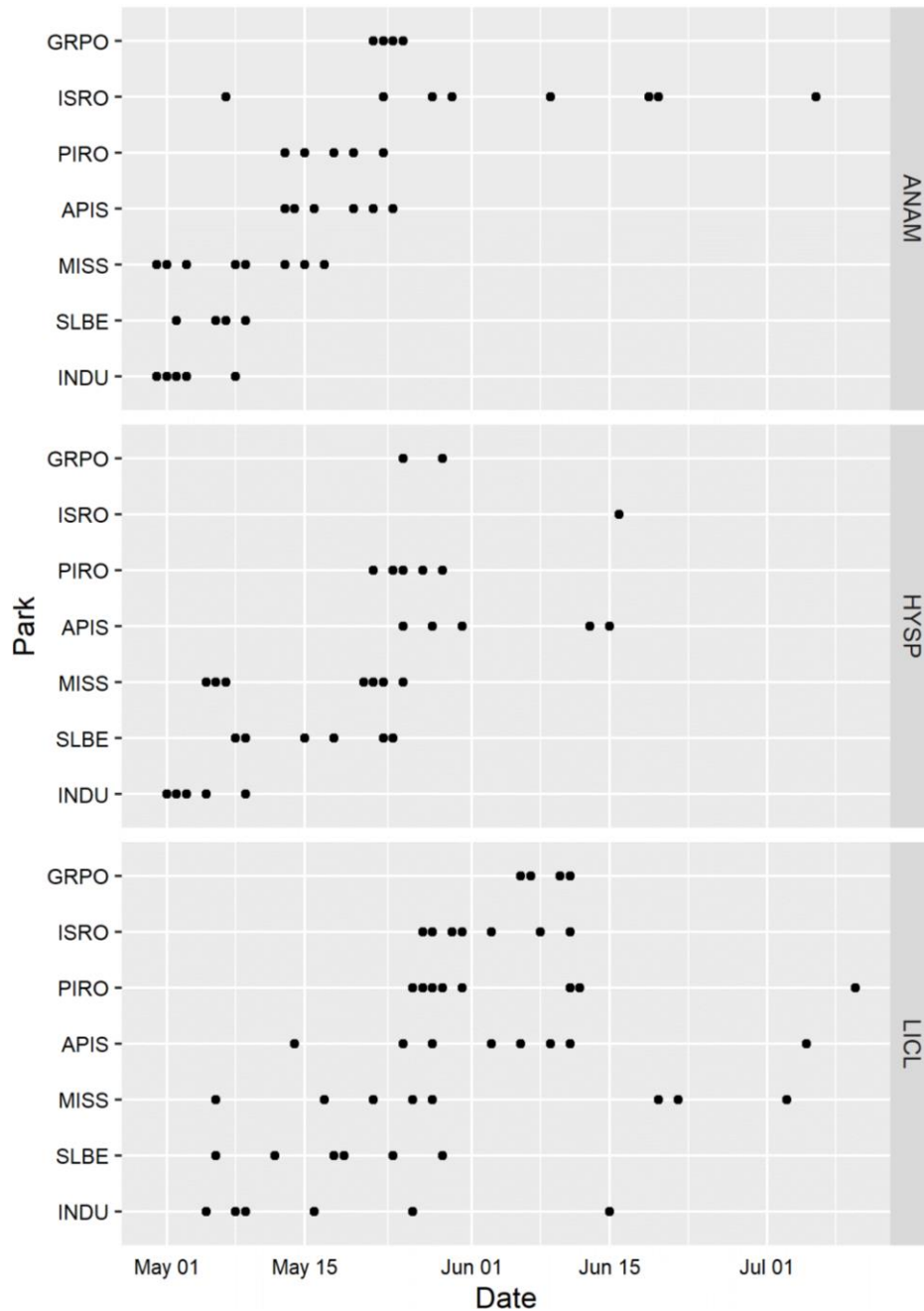


Figure 4. First detection dates of three species for all parks conducting monitoring (parks ordered north to south). ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog.

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 scanning where Cope's Gray Treefrog and Gray Treefrog are identified to species and are reported on separately. For example, Eastern American Toad (ANAM) at APIS04 had an equal number of samples with CIVs of 1 and 2, while at APIS02, Eastern American Toad called at the maximum CIV of 3 only 10% of the time. 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.

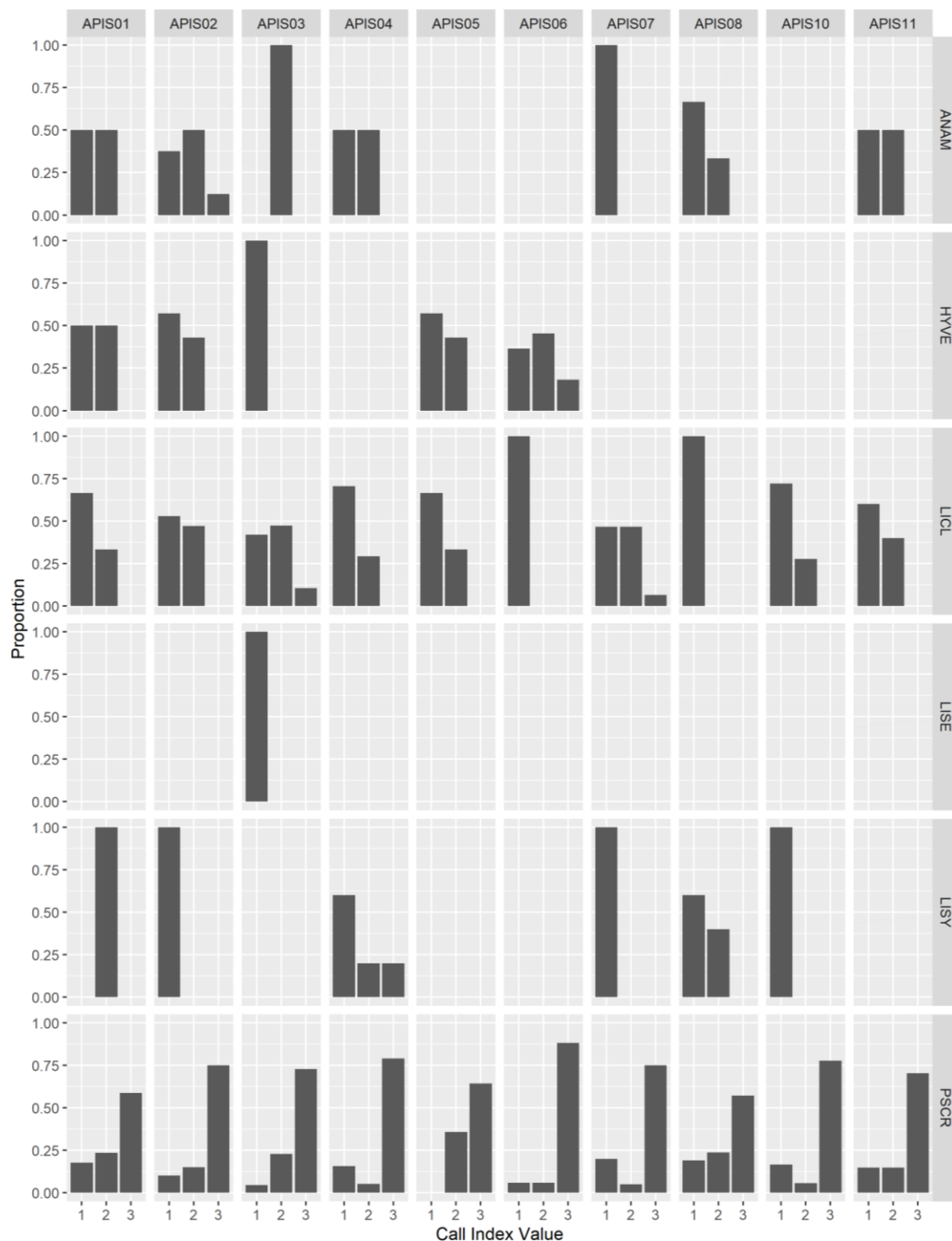


Figure 5. Call Index Value (CIV) distribution for each species at each site, Apostle Islands National Lakeshore, 2018. Only species detected on at least one site are displayed. ANAM = Eastern American Toad, HYVE = Gray Treefrog, LICL = Green Frog, LISE = Mink Frog, LISY = Wood Frog, PSCR = Spring Peeper.

Several sites/species never exceeded a CIV of 1 in 2018, indicating that few males were present and calling (ex., Eastern American Toad at APIS07, Gray Treefrog at APIS03, and Wood Frog at most sites). Conversely, where the maximum CIV reaches 3, this indicates that large populations are present, albeit not always calling at that intensity level (ex., Gray Treefrog at APIS06; and Green Frog, Mink Frog, and Spring Peeper at most sites where they occur).

3.6 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 (i.e., at least two observers agree on presence or absence). 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 types. Overall agreement rates for automated detections range from 11% to 91% (Table 2).

Table 2. Automated detection error rates for samples where manual verification identified a species in the sample. For example, for ANAM, of the 300 samples that were manually checked, 28 had ANAM present. Of these 28 samples, the automated method identified ANAM in 17 of these, giving an overall agreement rate of 60.71%. ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog, LISY = Wood Frog, PSCR = Spring Peeper

Species	Number of samples with species detected manually	Number of matches on automated detection	Agreement
ANAM	28	17	60.71%
HYSP	39	12	30.77%
LICL	135	86	63.70%
LISY	18	2	11.11%
PSCR	195	177	90.77%

Eastern American Toad (ANAM) detection rates were consistent across sites at APIS in 2018, but with fewer detections at APIS05 and APIS07 (Figure 6). However, Treefrog spp. (HYSP) was auto-detected from only four sites, with very few detections at two of those (APIS01 and APIS02), suggesting smaller populations present. Green Frog (LICL) detections were evenly distributed among all APIS sites at consistent detection rates, but fewer detections were reported from APIS06 and especially at the semi-permanent wetland APIS08 (Rocky Island). Wood Frog (LISY) detection rates were constant across sites as well, but highest at APIS01 and lowest at APIS06. Spring Peeper (PSCR) detection rates were the highest for any species and constant across all sites.

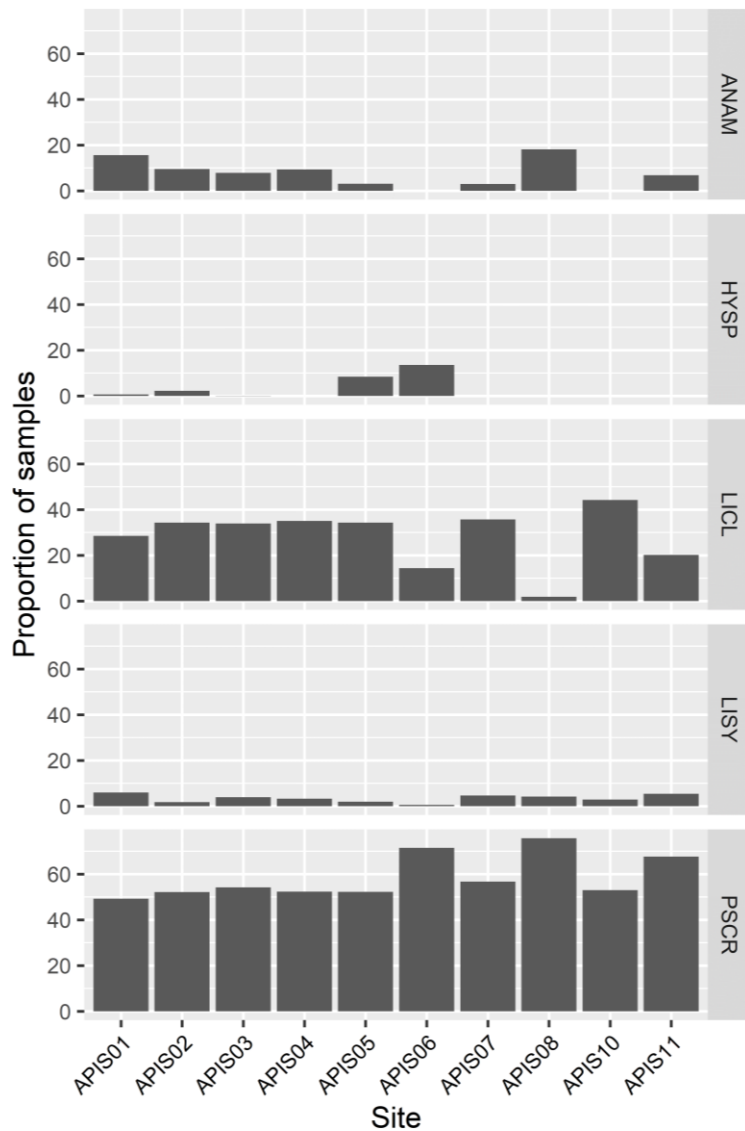


Figure 6. Percent of samples with detections by species at each site at Apostle Islands National Lakeshore in 2018. From top, Eastern American Toad (ANAM), Treefrog spp. (HYSP), Green Frog (LICL), Wood Frog (LISY), and Spring Peeper (PSCR).

Compared to other parks, detection rates at APIS for Eastern American Toad (ANAM) were average, few for Treefrog spp. (HYSP), high for Green Frog (LICL), low for Wood Frog (LISY), and high for Spring Peeper (PSCR) (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).

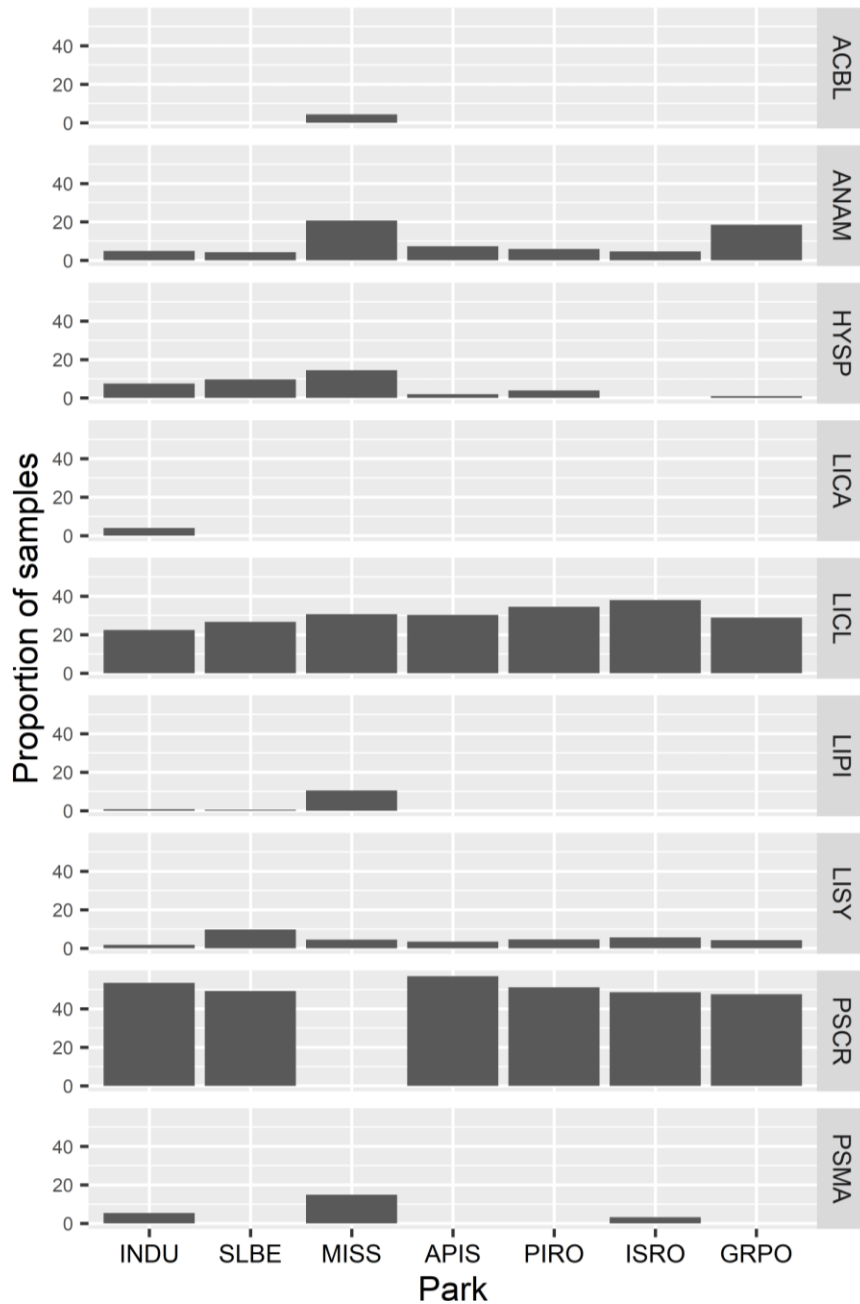


Figure 7. Percent of samples with detections by species across parks monitored in 2018, for all species potentially occurring at APIS (parks ordered south to north). Only species detected at any park are shown. Blanchard's Cricket Frog (ACBL) potentially occurs at only three parks (INDU, MISS, SLBE). From top, Blanchard's Cricket Frog (ACBL), Eastern American Toad (ANAM), Treefrog spp. (HYSP), American Bullfrog (LICA), Green Frog (LICL), 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 yielded six species of frogs and toads in 2018 (Table G1), with Green Frog and Spring Peeper occurring at every site. Mink Frog was found at only two sites in 2018 (Stockton and Michigan Island lagoons, APIS03 and APIS07, respectively), although they are also known from Long Island (Casper 2018). Northern Leopard Frog was not detected and is not confirmed to occur at any monitored sites. It does occur on Long Island, and there are unconfirmed reports from Bear, Devils, Stockton, and York islands (Casper 2018). Likewise, American Bullfrog and Boreal Chorus Frog were not detected, but are also not known to occur at APIS.

We expanded our sampling effort for Mink Frog in 2018 by adding three additional samples at 0400h, 0500h, and 0600h, starting on 15 May. This decision was based on results from Casper (2018), where morning samples originally analyzed for birds proved to have higher detection rates for Mink Frog than did nighttime samples. No Mink Frog automated detection algorithm is available, so this species is monitored solely by this expanded manual survey protocol.

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. 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.

The dual survey approach (manual and automated) with large sample sizes continues to return reliable results, providing a reliable 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 Northern Leopard Frog, American Bullfrog, Mink Frog, and Cope's Gray Treefrog. 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 ARS locations. American Bullfrog calls are often obscured by anthropogenic noise in its low frequency band. 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. 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. These difficult species are nevertheless adequately monitored by the dual survey approach, but they do have higher false absence rates than other species (Table D1).

Data collection issues in 2018 were minimal, and cumulative result summaries are provided in Appendices A and B. Somewhat late deployment of island ARS units did not seem to affect detection of early calling species in 2018. No significant equipment problems materialized in 2018. We do recommend programming island units for a delayed start and deploying them in the fall to better sample early calling species. 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 such as programming a lower gain setting or grounding ARS units.

Literature Cited

- Casper, G. S. 2018. Supplemental amphibian and breeding bird monitoring for the Apostle Islands National Lakeshore. Unpublished technical report to Apostle Islands National Lakeshore, National Park Service, Bayfield, Wisconsin.
- Casper, G. S., and S. M. Nadeau. 2019. Great Lakes Network amphibian monitoring: Initial synthesis report, 2013–2016. Natural Resource Report NPS/GLKN/NRR—2019/1955. National Park Service, Fort Collins, Colorado.
- Dodd, C. K. 2013. Frogs of the United States and Canada, volume 1. Johns Hopkins University Press, Baltimore, Maryland.
- Jaslow, A. P., and R. C. Vogt. 1977. Identification and distribution of *Hyla versicolor* and *Hyla chrysoscelis* in Wisconsin. *Herpetologica* 33:201–205.
- Mossman, M. J., L. M. Hartman, R. Hay, J. R. Sauer, and B. J. Dhuey. 1998. Monitoring long-term trends in Wisconsin frog and toad populations. Pages 169–198 in Michael J. Lannoo, editor. Status and Conservation of Midwestern Amphibians. University of Iowa Press, Iowa City, Iowa. Available at: [DOI: 10.2307/j.ctt20q20cw](https://doi.org/10.2307/j.ctt20q20cw).
- Route, B., U. Gafvert, G. S. Casper, and J. E. Elias. 2014. Standard operating procedure #4: Selecting and documenting sites (version 1.1). In G. S. Casper, E. Beever, U. Gafvert, and S. M. Nadeau. 2018. Amphibian monitoring protocol: Great Lakes Inventory and Monitoring Network (version 2.0). Natural Resource Report NPS/GLKN/NRR—2018/1761. National Park Service, Fort Collins, Colorado.

Appendix A. Acoustic Recorder Deployment Success

In 2018, recorders at the mainland sites collected data for the entire target period of 1 April through 1 August (Figure A1). Island deployments began the first week of May, which may have reduced detection rates for Wood Frog (the earliest calling species) at some sites.

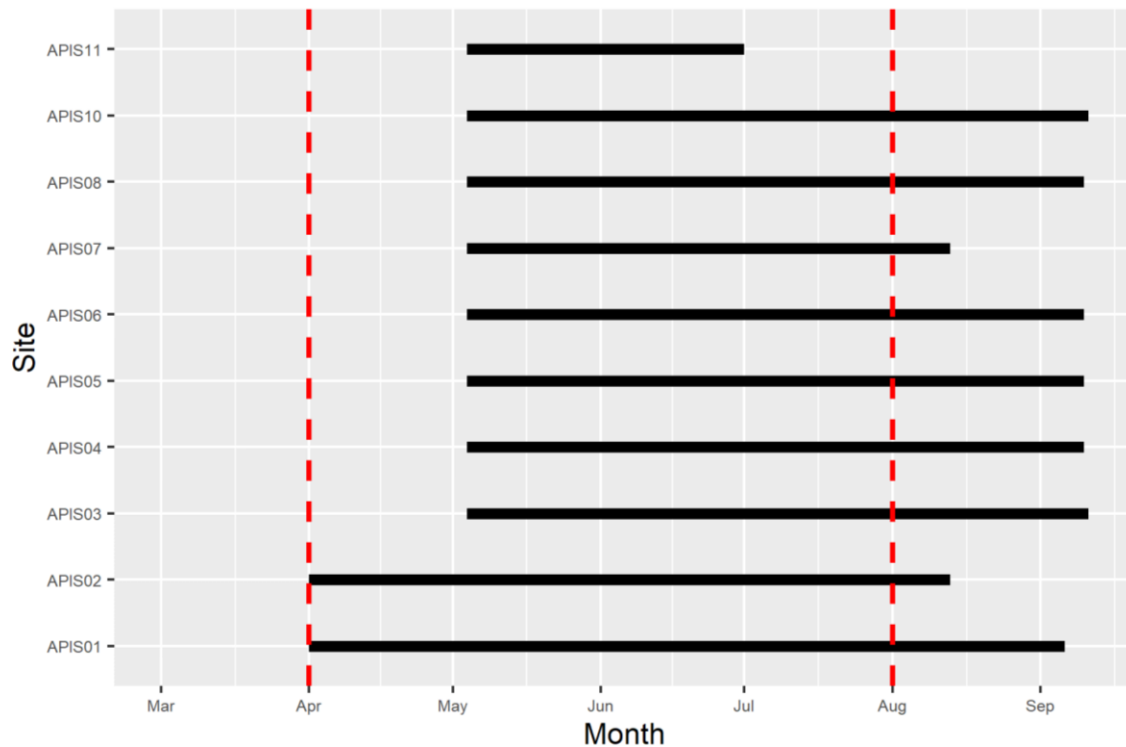


Figure A1. Successful recording periods for Apostle Islands National Lakeshore, 2018.

The ARS at APIS11 (Outer Island lagoon) failed early, with no July samples obtained, potentially reducing detection rates for both occupancy and the maximum Call Index Value for late calling species (Green Frog and Mink Frog).

Appendix B. ARS Samples

No ARS programming errors occurred in 2018. All programmed samples successfully recorded on the days that the recording devices were deployed (Figure B1).

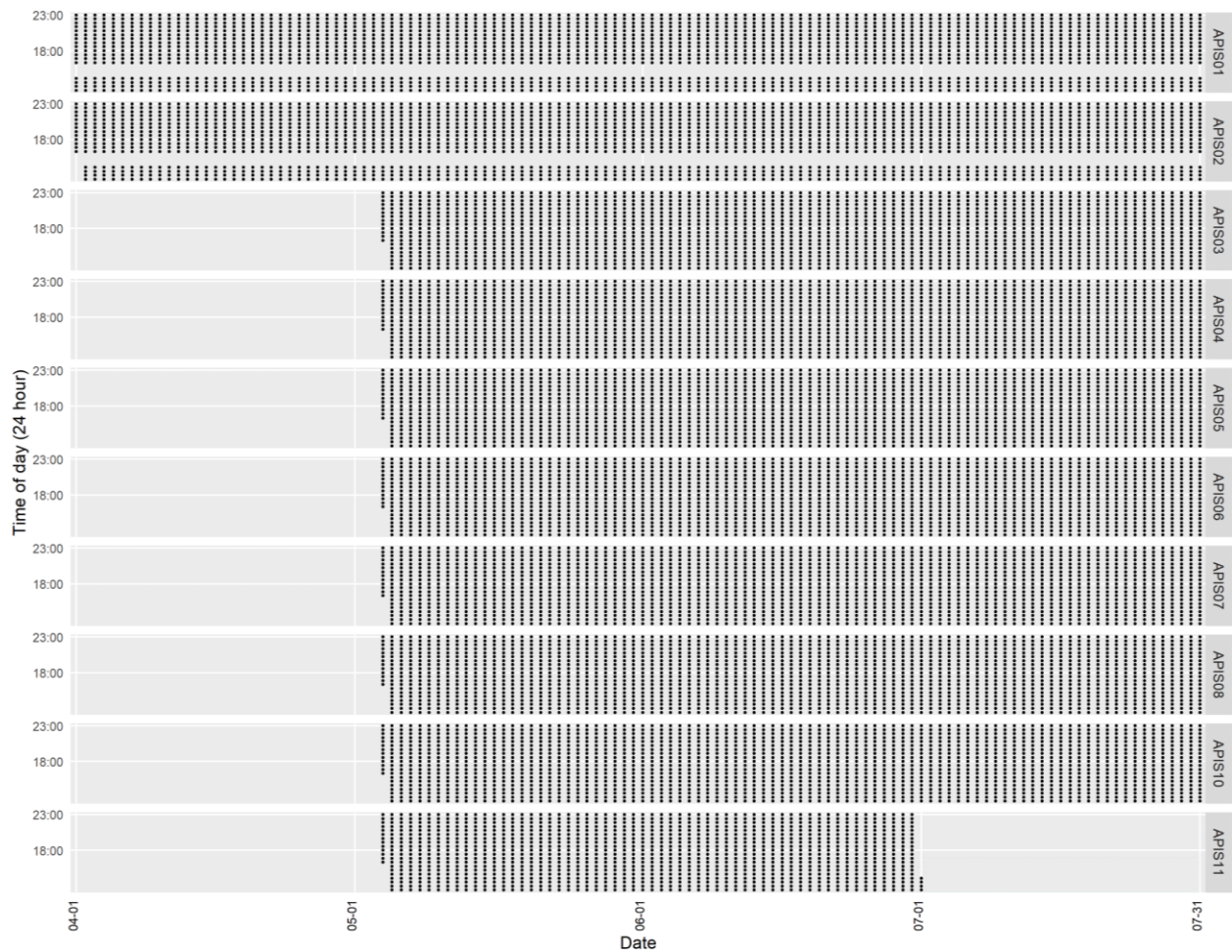


Figure B1. Sampling success for Apostle Islands National Lakeshore, 2018. Each dot represents a recording. Figure only shows the analysis period of 1 April through 31 July.

Appendix C. Temperature Logs

At APIS01 and APIS02, the maximum temperature exceeded the threshold of 40°F shortly after being deployed (Figure C1). At remaining sites frogs may have started calling before units were deployed.

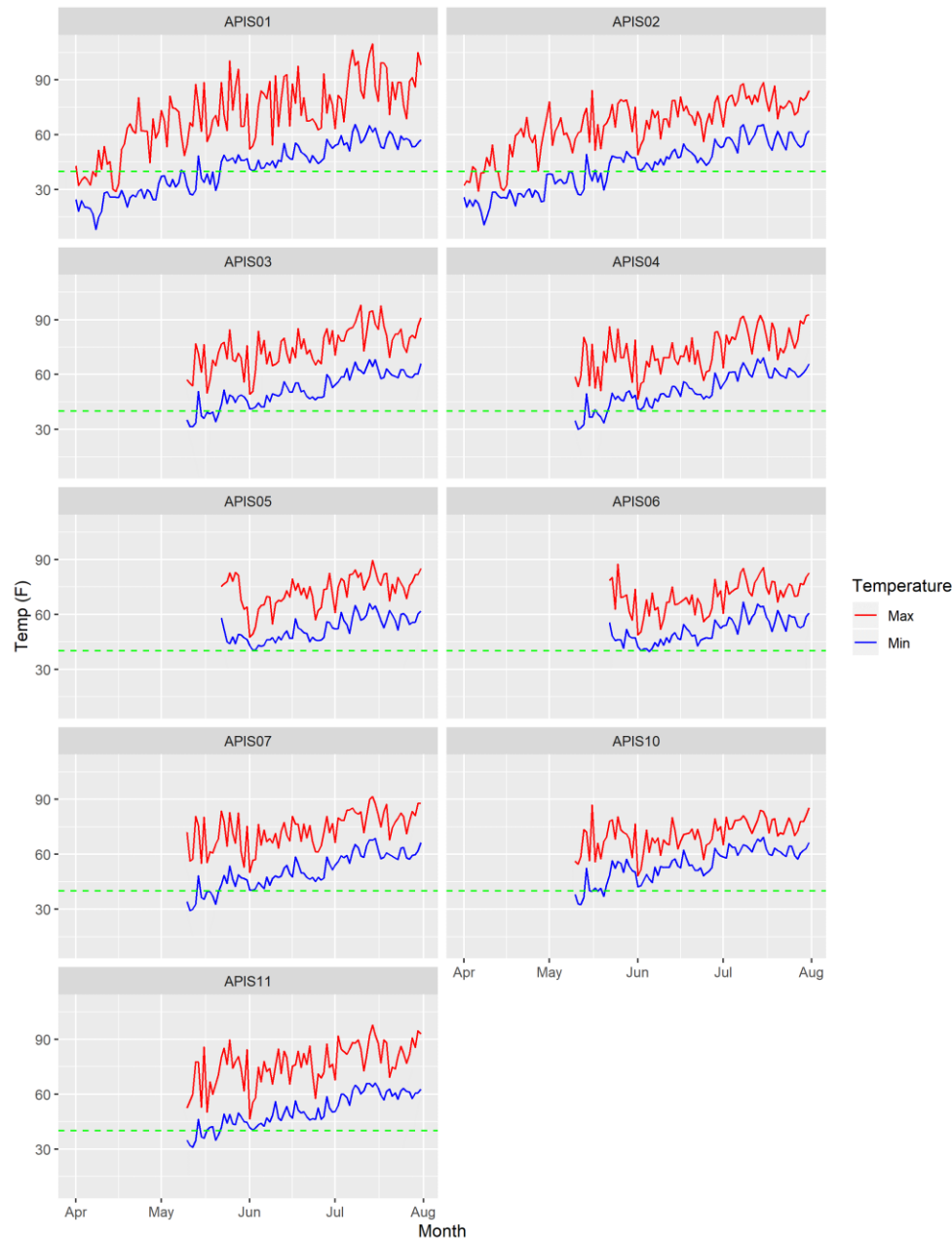


Figure C1. Temperature logs for each APIS site in 2018. The red line depicts daily maximum temperature; blue line daily minimum temperature. The dashed green line is the 40°F minimum temperature threshold for selection of samples for manual scanning. This figure only shows data from the target sampling period (1 April through 31 July).

Appendix D. Automated Detection Error Analysis

The number of samples from all APIS sites with any detection for each species in 2018 is presented in Table D1. For example, Eastern American Toad (ANAM) was detected in 28 of 300 samples by manual scans, with automated detections agreeing in 17 of these and returning false absences in 11. One sample had a false automated detection for ANAM (Manual ID = None). In this context, a false presence is an automated detection that cannot be manually confirmed because the signal is not visible in the spectrogram and/or the signal is not audible upon playback. In this example, ANAM was manually confirmed at this site in several other samples, including automated detections that were not among the 30 samples manually scanned but were part of the automated detection proofing process (automated detection results are proofed only for first and last detections, not for every detection). Therefore, false presences in the last row of Table D1 do not affect occupancy conclusions, but rather are used for estimating automated detection rates.

Table D1. Matrix of number of samples in which species' presence from automated detection algorithms (columns) was confirmed by manual scans (rows) for 30 samples at each of 10 sites.

Manual ID	Auto ID								
	ANAM	HYVE	LICA	LICL	LIPI	LISY	PSCR	PSMA	None
ANAM	17*	–	–	–	–	–	–	–	11
HYVE	–	12*	–	–	–	–	–	–	27
LICA	–	–	0*	–	–	–	–	–	0
LICL	–	–	–	86*	–	–	–	–	49
LIPI	–	–	–	–	0*	–	–	–	0
LISY	–	–	–	–	–	2*	–	–	16
PSCR	–	–	–	–	–	–	177*	–	18
PSMA	–	–	–	–	–	–	–	0*	0
None	1	0	11	8	87	5	1	100	1772*

*Indicates the number of samples where both methods agreed the species was present (also with a green background).

Interpreting Northern Leopard Frog (LIPI) results in Table D1, which had only false presences returned from the automated detection algorithm (N = 87), shows that this algorithm is often “fooled.” However, none of these false presences were entered into the site occupancy record, as they were all rejected by the automated detection proofing process.

We assessed automated detection rates by correcting results from 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 derived from Table D2 where error rates are calculated by comparing results from automated detections and manual scans on the same 30 samples. These correction factors are then applied to all samples run through the automated detection procedures (typically 100–200 samples per site per year) to assess

the number of samples with detections for each species at each site in each year as a potential metric for tracking trends in abundance.

Table D2. Percent error for automated algorithm results from 30 samples proofed manually at each site. Commission = false presence, Omission = false absence, Agree = correct result.

Species*	Commission	Omission	Agree (present)	Agree (absent)
ANAM	0.33%	3.67%	5.67%	90.33%
HYSP	0.00%	9.00%	4.00%	87.00%
LICA	3.67%	0.00%	0.00%	96.33%
LICL	2.67%	16.33%	28.67%	52.33%
LIPI	29.00%	0.00%	0.00%	71.00%
LISY	1.67%	5.33%	0.67%	92.33%
PSCR	0.33%	6.00%	59.00%	34.67%
PSMA	33.33%	0.00%	0.00%	66.67%

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

Error rates for automated detection algorithms are generally very low (<5%; Table D2). Exceptions are Northern Leopard Frog and Boreal Chorus Frog (PSMA), which return high false presence rates. For the remaining species, few false presences are returned by the automated detection process and all false presences are rejected by the proofing process.

Appendix E. Cumulative Data Collection Results

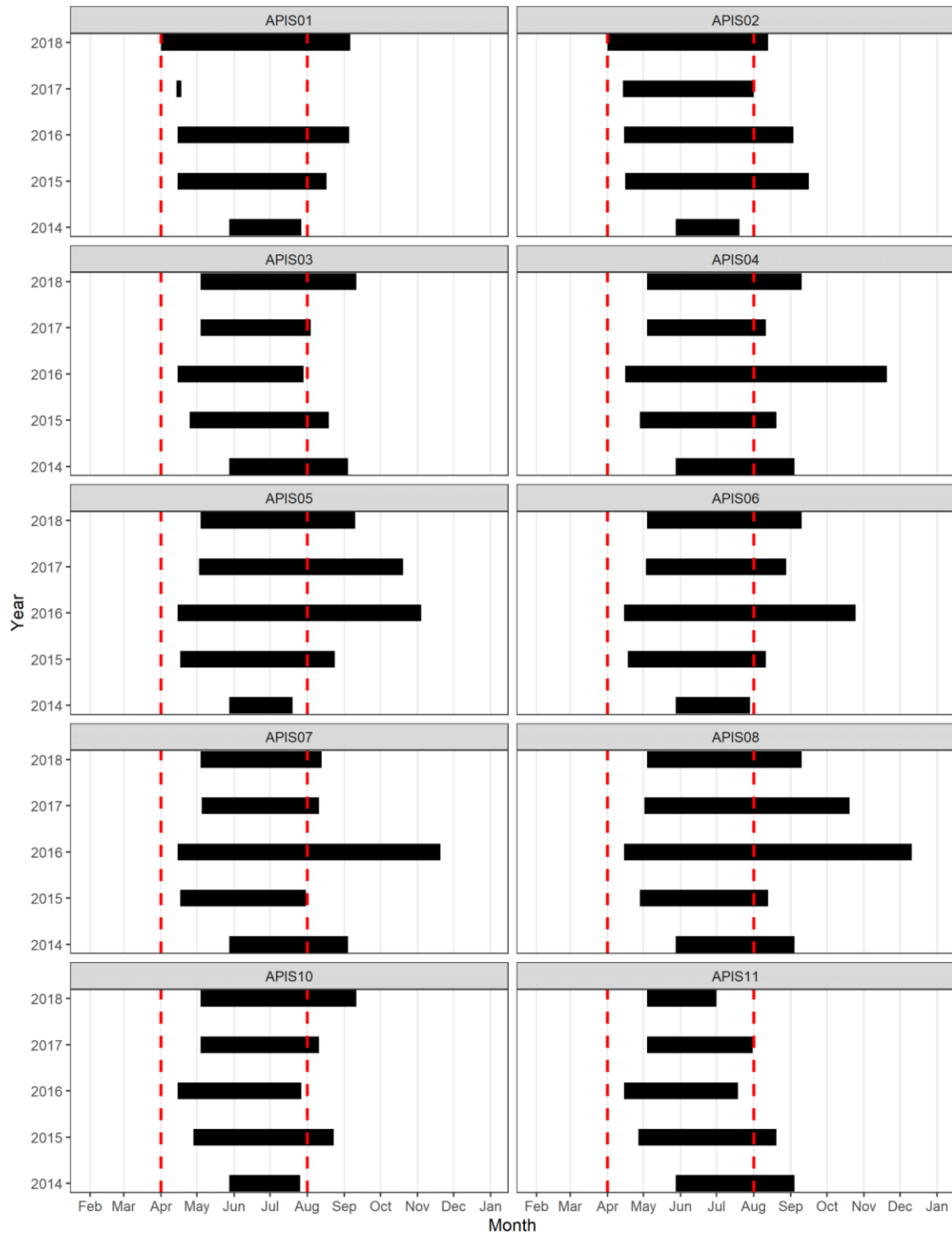


Figure E1. Successful data collection periods are shown for each site in each year. Our goal is to consistently collect data between April and August each year.

Appendix F. Cumulative Occupancy Record

The multi-year occupancy record (Figure F1) provides preliminary site occupancy trends. Dots indicate confirmed presence, while the absence of a dot indicates assumed absence (not detected by any method). Assumed 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 was present at every site in 2015 and 2016, but assumed absent at APIS06 in 2017 or 2018, or at APIS10 in 2018. Cope's Gray Treefrog was detected once in 2015 and not since. Gray Treefrog presence is sporadic but was detected at fewer sites in 2018 than in previous years. Green Frog was detected at more sites than ever in 2018 (all sites). Mink Frog was detected for the first time at APIS07 in 2018, although detection methods for this species were recently improved by adding early morning samples. Wood Frog reappeared at APIS02 after a two-year period of non-detection, but remains undetected from APIS05 and APIS06, which had earlier year detections. Spring Peeper has been detected at every site in every year.

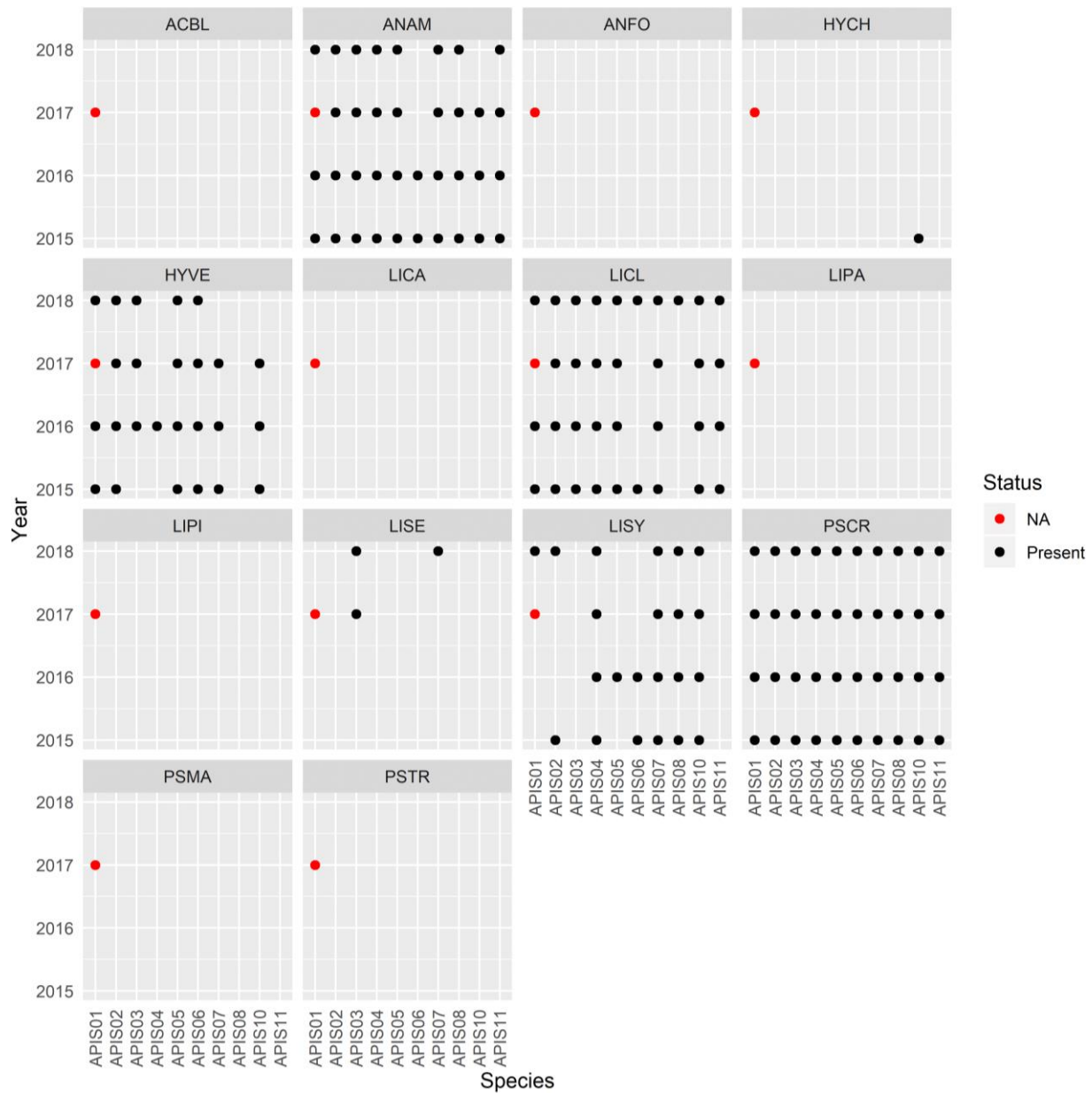


Figure F1. Cumulative occupancy record for each species and site at APIS since 2015. An 'NA' value indicates that there was insufficient sampling to determine occupancy. Dots indicate occupancy; no dot indicates the species was absent.

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