



Acoustic Amphibian Monitoring, 2018

Isle Royale National Park

Natural Resource Data Series NPS/GLKN/NRDS—2020/1291



ON THE COVER

A calling Gray Treefrog (*Hyla versicolor*) was documented for the first time near Windigo in 2018.
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Acoustic Amphibian Monitoring, 2018

Isle Royale National Park

Natural Resource Data Series NPS/GLKN/NRDS—2020/1291

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Abstract

The National Park Service Great Lakes Inventory and Monitoring Network (GLKN) established ten permanent acoustic amphibian monitoring sites at Isle Royale National Park (ISRO) in 2015. Digital acoustic samples of 5-minute duration are collected by placing automated recorders with omnidirectional stereo microphones at each site. Temperature loggers co-located with the recorders collect air temperature during the sample period.

The monitoring program detected six species of frogs and toads at ISRO in 2018, including the first confirmed occurrence of Gray Treefrog near Windigo. Three species were found at nearly every site: Eastern American Toad, Green Frog, and Spring Peeper. Gray Treefrog and Boreal Chorus Frog were found at only single sites each. Northern Leopard Frog and Mink Frog were not detected at monitored sites in 2018.

We expanded analyses and reporting in 2018 to address calling phenology and to provide additional metrics 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 methodology for analyzing false presence error rates from automated detection algorithms, as a correction factor for estimating the number of samples with automated detections annually for each species.

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 in 2018 did not meet program goals for sampling early calling species due to several late deployments, however new recorders supplied in 2019 and options for fall deployments on delayed starts should resolve this issue moving forward.

A recent publication on splash pools at Isle Royale National Park (Egan et al. 2015) also alerted us to additional data now available for the rare Boreal Chorus Frog. The species uses splash pool habitats along the southeastern coastal areas and appears to be more widespread than previously reported. However, we have only one monitoring site currently established in this unique habitat (ISRO10 on Passage Island). This species is not showing up in interior wetlands. We recommend considering adding one or more additional recorders to better monitor this rare species in this unique habitat, if funding can be found. Since several potential sites are very accessible near the Mott Island headquarters, deploying additional units should be fairly easy. Costs for new units are a one-time capital expense of ca. \$1,000 plus ca. \$350/year for data analysis.

Appendices present summaries of five years of cumulative results.

Introduction

The National Park Service Great Lakes Inventory and Monitoring Network (GLKN) established 10 permanent acoustic amphibian monitoring sites at Isle Royale National Park (ISRO) in 2015. 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.

Seven frog and toad species are known to occur at ISRO, with one additional species possibly present (Northern Leopard Frog; Table 1). All eight species are monitored 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 B and C.

Table 1. Species monitored and their current status at Isle Royale National Park.

Common Name	Scientific Name	Code	ISRO Status	ISRO Calling Period Analyzed
Blanchard's Cricket Frog	<i>Acris blanchardi</i>	ACBL	Absent	NA
Eastern American Toad	<i>Anaxyrus americanus americanus</i>	ANAM	Present	20 April–31 July
Fowler's Toad	<i>Anaxyrus fowleri</i>	ANFO	Absent	NA
Cope's Gray Treefrog	<i>Hyla chrysoscelis</i>	HYCH	Absent	NA
Gray Treefrog	<i>Hyla versicolor</i>	HYVE	Present	15 May–31 July
Treefrog spp.	<i>Hyla</i> spp.	HYSP	Present	15 May–31 July
American Bullfrog	<i>Lithobates catesbeianus</i>	LICA	Absent	NA
Green Frog	<i>Lithobates clamitans</i>	LICL	Present	10 May–31 July
Pickerel frog	<i>Lithobates palustris</i>	LIPA	Absent	NA
Northern Leopard Frog	<i>Lithobates pipiens</i>	LIPI	Unconfirmed	1 April–31 May
Mink Frog	<i>Lithobates septentrionalis</i>	LISE	Present	1 June–31 July
Wood Frog	<i>Lithobates sylvaticus</i>	LISY	Present	1 April–30 June
Spring Peeper	<i>Pseudacris crucifer</i>	PSCR	Present	1 April–31 July
Boreal Chorus Frog	<i>Pseudacris maculata</i>	PSMA	Present	1 April–1 July
Western Chorus Frog	<i>Pseudacris triseriata</i>	PSTR	Absent	NA

Methods

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. 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). Final site selection for ISRO monitoring stations were six permanent wetlands (sites 1, 4–8), three semi-permanent (sites 2, 3, and 10), and one ephemeral (site 9).

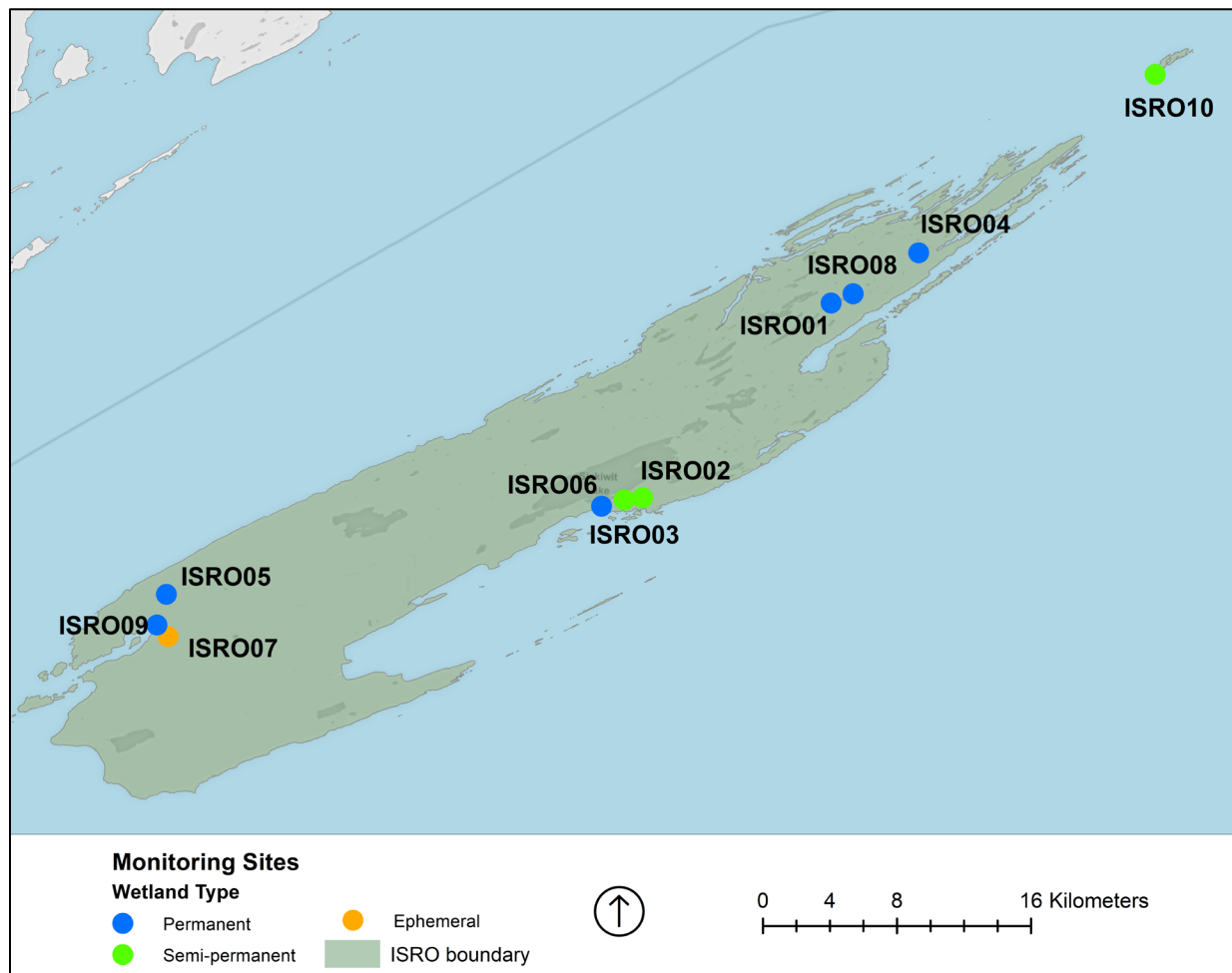


Figure 1. Map of the ten monitoring sites chosen at Isle Royale National Park.

Data Collection

Automated Recording Systems

An automated recording system (ARS) with omnidirectional stereo microphones (Wildlife Acoustics, Inc., Concord, MA USA; Song Meter models SM3 and SM4) is placed at each monitoring site. They are programmed to record seventeen 5-minute samples each day on the top of each hour from 15:00h to 03:00h. Four extra samples are collected immediately after sunset on the half-hour mark. An additional three samples are collected at 04:00h, 05:00h, and 06:00h 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 saved as .wav files 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.

Temperature Logs

Temperature loggers (HOBO Pendant® model UA-002-08, Onset Computer Corporation, Bourne, MA, USA) are co-located with the ARS and programmed to record air temperature every hour. This information is used for filtering data analyses so that only recordings collected when ambient air temperature is $\geq 40^{\circ}\text{F}$ are used for manual surveys. Temperature loggers are typically attached underneath the roof of the ARS mounting backboard (Figure 2) or hung within solar shields. 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. An automated recording device deployed in the field. This device is attached to a backer board and strapped to a tree trunk. The temperature logger is located under the backboard roof.

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 for each species 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 for each species, with proofing limited to within the calling periods determined from annually updated results. 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 in four parks (Apostle Islands, Isle Royale, Grand Portage, and Pictured Rocks), 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

Acoustic Recorder Deployment Success

No ARS programming errors were evident in 2018. Most programmed samples successfully recorded on the days that the recording devices were operational (Figure 3), with some sampling gaps at sites 1, 3, 5, 7 and 9. The reason for these failures to record samples is not apparent, but may be related to aging SM2+ ARS models malfunctioning. New SM4 model ARS units deployed in 2019 should resolve this issue. See Appendix A for a figure showing each recording for each site during the 2018 field season.

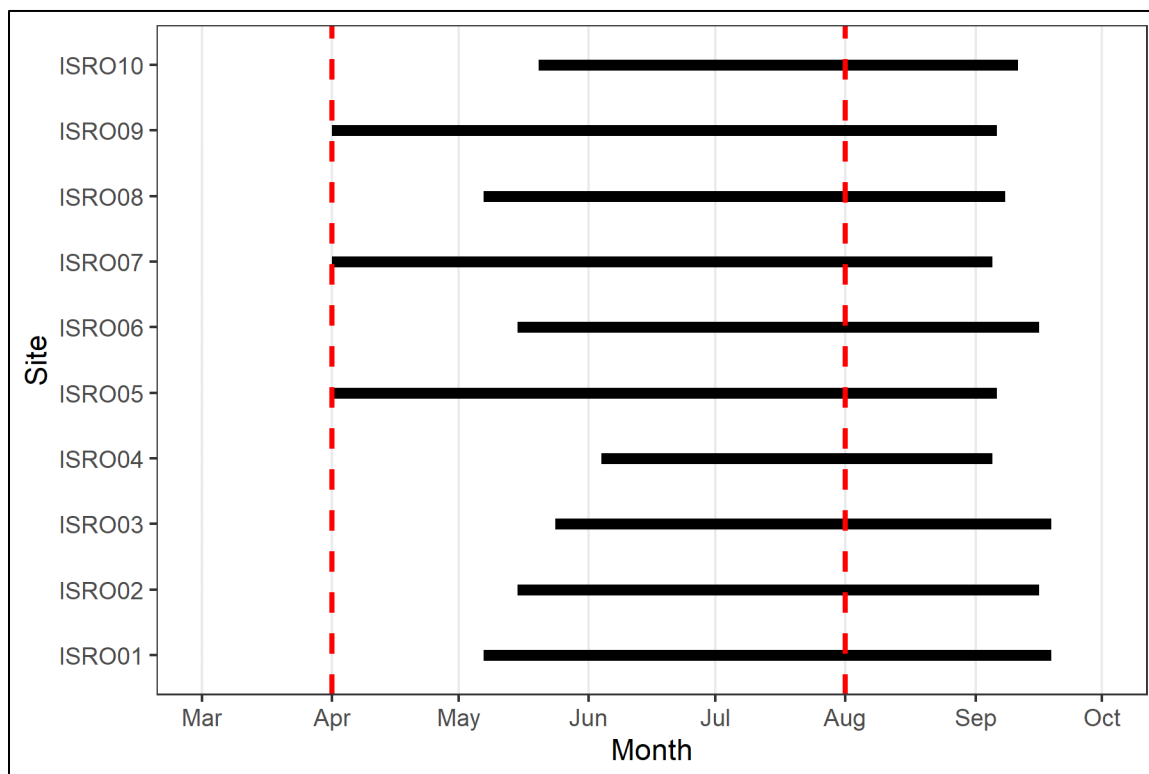


Figure 3. Successful recording periods for Isle Royale National Park, 2018. Red lines indicate the target sampling period.

Temperature Logs

Temperature data was not collected at sites 2, 3, 6, and 10. For data analyses we used the nearest available temperature data to filter samples for meeting a minimum 40°F threshold. Daily maximum temperatures were exceeding the threshold of 40°F as soon as ARS were deployed for sites 1, 4, and 8 (Figure 4). Frogs at these sites likely started calling before sampling began.

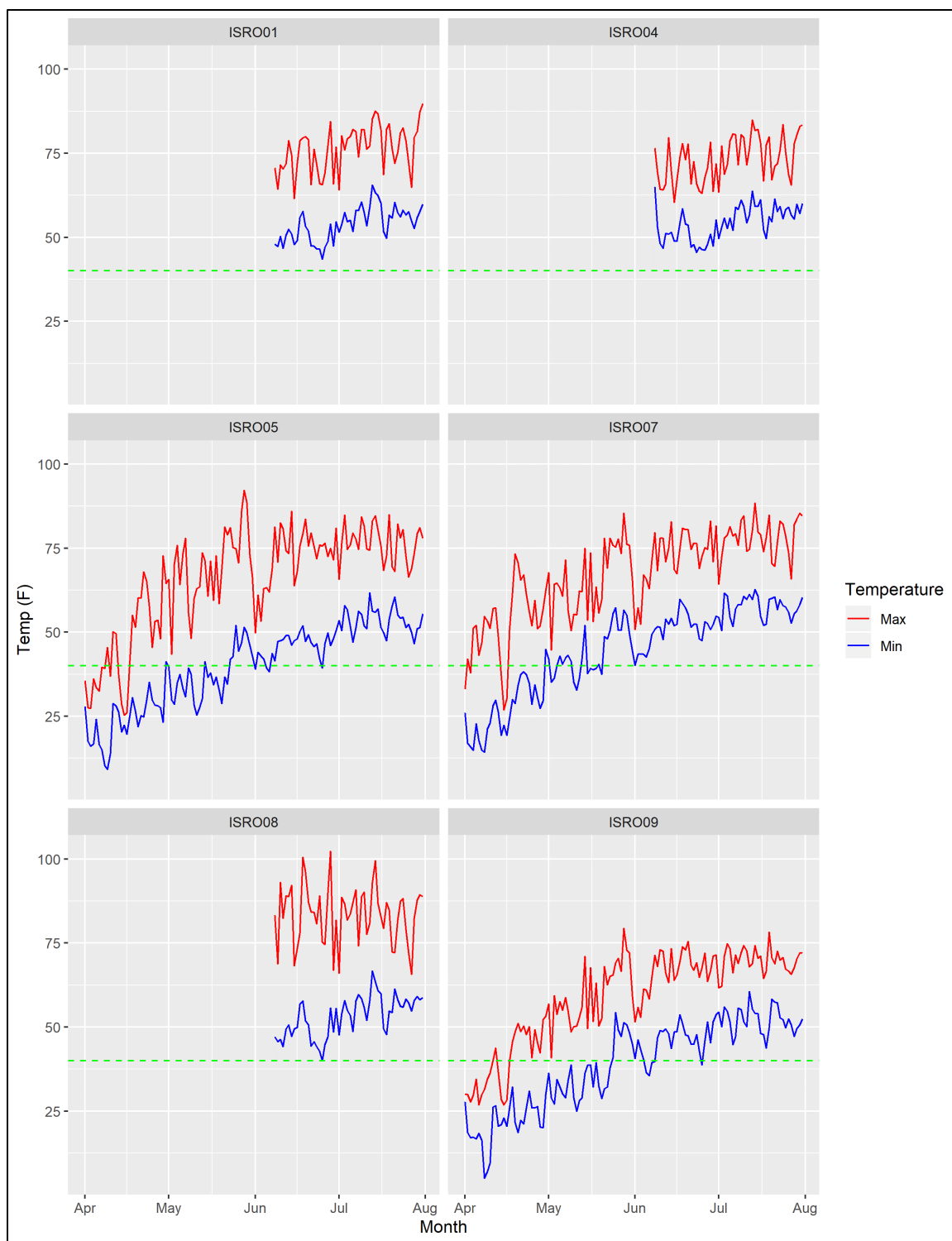


Figure 4. Temperature logs for each ISRO site in 2018. The red line depicts daily maximum temperature; blue line daily minimum temperature. The green line is the 40°F minimum temperature threshold for selection of samples for manual scanning. This figure only shows data from the target sampling period of 1 April through 31 July.

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.

These 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 phenology 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.

At ISRO in 2018, earliest calling dates (Figure 5) for Eastern American Toad (ANAM) were highly inconsistent. It is premature to speculate on possible explanations for this, but we note that this species appears very opportunistic in breeding (especially in extreme environments), has an extended calling season, and that once a single toad starts up it often attracts others within hearing range (perhaps increasing detection probabilities). This is the first confirmation for Gray Treefrog (HYSP) on ISRO. Green Frog earliest calling dates were fairly synchronous given the varying conditions at wetlands subject to lake effects.

As expected from climate differences, frogs begin calling earlier at more southerly parks and later at more northern parks. ISRO start dates were among the latest, as is expected from a northern park surrounded by the cool waters of Lake Superior (Figure 6). Late first-calling dates typically represent lone frogs at sites where no breeding population is established.

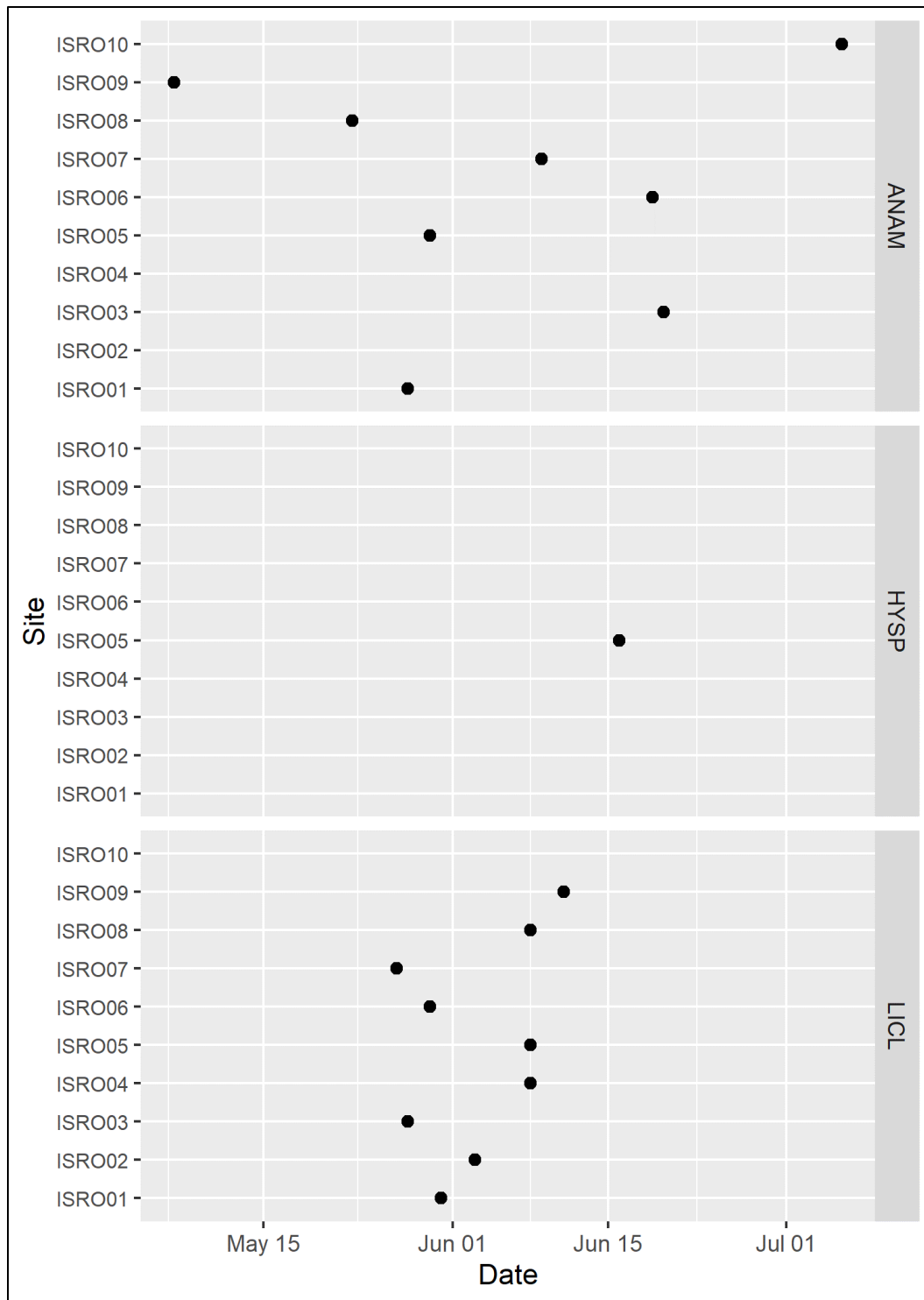


Figure 5. Dates of first confirmed detections for Eastern American Toad (ANAM), Treefrog spp. (HYSP), and Green Frog (LICL) at Isle Royale National Park, 2018.

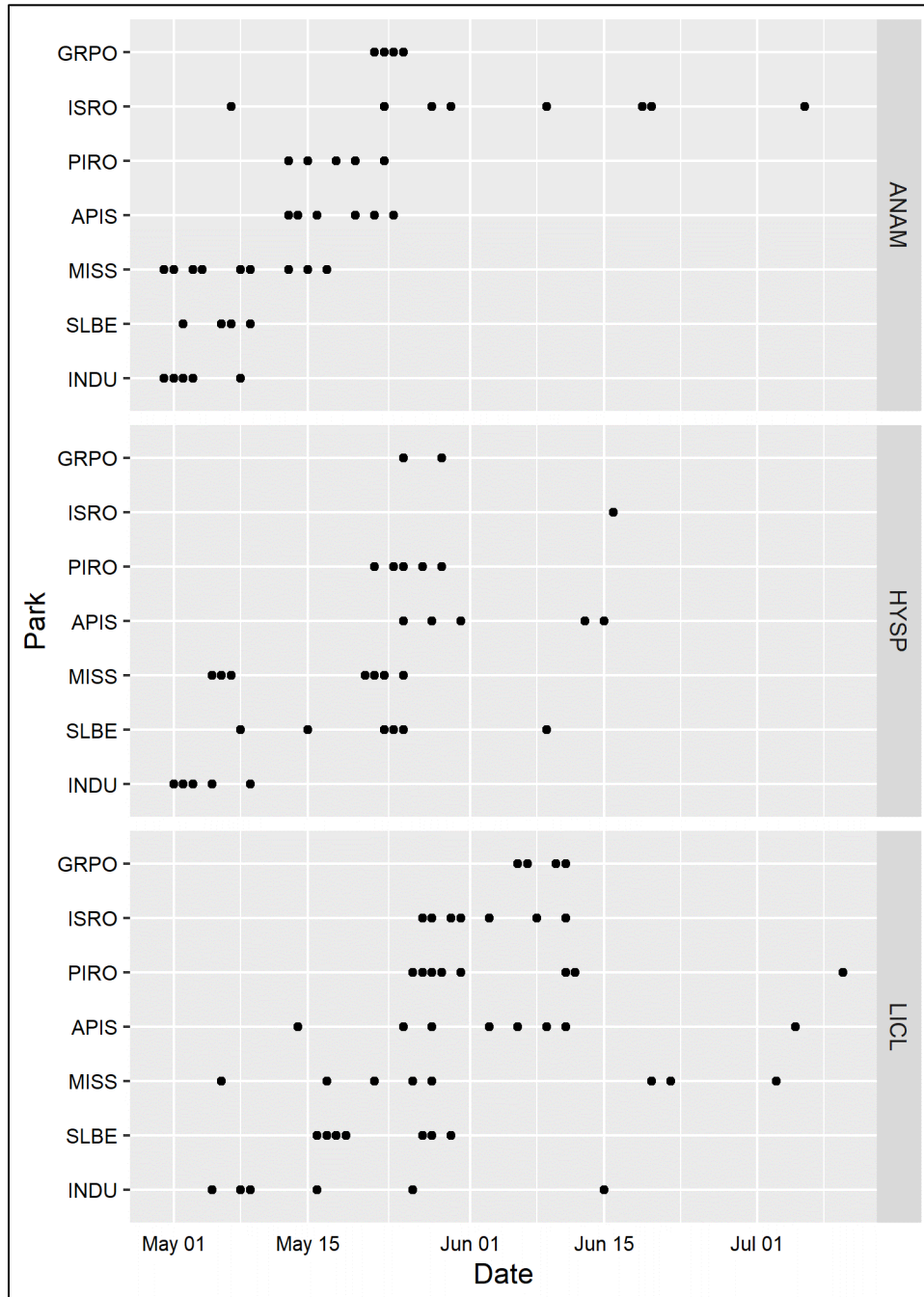


Figure 6. First detection dates of three species for all parks conducting monitoring, 2018. Parks (ordered north to south): GRPO = Grand Portage, ISRO = Isle Royale, PIRO = Pictured Rocks, APIS = Apostle Islands, MISS = Mississippi River, SLBE = Sleeping Bear Dunes, INDU = Indiana Dunes. ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog.

Call Index Values (CIV)

We also track calling intensity among the 30 samples manually scanned at each site, as the proportion of samples falling within each of three call intensity rank values (Figure 7). CIV is scored

in manual scanning where Cope's Gray Treefrog and Gray Treefrog are identified to species and hence are reported on separately. For example, in 2018 at ISRO02 Green Frog (LICL) had more samples with a CIV of 1 than 3, while the reverse pattern is shown for Spring Peeper (PSCR) at ISRO02. 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.

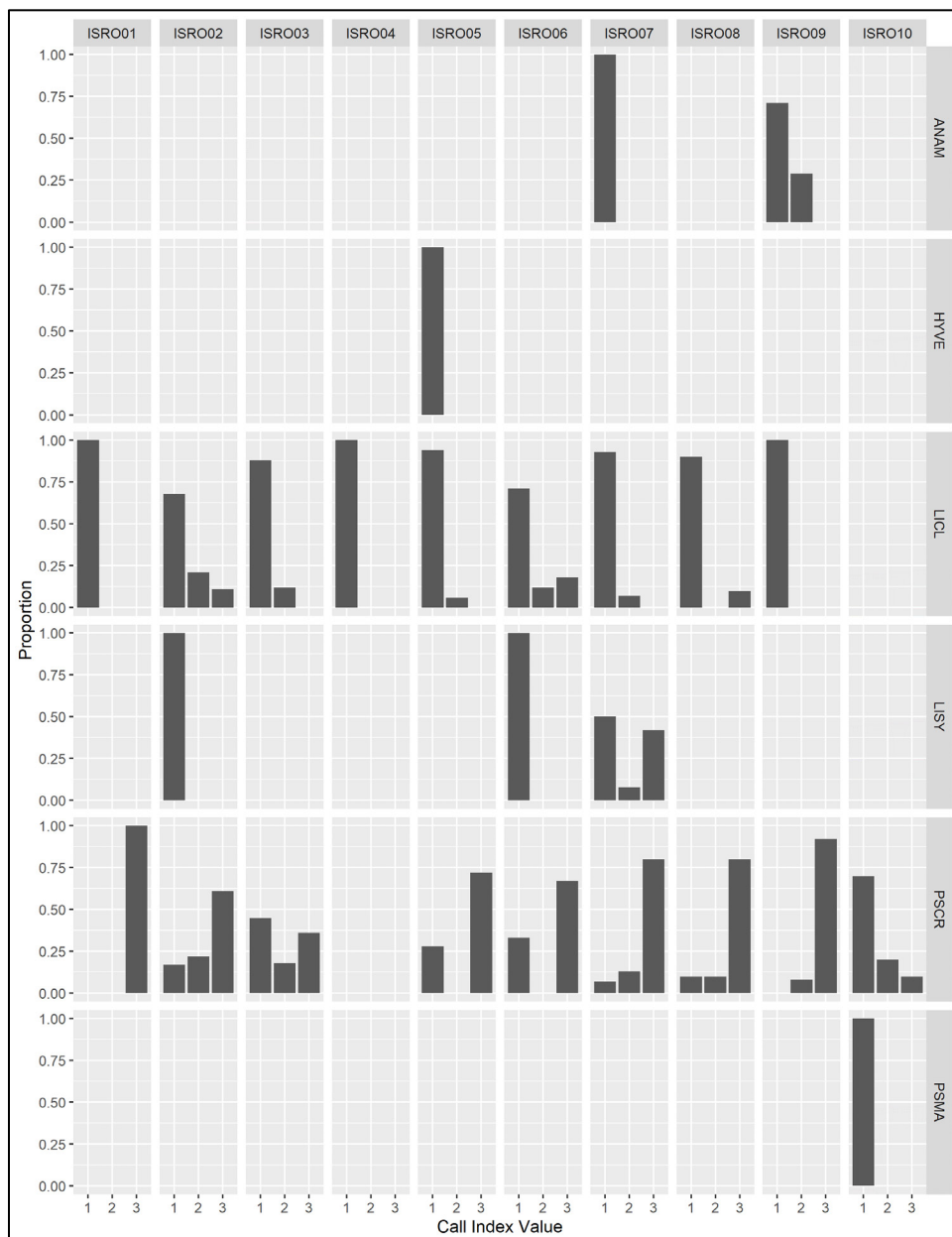


Figure 7. Call Index Value (CIV) distribution for each species at each site at Isle Royale National Park, 2018. Only species detected on at least one site are displayed. ANAM = Eastern American Toad, HYVE = Gray Treefrog, LICL = Green Frog, LISY = Wood Frog, PSCR = Spring Peeper, PSMA = Boreal Chorus Frog.

At ISRO in 2018 Green Frog (LICL), Spring Peeper (PSCR), and Wood Frog (LISY) were detected at the maximum CIV of 3 at one or more sites. Note, however, that the relationship between this calling activity metric and actual population size varies among species, and this metric is designed to measure relative abundance within a species across years, rather than to compare abundance among species.

Automated Detection Rates

Before calculating automated detection rates for each species, we first assessed error rates in automated detection. This was done 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 because 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 it was not 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). For more details regarding detection error types, see Appendix B.

Overall agreement rates for automated detections ranged from 0.00% to 92.44% (Table 2). For example, Green Frog (LICL) was found in 86 of the 300 samples that were manually surveyed. Of these 86 samples, the automated method identified Green Frog in 73 of these, giving an overall agreement rate of 84.88%.

It is important to keep this analysis in context. While agreement rates for the two surveys may sometimes seem poor on the 300 samples compared, agreement on site occupancy is typically much better, which was the original goal for developing the automated detection algorithms. This is because the algorithms only identify high quality recordings, which are usually found within the hundreds of samples analyzed at each site but not necessarily within the 30 samples manually scanned at each site. This was an intentional trade off to reduce the number of false positives in automated detection.

Table 2. Automated detection error rates for samples where manual verification identified a species in the sample. ANAM = Eastern American Toad, HYSP = Treefrog spp., LICL = Green Frog, LISY = Wood Frog, PSCR = Spring Peeper, PSMA = Boreal Chorus Frog.

Species	Number of Samples with Species Detected Manually	Number of Matches on Automated Detection	Agreement (%)
ANAM	7	0	0%
HYSP	1	0	0%
LICL	86	73	84.88%
LISY	13	1	7.69%
PSCR	119	110	92.44%
PSMA	7	1	14.29%

Figure 8 displays the automated detection rates for each species at each site in 2018. Eastern American Toad (ANAM) was confirmed at all but three sites, but with consistently low rates. A single calling male Treefrog spp. (HYSP; was Gray Treefrog) was confirmed at one site. Green Frog (LICL) was detected at all sites except ISRO10 (the Passage Island splash pool), with highest detections at ISRO04. Wood Frog (LISY) was confirmed only at ISRO05 and ISRO07. Spring Peeper (PSCR) had consistently high detection rates at every site except ISRO04, which ARS began recording late (4 June). While Spring Peeper was not detected in either automated or manual after sunset surveys at ISRO04, upon further review of the data a CIV of 1 was noted in sample ISRO04_20180604_150000.wav, indicating the species was present in low numbers and this is a rare false absence for this species in the program analyses. Boreal Chorus Frog was detected only at ISRO10 (as has been the case in all program years). No Northern Leopard Frog or Mink Frog were detected in 2018.

Compared to other parks, detection rates at ISRO were relatively low for all species except Green Frog (LICL) and Spring Peeper (PSCR; Figure 9).

For site occupancy conclusions at ISRO in 2018, automated results reported only two false absences compared to manual results: Wood Frog (LISY) at sites 2 and 6. The manual process reported seven false absences (where species presence was confirmed only by automated detection in samples not selected for manual scanning): Eastern American Toad (ANAM) at sites 1, 3, 5, 6, 8, and 10; and Wood Frog (LISY) at site 5. Both methods reported a false absence for Spring Peeper at ISRO04. The error rates calculated here for automated detections are only utilized to improve the accuracy of the percent of samples with detections reported in Figure 6, a new metric developed in 2018.

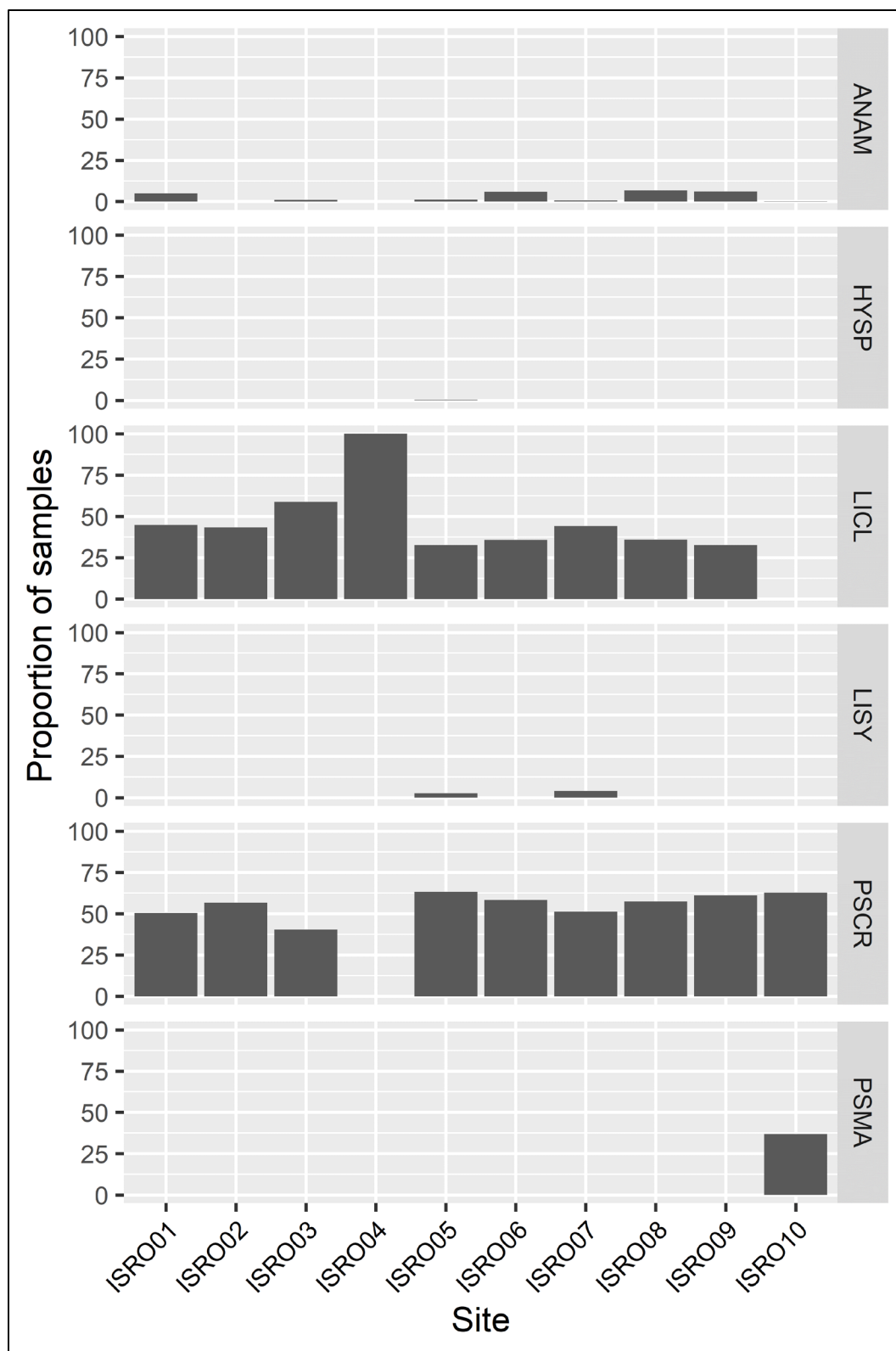


Figure 8. Percent of samples with automated detections by species at each site at Isle Royale National Park in 2018. From top, Eastern American Toad (ANAM), Treefrog spp. (HYSP), Green Frog (LICL), Wood Frog (LISY), Spring Peeper (PSCR), and Boreal Chorus Frog (PSMA).

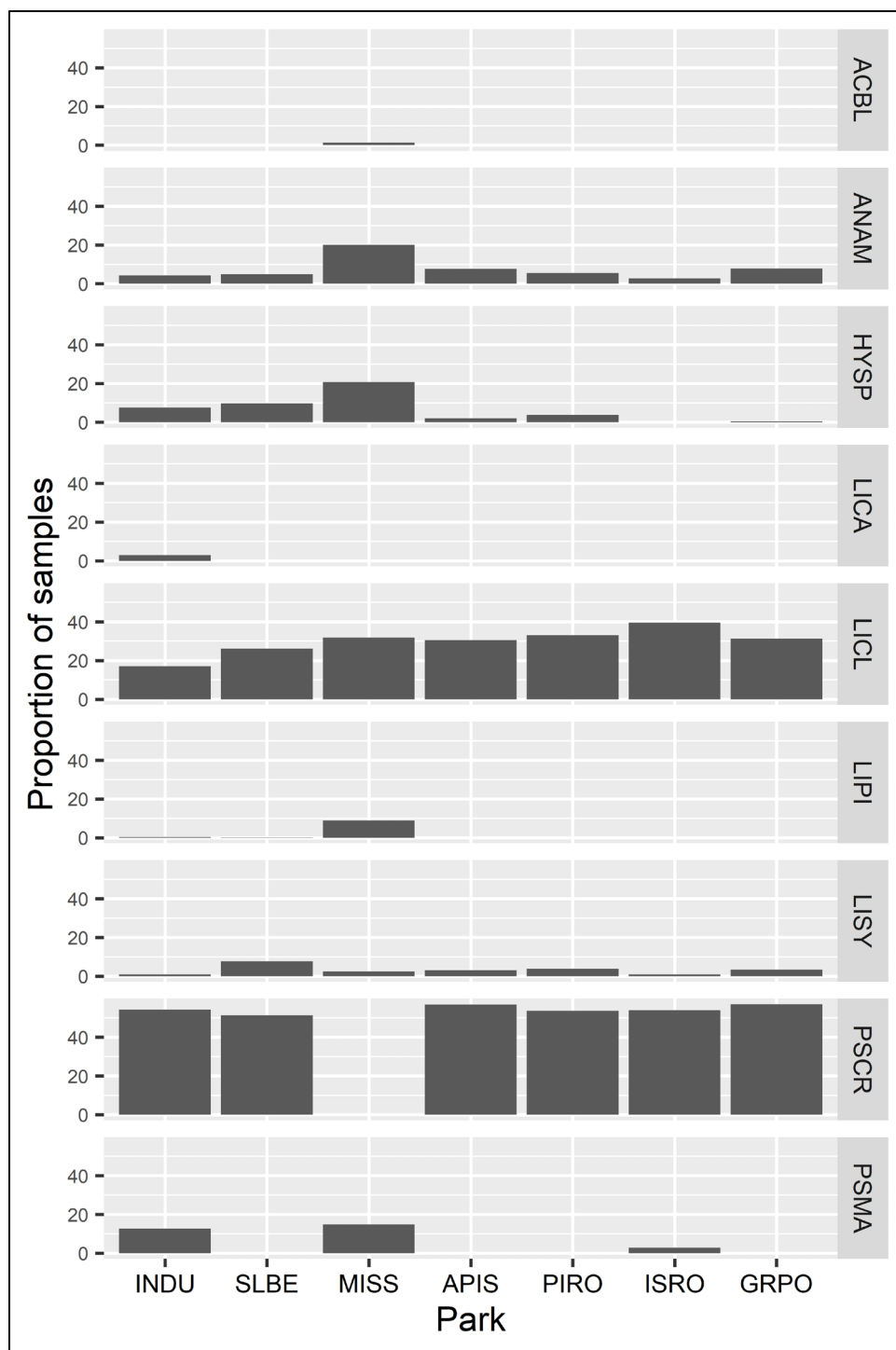


Figure 9. Percent of samples with automated detections by species across parks monitored in 2018 (parks ordered south to north). Only species detected at any park are shown. Blanchard's Cricket Frog (ACBL) potentially occurs at only three parks (INDU, MISS, SLBE). From top, Blanchard's Cricket Frog (ACBL), 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).

Discussion

The monitoring program detected six species of frogs and toads at ISRO in 2018, with three species occurring at nearly every site: Eastern American Toad (ANAM), Green Frog (LICL), and Spring Peeper (PSCR). Gray Treefrog (HYSP; a single male Gray Treefrog) and Boreal Chorus Frog (PSMA) were found at only one site each. Northern Leopard Frog (LIPI) and Mink Frog (LISE) were not detected at monitored sites in 2018.

We expanded analyses and reporting in 2018 to address calling phenology, and to provide additional metrics 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 an accurate 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 B.

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, and this more southern frog is confirmed only at INDU. Mink Frog calls are quiet, often obscured by noise or the calls of Green Frog, and 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. However, Cope's Gray Treefrog does not occur on ISRO or on the north shore of Lake Superior, where all *Hyla* are *H. versicolor*. These difficult species are nevertheless adequately monitored by the dual survey approach but do have higher false absence rates than other species (see Appendix B).

Data collection issues in 2018 were of some concern, with most ARS not operational in the field until after daytime temperatures reached 40°F (see Figures 3 and 4 and Appendix A). This means that sampling effort for early calling species like Boreal Chorus Frog, Wood Frog, and Northern Leopard Frog was not consistent with program goals. We recommend continuing fall deployments on delayed starts, with early spring equipment checks, to resolve this issue. Also, aging SM2+ ARS units were replaced with new SM4 units in 2019, which should be more reliable and have improved battery life.

Cumulative result summaries are provided in Appendices C and D. 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, which 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.

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Appendix A. ARS Samples

No ARS programming errors were evident in 2018. Most programmed samples successfully recorded on the days that the recording devices were operational (Figure A1), with some sampling gaps at sites 1, 3, 5, 7 and 9. The reason for these failures to record samples is not apparent, but may be related to aging SM2+ ARS models malfunctioning. New SM4 model ARS units deployed in 2019 should resolve this issue.

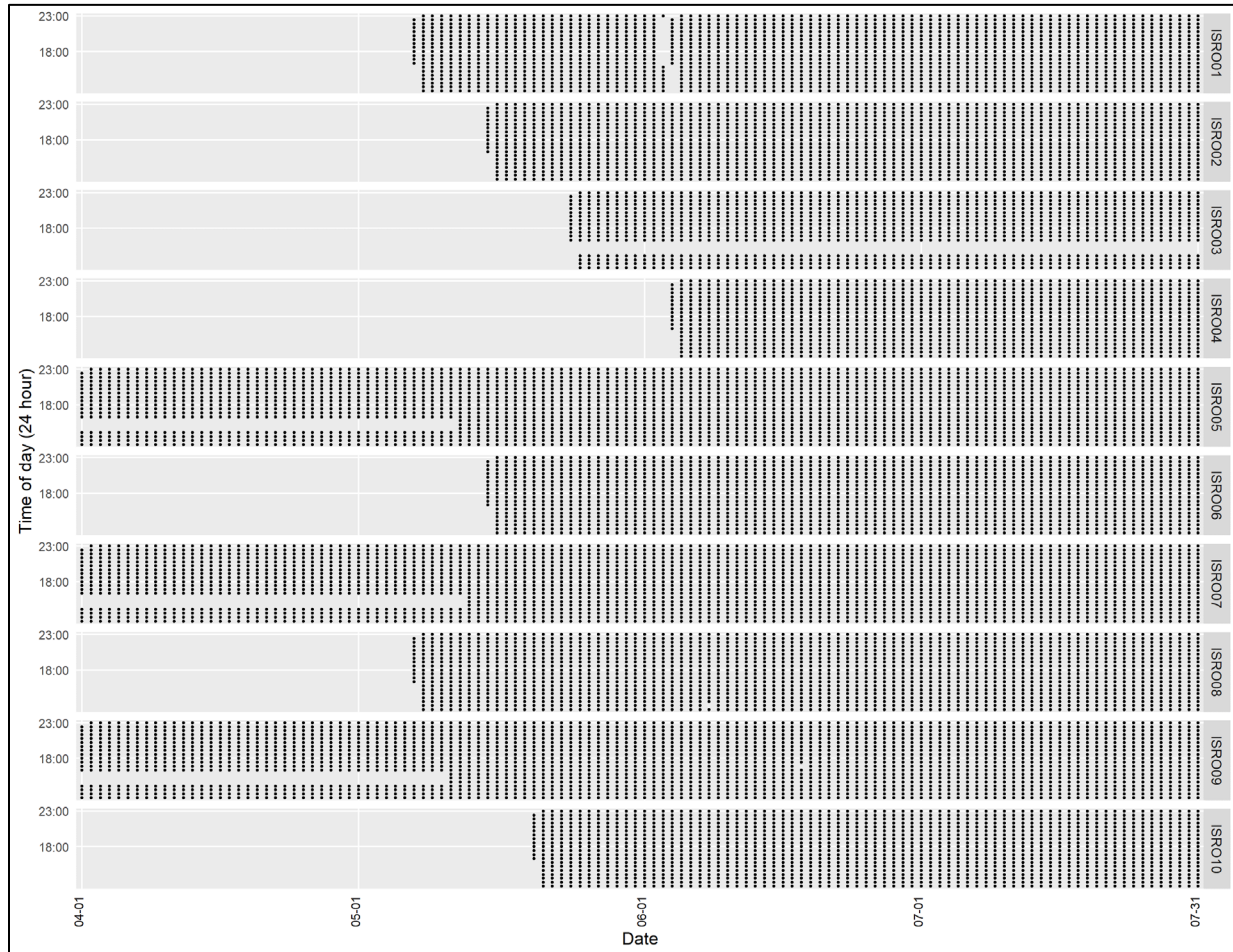


Figure A1. Sampling success for ARS units deployed at Isle Royale National Park, 2018. Each dot represents a recording. Figure only shows the analysis period of 1 April through 31 July.

Appendix B. Automated Detection Error Analysis

The number of samples from all ISRO sites with any detection for each species in 2018 is presented in Table B1. For example, Green Frog (LICL) was detected in 86 of 300 samples by manual scans, with automated detections agreeing in 73 of these and returning false absences in 13. False presences in the last row of Table B1 do not affect occupancy conclusions, but rather are used for estimating automated detection error rates. These false presences were not entered into the site occupancy record as they were all rejected by the automated detection proofing process.

Table B1. 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 (N=300).

Manual ID	Auto ID							
	ANAM	HYSP	LICL	LIPI	LISY	PSCR	PSMA	None ^a
ANAM	0 ^c	–	–	–	–	–	–	7
HYSP	–	0 ^c	–	–	–	–	–	1
LICL	–	–	73 ^c	–	–	–	–	13
LIPI	–	–	–	0 ^c	–	–	–	0
LISY	–	–	–	–	1 ^c	–	–	12
PSCR	–	–	–	–	–	110 ^c	–	9
PSMA	–	–	–	–	–	–	1 ^c	6
None ^b	0	0	60	0	0	23	0	1819

^a The 'none' column represents the number of samples with a manual detection with no automated detection.

^b The 'none' row represents the number of samples with an automated detection with no manual detection.

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

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). Commission error rates will be utilized as correction factors when comparing the number of samples with detections at each site across years for tracking trends in abundance (the number of putative automated detections will be reduced by this amount annually). Correction factors are derived from Table B2 where error rates are calculated by comparing results from automated detections and manual scans on the same 30 samples per site. Mink Frog is not analyzed because no automated identification algorithm has been developed for this species.

Commission (false presence) error rates returned by the automated detection process were 0% for most species (Table B2). More significant commission error rates were returned for Green Frog (LICL; 27.40%) and Spring Peeper (PSCR; 12.37%). No commission errors enter into site occupancy statistics, as they are rejected by the proofing process. Omission (false absence) error rates were variable in 2018 with some species harder for the algorithms to detect than others. Note that as

calling intensity increases (more frogs present) omission error also increases, as algorithms often cannot identify individual calls in noisy choruses. In these conditions algorithms almost always detect the species at the site later in the night as calling intensity diminishes with falling temperatures; hence, large sample sizes are important. Omission error is addressed in long-term trend analysis models as a false absence rate.

Table B2. Rates of commission, omission, and agreement for automated algorithm results from 30 samples proofed manually at each site (N=300). Commission = false presence, Omission = false absence, Agree = correct result.

Species ^a	Commission ^b	Omission ^c	Agree (present) ^d	Agree (absent) ^e
ANAM	0.00	100.00	0.00	100.00
HYSP	0.00	100.00	0.00	100.00
LICL	27.40	15.12	84.88	72.60
LIPI	0.00	0.00	0.00	100.00
LISY	0.00	92.31	7.69	100.00
PSCR	12.37	7.56	92.44	87.63
PSMA	0.00	85.71	14.29	100.00

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

^b Commission = percent of samples with any putative automated species detection which was not confirmed by manual survey results (false presence rate).

^c Omission = percent of samples without any putative automated species detection which did have manual survey detections (false absence rate).

^d Agree (present) = percent of samples with manual detections that automated surveys also detected, i.e., agreement on species' presence.

^e Agree (absent) = percent of samples without manual detection that automated surveys agreed with.

Appendix C. Cumulative Data Collection Results.

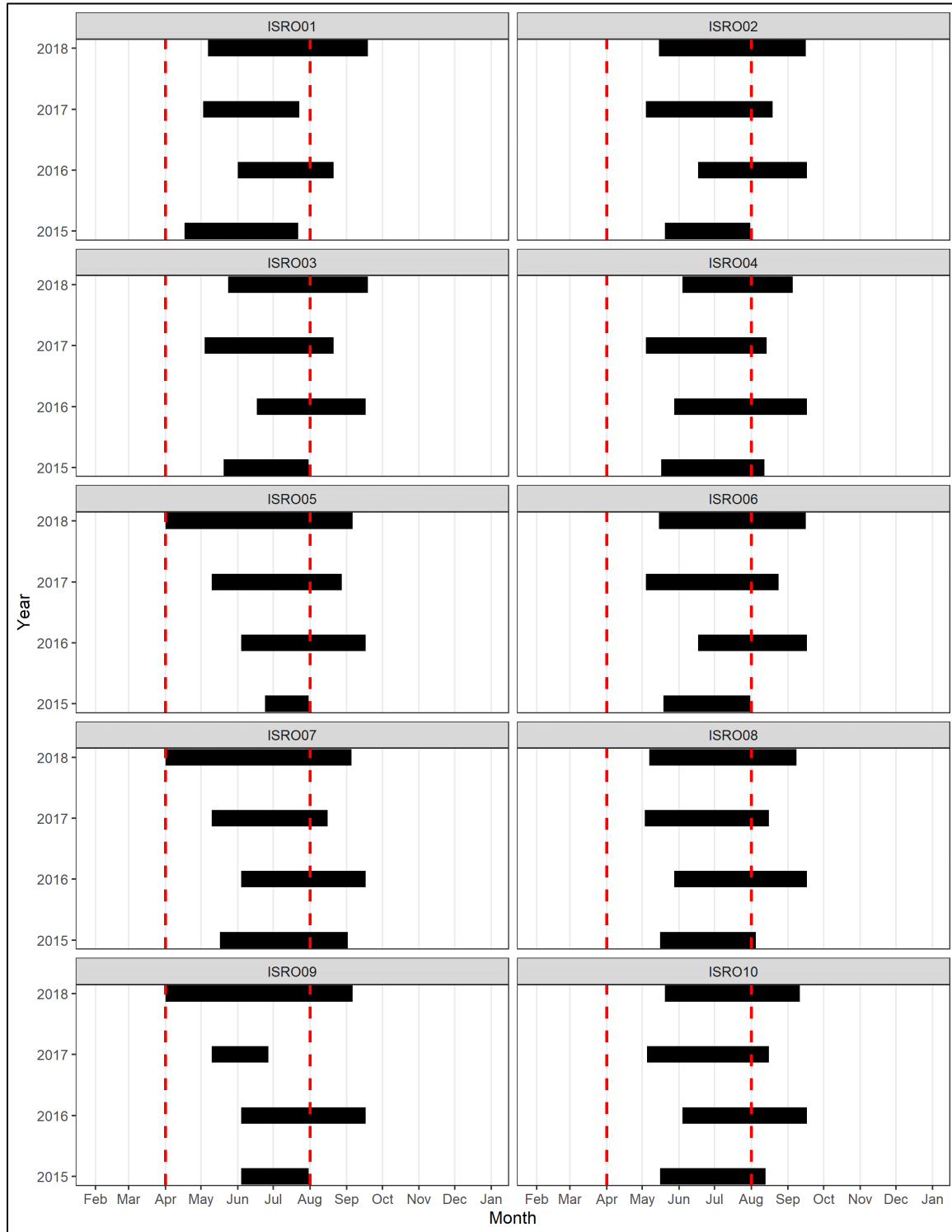


Figure C1. Successful data collection periods for each amphibian monitoring site at Isle Royale National Park, 2015–2018. Red lines indicate target sampling period.

Appendix D. Cumulative Occupancy Record.

The multi-year occupancy record (Figure D1) provides preliminary site occupancy trends. 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.

Eastern American Toad (ANAM), Green Frog (LICL), and Spring Peeper (PSCR) were consistently present at most sites in most years. Gray Treefrog (HYSP) was confirmed in 2018 at ISRO05. This species has been reported previously but this is the first empirical evidence that it is actually present (Casper 2008). Boreal Chorus Frog (PSMA) has persisted at ISRO10 but has not been found at any other monitored sites. The occupancy record for Wood Frog (LISY), an early calling species, is less consistent but should improve with earlier deployment of ARS. Northern Leopard Frog has not been detected at ISRO and no prior records exist. They are however common in the Thunder Bay region (Casper 2008) and could colonize ISRO in the future. Mink Frog, a species with low acoustic detection rates due to quiet calls, is only surveyed by the manual method, and has so far been confirmed only at two sites in 2016. In 2018 additional morning samples were added to programming to better detect this species.

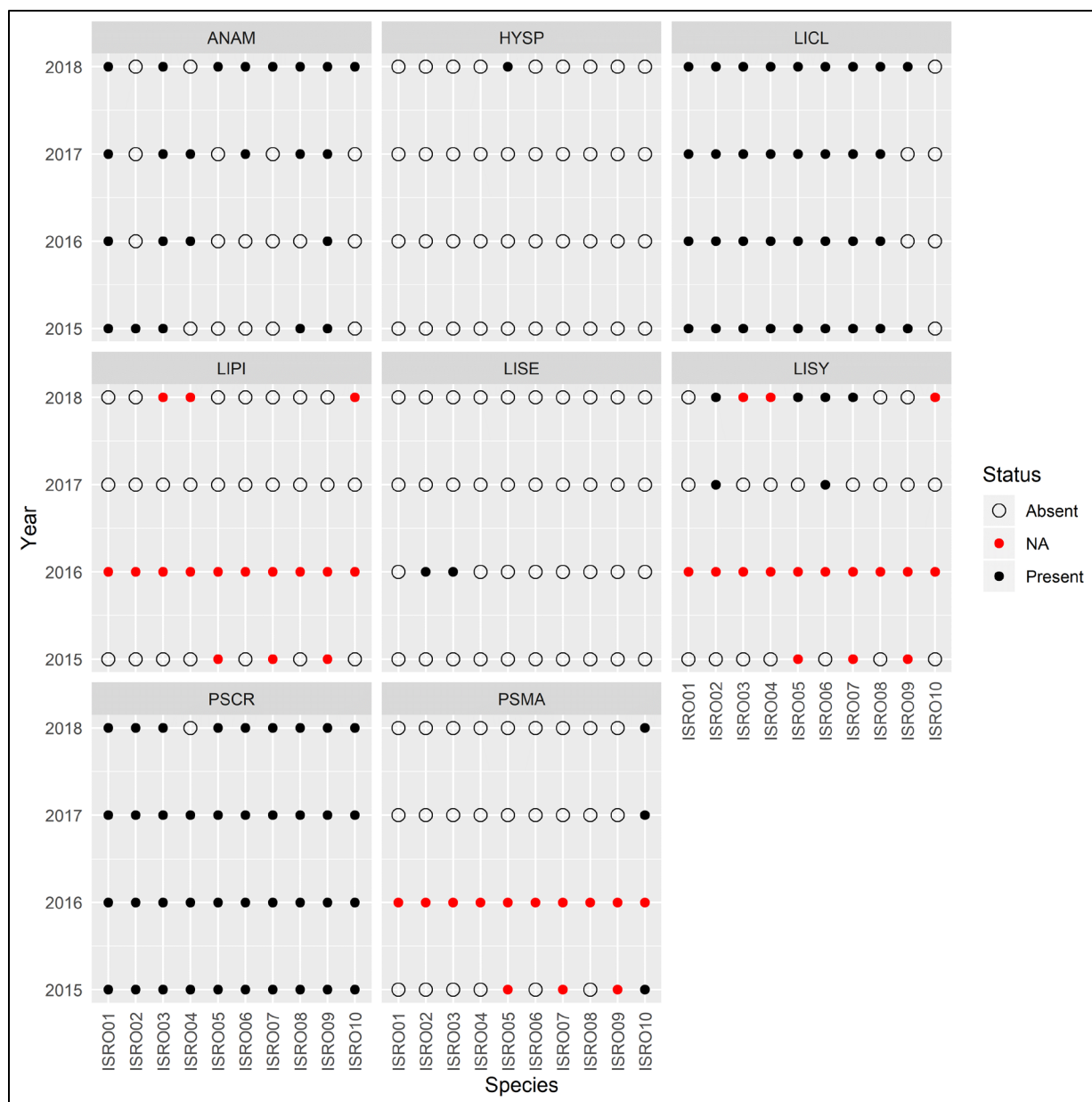


Figure D1. Cumulative occupancy record for each species and site at ISRO since 2015. Black dots indicate occupancy; no dot indicates the species was absent; red dots indicate the sampling was insufficient to draw any occupancy conclusion.

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