

Gulf Coast Network

National Park Service
Inventory and Monitoring Division



Monitoring Amphibians on Gulf Coast Network Parks: Supplemental Information

Close-out of the Pilot Phase and Recommended Modifications for Final Amphibian Monitoring Design

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Summary

This unpublished report is supplemental information to the protocol narrative for Monitoring Amphibians on Gulf Coast Network Parks (Carlson et al. 2018). Included are a detailed overview and a summary of results from the pilot effort in GULN parks from 2011-2017. Also presented are the results of internal and external reviews of the protocol's design and the network's responses to these reviews.

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Introduction

In the Inventory & Monitoring (I&M) division of the National Park Service, amphibians were selected for monitoring as key indicators of a park's ecological health. For Gulf Coast Network (GULN) parks, three main sampling techniques were proposed for their amphibian monitoring protocol: PVC pipes on trees, coverboards on the ground, and minnow traps in standing water. As early as 2009, the network began testing these techniques during monthly sampling events in all GULN parks except Padre Island National Seashore (PAIS). The trials lasted between several months to more than six years. The longest running studies, with 6+ years of data, were at Jean Lafitte National Historical Park & Preserve (JELA), Gulf Islands National Seashore (GUIS), and San Antonio Missions National Historical Park (SAAN)-Missions unit. Data were collected for five years at two parks: the Natchez Trace Parkway (NATR) and Vicksburg National Military Park (VICK). The pilot studies at San Antonio Missions NHP-Rancho unit and Palo Alto Battlefield National Historical Park (PAAL) lasted two to three years. Finally, the pilot study at Big Thicket National Preserve (BITH) lasted only six months. Despite fairly intensive efforts in some parks, amphibian yields were extremely low in most parks across the three techniques. In 2016, it was decided that data collection would only continue in parks that could produce data sets rich enough for eventual trend analyses on species richness, diversity, or relative abundance (counts per sampling object), based on one or more sampling technique. Only three parks met these criteria and were deemed viable for a monitoring protocol using both PVC pipes and coverboards as artificial cover objects: Jean Lafitte NHP&P, Gulf Islands NS and San Antonio Missions NHP-Missions unit. The 2018 Amphibian Monitoring Protocol is written for these three parks.

The monitoring objectives for the 2018 Amphibian Monitoring Protocol are as follows:

1. Determine species composition of the amphibian communities that use the monitored cover objects (PVC pipes or coverboards) at each site, and determine species richness for native and exotic species separately.
2. Determine the frequency (yes/no detected) and relative abundance (counts per pipe or board) of the more-commonly-encountered amphibian species at each site, and determine trends over time.

To address these objectives in a revised amphibian monitoring protocol, the Gulf Coast Network had to modify its current methodology. The modifications were based on pilot data and external and internal recommendations, all of which are summarized in this report. External recommendations come from two unpublished reports produced by Ellen Cheng at the University of Georgia (UGA). The first is a preliminary analysis of the status and trends in species richness and species diversity in four parks (Cheng 2016). The second is a power analysis on abundance data from nine common species (Cheng 2017). Internally, the network has conducted several additional analyses to address questions that were not considered by the UGA consultant. These findings, along with suggestions from GULN staff members, were central to the protocol's revision process and final content.

This narrative outlines the information available for revising the pilot design and how revisions were made in three main sections. First, there is an overview of Ellen Cheng’s analyses and recommendations. Second, there is a report by the Gulf Coast Network that describes findings on the spatial arrangement of artificial cover objects and the most suitable materials. Third, there is a list of changes to the amphibian protocol, developed in response to Ellen Cheng’s reports and internal recommendations.

Although this report focuses on the three parks where monitoring has been successful, the network recognizes the need to monitor amphibians in the five remaining parks as well. An appropriate monitoring approach for these parks has yet to be determined. One potential approach, which should work in all parks, is a week-long “mini-inventory” repeated in five to eight year intervals using a range of techniques, including area-constrained ground or stream surveys, frog call surveys, drift fences, dip nets, minnow traps, coverboards, PVC pipes, or leaf litter traps in streams. There is currently no time frame or sampling design for this proposed approach, but these could be developed, with park input in the future.

Reports by Ellen Cheng

Cheng (2016): GRAMP* Amphibian Diversity Summary for 2011-2015

Two primary questions were addressed in Cheng (2016): (1) whether there were changes in species diversity and richness from 2011–2015, and (2) whether these variables could be estimated reliably in each site. Four parks were considered: Vicksburg NMP, Gulf Islands NS, Jean Lafitte NHP&P, and San Antonio Missions NHP. *GRAMP stands for “GULN Reptile and Amphibian Monitoring Protocol”, which was the name of the network’s pilot effort for the amphibian vital sign. This acronym is no longer used, and reptiles are no longer monitored under this protocol.

Report Conclusions: The report concludes that no linear trends were apparent in amphibian species richness or diversity thus far; however, five years of data are too few for trend detection in amphibians. Even over longer timespans, trend detection will be difficult because encounter rates are so low for most species. Further, the report provides evidence that a reduction in sampling frequency will have negative consequences for the quality of diversity and richness estimates.

Methods and Results: The analyses in Cheng (2016) focused on three variables: species richness, species diversity, and the dynamic index. Species richness was calculated as the total number of species recorded at least once within a given year, and species diversity included both richness and evenness, based on the maximum number of individuals recorded during a single survey event within a given year. The dynamic index was the number of species observed in a given year or survey event divided by the total number of species recorded at that site during the five-year sampling period. Preliminary comparisons using these three metrics drew into focus the issues of low detection probabilities (or frequent movement on and off site) for most species, as well as the problem of combining relative abundance measures based on different sampling techniques into one diversity measure. No linear trends in species richness or diversity were apparent over the first five years, but annual estimates were deemed unreliable for most parks. Specifically, *it was unclear whether*

undetected species were truly absent or just missed by the sampling for that year. At San Antonio Missions NHP, four of the five species known to occur in the site went undetected for least one year. For Gulf Islands NS, it was ten of fifteen species, and for Jean Lafitte NHP&P, it was seven of fourteen. For Gulf Islands and Jean Lafitte, only 30–45% of the species known to the site were observed in an average survey event, during which 30 coverboards were flipped, 25 minnow traps set and 48–52 pipes checked. The consultant also performed analyses on data that were subsetted to reflect every-other-month sampling. Patterns of change in diversity and richness were often different in the subsetted versus full data sets, suggesting that any reductions in sampling effort would substantially diminish the quality of richness and diversity estimates.

Cheng (2017): Power of GRAMP Surveys to Monitor Amphibian Abundance

Three primary questions were addressed in Cheng (2017): (1) whether the current GULN sampling effort is sufficient to allow for detection of trends in relative abundance of nine common species over five or 10 years; (2) whether monthly effort could be reduced to alternate months; and (3) whether increasing the number of pipes and boards by 50% per site would improve trend detection. Four parks were considered (VICK, GUIS, JELA, and SAAN) and the time range for the preliminary data was 2011–2015.

Report Conclusions: Based on Cheng (2017), the network will not have the power to detect a net increase or decrease in species relative abundance of up to 54% over 10 years under the current sampling regime, even in parks where pipe or board yields are relatively high. However, given that sampling every other month provides equivalent power as the current monthly sampling regime, the network could potentially shift effort to alternate months. The network should also measure more covariates and sample more sites per park.

Methods and Results: The first step by Cheng (2017) was to estimate how much of the variation in species abundance was attributed to variation across-years, within-years, and by location, using the first five years of pilot data. This pilot data set was also used to estimate the effects of covariance parameters on species abundance, including time of year, temperature, relative humidity, and rainfall. The species selected for these analyses are listed in Table 1.

Table 1. Amphibian (and one reptile) species used in study of statistical power of abundance data.

JELA	GUIS	SAAN	VICK
<i>Hyla mix Squirrel & Green</i>	<i>Eleutherodactylus planirostris</i>	<i>Eleutherodactylus cystignathoides</i>	<i>Eurycea guttolineata</i>
<i>Lithobates clamitans</i>	<i>Hyla mix Squirrel & Green</i>	<i>Incilius nebulifer</i>	<i>Scincella lateralis</i>
<i>Eleutherodactylus planirostris</i>			

The second step was to simulate 500 ten-year data sets of count data for each species, with each data set reflecting the variance and covariance parameters from the first step. Crucially, some of these data sets were assigned an additional characteristic: their abundance values had to increase or

decrease each year by up to 6% (i.e., 53.8% change overall). In this way, the “true” trend in each data set was known with 100% certainty, even if statistical testing failed to detect it. Additional simulations were performed to produce data sets reflecting a 50% increase in pipes and boards per site (JELA only) or a 50% reduction in sampling effort (every other month rather than monthly). For the third and final step, the simulated data were analyzed for cross-year trends using generalized linear mixed models (negative binomial distributions), and counts were made of the number of tests that detected significant trends. If 80% of tests showed a significant negative trend when the ‘true’ trend in the simulated data was indeed negative, then the current approach would be said to provide 80% power.

Unfortunately, statistical power was never more than 45% for any species by site combination, which was far below the 80% power target. These results indicate that even if an amphibian population suffered a 54% loss cumulatively over 10 years, the current effort would be unlikely to detect it. When the number of pipes and boards was increased by 50% (only at JELA), there was no major change in the power to detect trends. This was also the case when the frequency of sampling was reduced to every other month. A final observation in the report was that across the studied species, there was a strong negative correlation between estimated variation among years and the power to detect trends. In other words, species that had the greatest variation in abundance across year will be the most challenging to monitor, and it will be difficult to reliably detect increases or declines in their populations over time.

Recommendations across both Cheng (2016) and Cheng (2017)

1. **Measure more covariates** to improve the model’s ability to account for within- and cross-year variation. Recommended covariates include time-of-year, temperature, precipitation, vegetation structure and type, availability of freshwater bodies including coverage, proximity, and transience.
2. **For existing covariates, improve the quality of data.** First, ensure there are no gaps in the data, which may be caused, for example, by lost data loggers or dead batteries. Second, attempt to collect temperature and RH readings closer in time to the actual sampling event. Third, get rainfall data onsite rather than from off-site weather stations.
3. **Incorporate data on breeding cycles for species.**
4. **Estimate detection probabilities for each species.** This can be done with replicate surveys of populations conducted over short time periods. Data on detection probabilities will help prevent researchers from drawing the wrong conclusions about observed changes. For example, if natural cover at a site declines over time, species richness in the coverboards and pipes may increase because more rare species will be detected. This would not reflect a true increase in richness or diversity in the site, however. Similarly, certain species may be more likely to use these artificial cover objects than others, which could falsely indicate higher abundance (e.g., Glorioso and Waddle 2013, Zacharow et al. 2003). For example, a refuge-choice field study showed that Cuban treefrogs were eight times more likely to choose a plant

than a PVC pipe, squirrel treefrogs were two times more likely to choose a PVC pipe than a plant, and both green and pine woods treefrogs showed no preference between refuge types (Hoffmann et al. 2009).

5. **Monitoring for a longer duration**, as in more than 10 years.
6. **Reduce survey frequency from monthly to alternate months**, because in the power analyses, this change had no noticeable effect on power for any site by species combination.
7. **For abundance data at Jean Lafitte NHP&P and Gulf Islands NS, do not sample in May, June, July or August.** In her analyses, Cheng (2017) used data from October to March. Although this seems reasonable for most *Hyla* species, it seems less so for the *Eleutherodactylus* species (Figure 1).

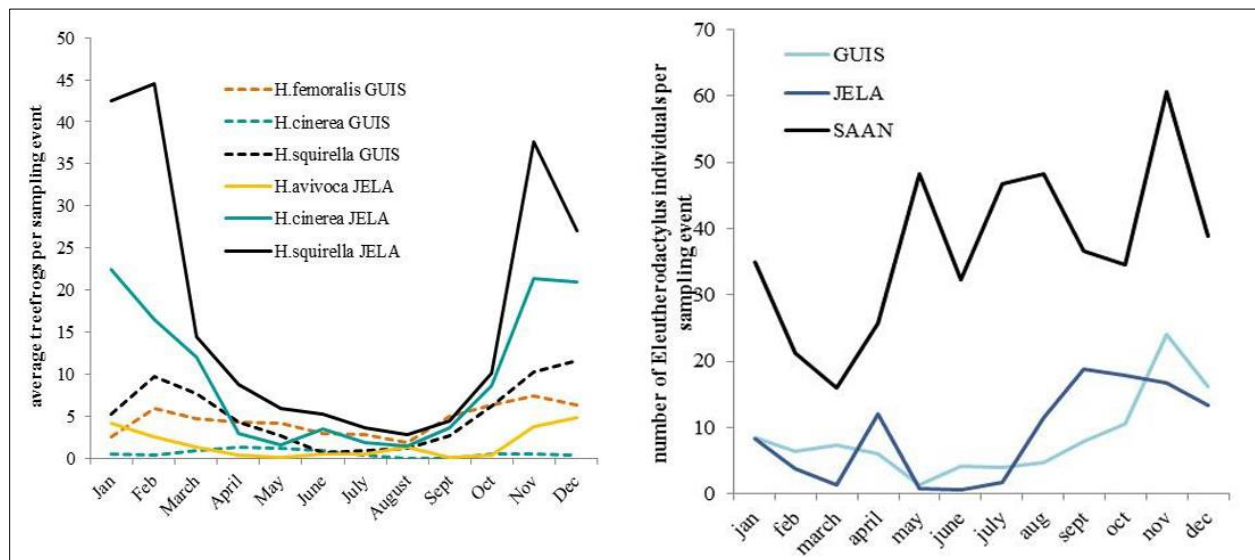


Figure 1. Left, *Hyla* treefrog counts by month in two parks. Right, *Eleutherodactylus* counts by month.

8. **Do not increase the number of coverboards or pipes within the site at Jean Lafitte NHP&P.** Fifty percent more pipes or coverboards within the JELA site did not improve statistical power by more than 5% for the *Hyla* mix, and it did not improve statistical power by more than 2% for *Eleutherodactylus planirostris*.
9. **Increase the number of sites within the park.** Increasing the number of sites of the same habitat would help distinguish between local and widespread changes in amphibian dynamics. It would also help obtain better covariate estimates and improve the accuracy of model predictions for all sites.

Reports by the Gulf Coast Network

Analyses were performed internally by the Gulf Coast Network to address three additional issues that were not considered by Ellen Cheng, the UGA consultant. These issues are related to the spatial design of the pilot monitoring effort, the use of two different sizes of PVC pipes and the use of two different materials for coverboards. In the sections below, each issue is explained and analyses are performed on existing data when appropriate. Recommendations for modifications to the sampling design follow.

Spatial Sampling Design

Pilot Study Arrangement

For the pilot study, the spatial distributions of PVC pipes and coverboards differed between Jean Lafitte NHP&P, Gulf Islands NS and San Antonio Missions NHP, as described below. For all three parks, 50% of PVC pipes were 1-inch (2.5-centimeters [cm]) diameter, and 50% were 2-inch (5-cm) diameter. Also for all three parks, 50% of coverboards were tin and 50% were untreated pine plywood. For the final design, the tin boards have been replaced with plywood boards, and sometimes in new locations (see sections “Analysis of Coverboard Materials” and “GULN Responses”).

- San Antonio Missions NHP had 40 PVC pipes and 50 boards. The artificial cover objects were arranged in four small clusters scattered throughout the park. The clusters were called arrays C, D, E, and F. Three arrays were close together (C, D and F) at less than 1 kilometer (0.6 miles [mi]) apart. Array E was approximately 3 kilometers (1.8 mi) from the rest (Figure 2). Arrays C and D each had 10 coverboards. Arrays E and F each had 10 pairs of PVC pipes and 10 (in E) or 20 (in F) coverboards. Figure 2 shows the pilot arrangement of all pipes and boards at San Antonio Missions NHP.
- Gulf Islands NS had 48 pipes and 30 coverboards, all within a small area of approximately 230×100 meters (754×328 feet [ft]). The cover objects were in six small clusters (arrays A–F). All six clusters had four pairs of PVC pipes each, and five of these clusters had six coverboards each (Figure 3). In addition to the coverboards and pipes, there were 25 minnow traps at Gulf Islands. These minnow traps were eliminated from the final design.
- Jean Lafitte NHP&P had 52 pipes and 30 coverboards, all within a small area of approximately 100×100 meters (328×328 ft). The cover objects were in seven small clusters of eight to 12 PVC pipes each (arrays F–K). Five of these clusters had six coverboards each (Figure 4). There were 25 minnow traps at Jean Lafitte, which were eliminated from the final design.

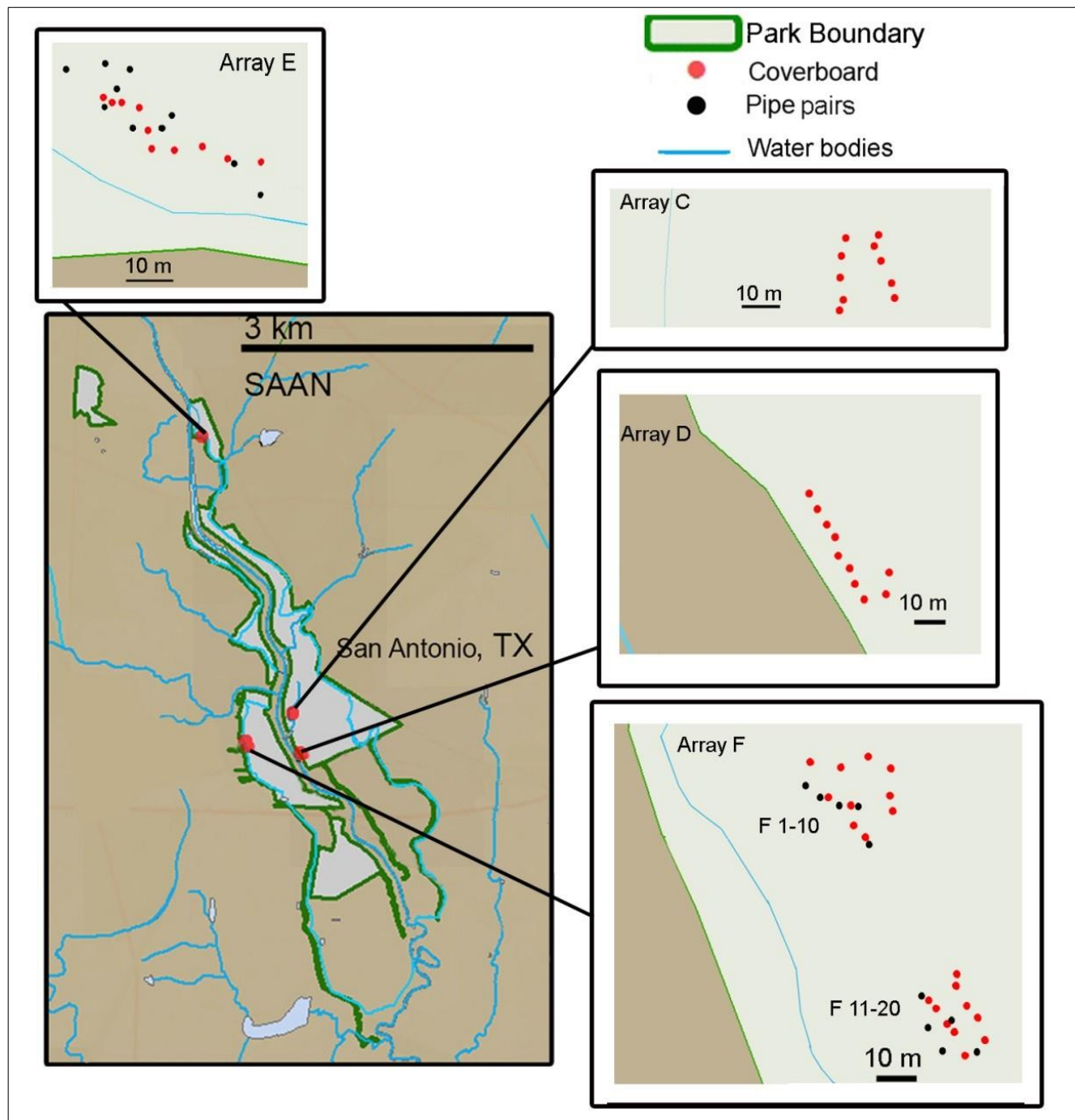


Figure 2. Pilot study arrangement of PVC pipes and coverboards in San Antonio Missions National Historical Park. The inset diagrams show the approximate location of each artificial cover object within an array.

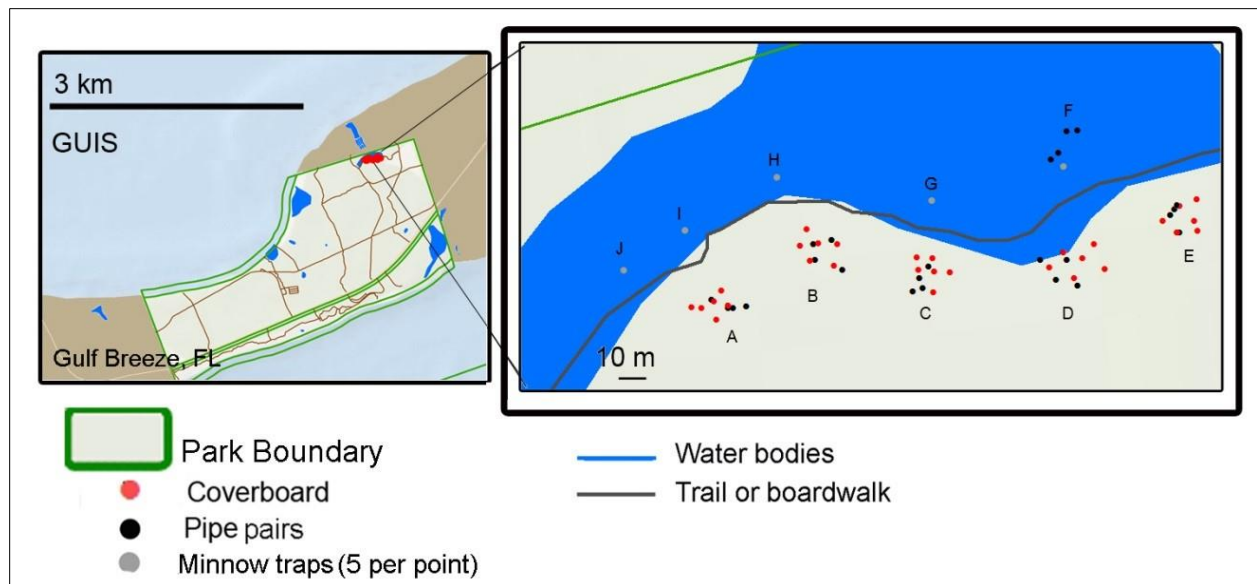


Figure 3. Pilot study arrangement of PVC pipes, coverboards and minnow traps in the Naval Live Oaks section of Gulf Islands National Seashore. The inset diagrams show the approximate location of each monitoring device within the study site.

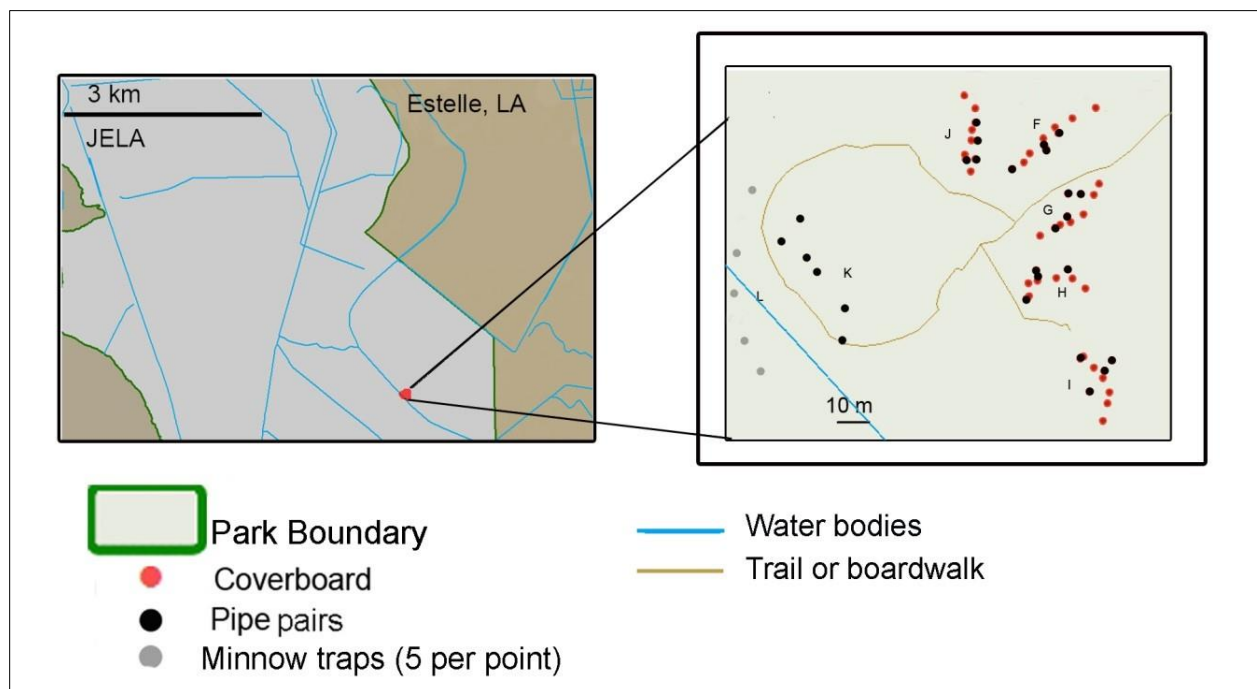


Figure 4. Pilot study arrangement of PVC pipes, coverboards and minnow traps by the Education Center of the Barataria Unit, Jean Lafitte National Historical Park and Preserve. The inset diagrams show the approximate location of each monitoring device within the study site.

Gulf Coast Network Recommendations

1. For the final design, Jean Lafitte NHP&P and Gulf Islands NS each need one more study site, to function as replicate sites in a similar habitat. Ideally, they should be 0.5 kilometers (0.3

mi) apart, if not farther. Two more sites per park would be preferred, but are not considered possible at this time. If there is ever a desire to sample additional habitats, they should be represented by two to three sites.

2. Effort must be even among sites for all three parks. This means equal numbers of PVC pipes in each site where pipes are appropriate and equal number of coverboards in each site.
3. The spatial arrangement of pipes and boards within sites should be approximately consistent across sites. In the pilot arrangement, most arrays are too close to each other and seem haphazard. Ideally, boards and pipes should be placed on a grid, transect or assigned random locations within a relatively small area.
4. As often as possible, existing coverboards and pipes should be kept in their current locations. This allows the network to lengthen the existing microsite-specific data sets.

Analysis of PVC Pipe Sizes

Pilot Study Arrangement

Across all study sites, 2-foot (0.6-meters [m]) long PVC pipes were hung in pairs on the same tree. One pair-member was 1-inch (2.5-cm) diameter PVC and the other was 2-inch (5-cm) diameter PVC. As soon as pipes were hung, the crew recorded the tree species identity, its diameter at breast height and its GPS location for potential use as a covariate in analyses. During sampling, the two PVC pipes in a pair were checked one after the other, once a month by a crew of two people. One crew member lifted the pipe from the tree, checked inside and called out the species present and the number of each species. The other crew member was the data recorder. In this section of the report, the PVC pipe data are used to address whether treefrog counts differ between the two pipe sizes.

From mid-2011 to January 2017, PVC pipes were checked each month in Jean Lafitte NHP&P, Gulf Islands NS and San Antonio NHP. Natchez Trace Parkway and Vicksburg NMP were also monitored for five years, but sampling stopped in February 2016 because very few animals were detected in pipes or under coverboards. Big Thicket NP and the Rancho parcel at San Antonio Missions NHP were also sampled with PVC pipes for less than three years and then abandoned because the selected methods had very low yields. At Big Thicket, sites in Turkey Creek and Big Sandy were monitored during six months only (June, August, September, November, and December of 2014; and February of 2015). The San Antonio Missions NHP-Rancho parcel was monitored from June 2011 to April 2014. Although coverboards were placed at the seventh park, Palo Alto Battlefield NHP, no PVC pipes were placed there.

Overview of Treefrog Encounters Since 2011

Jean Lafitte NHP&P: 52 pipes checked on each of 68 site visits = 3,536 individual pipe checks

- 1,996 individuals total, 115 *H. avivoca*, 673 *H. cinerea*, 1,208 *H. squirella*
- Maximum recorded in one visit was 162 individuals, on 27 February 2013
- For any individual species, the maximum per visit was 153 of *Hyla squirella*
- Twelve pipes were over water and forty pipes were over land. A pipe contained one or more *H. cinerea* on 23% of checks if over water, and 8.2% of checks if over land. A pipe

contained one or more *H. squirella* on 10% of checks if over water and 18.8% of checks if over land. For *H. avivoca*, there was no clear difference in water versus land pipes.

- Percent of pipe checks with at least one frog = **30%** (1,065 pipe checks had a frog)

Gulf Islands NS: 48 pipes checked on each of 71 site visits = 3,381 individual pipe checks

- 727 individuals total, 315 *H. femoralis*, 42 *H. cinerea*, 365 *H. squirella*, 5 unidentified *Hyla*
- Maximum recorded in one visit was 53 individuals, on 20 December 2012
- For any individual species, the maximum per visit was 42 of *Hyla squirella*
- Eight pipes were over water and forty pipes were over land. A pipe contained one or more *H. cinerea* on 5% of checks if over water, and 0% of checks if over land. A pipe contained one or more *H. squirella* on 1% of checks if over water, and 8.4% of checks if over land. For *H. femoralis*, there was no strong difference in use of pipes over water versus land.
- Percent of pipe checks with at least one frog = **16%** (553 pipe checks had a frog)

San Antonio Missions NHP-Missions: 40 pipes checked on each of 62 site visits = 2,480 individual pipe checks

- Seven individuals total, all *Hyla cinerea*
- Maximum recorded in one visit was two individuals of *Hyla cinerea*. This has happened three times, in November 2015, March 2016 and January 2017
- Percent of pipe checks with at least one frog = **0.3%** (6 pipe checks had a frog)

Vicksburg NMP: 10-plus pipes checked on each of 55 site visits = 606 individual pipe checks

- 46 individuals total, 34 *H. versicolor/chrysoscelis*, 12 *H. cinerea*
- Maximum recorded in one visit was 6 individuals: 2 green, 4 grey on October 31, 2013
- Percent of pipe checks with at least one frog = **7%** (40 pipe checks had a frog)

Natchez Trace Parkway: Rocky Springs: 20 pipes checked on each of 54 site visits = 1,080 individual pipe checks; Jeff Busby: 20–38 pipes checked on each of 55 site visits = 1,981 pipe checks

- 73 individuals total across sites, 70 *H. versicolor/chrysoscelis*, 2 *H. cinerea*, 1 *H. squirella*
- 58 individuals were at Jeff Busby, including all 3 species
- 15 individuals were at Rocky Springs, where only grey treefrogs were found
- Maximum recorded per visit was 6 individuals at Jeff Busby, all grey, on April 1, 2015
- Percent of pipe checks with at least one frog = **3%** for Jeff Busby and **1%** for Rocky Springs

Big Thicket NP: Big Sandy: 40 pipes checked on each of six site visits = 240 individual pipe checks; Turkey Creek: 40 pipes checked on each of six site visits = 240 individual pipe checks

- 59 individuals total across sites, 55 *H. versicolor/chrysoscelis*, 3 *H. squirella*, 1 *H. cinerea*
- 27 individuals were at Turkey Creek of *H. versicolor/chrysoscelis* and *H. squirella*
- 25 individuals were at Big Sandy, including all 3 species
- Maximum recorded in one visit was 18 individuals, 16 grey and 2 squirrel, Dec. 11, 2014, half in Big Sandy, half in Turkey Creek
- Percent of pipe checks with at least one frog = **20%** (48 pipe checks had a frog)

San Antonio Mission NHP&P-Rancho unit: 20 pipes checked on each of 34 site visits = 680 individual pipe checks

- 13 individuals total, 11 *H. cinerea* and 2 *H. versicolor/chrysoscelis*
- Maximum recorded in one visit was 6 individuals, all green, on February 15, 2013
- Percent of pipe checks with at least one frog = **2%**

Methods for Comparing Pipe Sizes

Only Jean Lafitte NHP&P and Gulf Islands NS were included in the formal analysis of pipe sizes because the other parks had such low yields in PVC pipes (or had a short study period, as for Big Thicket NP). The dataset analyzed for Jean Lafitte spanned from February 24, 2011 to February 2, 2017. For Gulf Islands, it spanned from March 23, 2011 to January 17, 2017. Frog species compared at Jean Lafitte were *Hyla avivoca*, *Hyla squirella* and *Hyla cinerea*. Frog species compared at Gulf Islands were *Hyla femoralis*, *Hyla squirella* and *Hyla cinerea*. Some months were missed for each park (Jean Lafitte: December 2014 and October 2015; Gulf Islands: October 2013). Each park and each frog species were analyzed separately, and then all *Hyla* species per park were summed for an additional analysis. To compare the number of encounters in small versus large pipes, a generalized linear model was used with a Poisson distribution, which is appropriate for count data. The response variable was the number of treefrogs of a given species found in a single sampling visit. The fixed effect was small versus large pipe. A random effect was included for the sampling event, but there was no random effect to account for repeated sampling of individual pipes in this simplified model. Analyses were performed using the glmer function in R (version 3.1.1; R Core Team 2014).

Results

There were significant differences in treefrog counts in small versus large pipes at Gulf Islands NS (Figure 5, left) and Jean Lafitte NHP&P (Figure 5, right), but the preferred pipe-type varied by species. In both parks, there were significantly more *Hyla squirella* in small pipes, relative to large pipes ($p = 0.000148$ at GUI; $p < 0.0001$ at JELA). For *Hyla cinerea*, in contrast, more individuals were seen in large pipes ($p = 0.00727$ at GUI; $p = 0.0189$ at JELA). For the other two species, there were no differences between pipe sizes ($p > 0.17$). When the sum total for all treefrog species was compared between pipe-types, the small pipe had more treefrogs in both parks ($p = 0.00228$ for GUI and $p < 0.0001$ for JELA).

To complement these findings on the four most-common species, data from Vicksburg NMP, Natchez Trace Parkway and Big Thicket NP were used in an informal, supplementary analysis to compare counts of grey treefrogs, *Hyla versicolor/chrysoscelis*. At Natchez Trace-Jeff Busby, there were twelve grey treefrogs in small pipes and forty in large pipes. Each pipe-type was checked 990 times. Similarly at Big Thicket, there were thirteen grey treefrogs in small pipes and forty-eight in large pipes, with each pipe type checked 237 times. For each of these sites, the difference was significant at $p < 0.0001$, using a chi-square test of a contingency table. There were no significant differences at Natchez Trace-Rocky Springs and Vicksburg, however ($p > 0.4$). At Rocky Springs, there were nine grey treefrogs in large pipes and six in small pipes, with a total of 540 pipe-checks each. At Vicksburg, there were nineteen grey treefrogs in large pipes and fifteen in small pipes, with a total of 303 pipe-checks each.

Independent of pipe size effects, treefrog counts in pipes at Jean Lafitte and Gulf Islands showed striking patterns over time (Figures 6 and 7). Specifically, there was a peak in *H. squirella* counts in the cool season (October–March) of 2013 at both Jean Lafitte and Gulf Islands, followed by a decline

in counts each cool-season since. *Hyla cinerea* and *H. avivoca* at Jean Lafitte showed a contrasting pattern, however, in that counts per pipe were higher than normal in the 2016 and 2017 seasons.

Finally, *H. femoralis* and *H. cinerea* in Gulf Islands showed no apparent temporal trends. Although trend analyses have not been performed on these data, Cheng (2017) indicates that trend detection will be difficult because of low statistical power (see section “Cheng (2017): Power of GRAMP Surveys to Monitor Amphibian Abundance”). The Gulf Coast Network views these low power estimates with caution, however, because of the apparent trends mentioned above. If these trends are real, this violates the assumption that cross-year variance in the pilot data reflects natural, baseline fluctuations and not actual declines or increases. It should be noted that some power analyses do account for trends in pilot data, by estimating variance with the residuals on a linear or quadratic regression of years versus abundance (e.g. Seavy and Reynolds 2007). The UGA consultant did not take this approach, most likely because the cross-year sample size is small (n=5). They did, however, include year as a random effect when estimating variance (see page 9 in Cheng 2017).

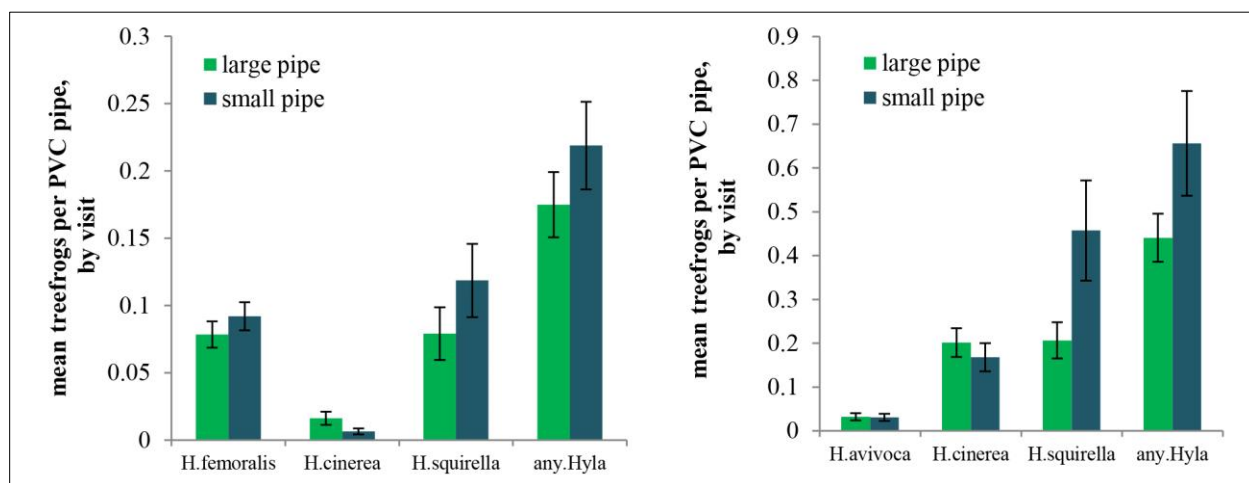


Figure 5. Left, average treefrogs per pipe at GUIs (48 pipes). Error bars represent one standard error. Right, average treefrogs per pipe at JELA (52 pipes). Error bars represent one standard error.

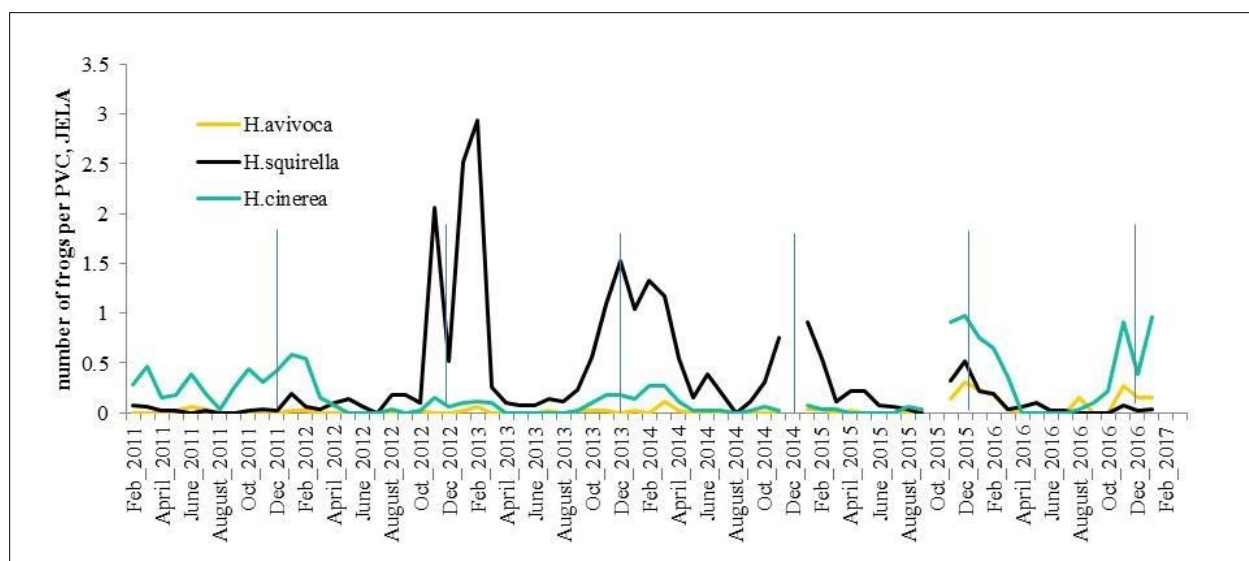


Figure 6. Trends in treefrog counts over time at JELA. Vertical lines mark transitions between years.

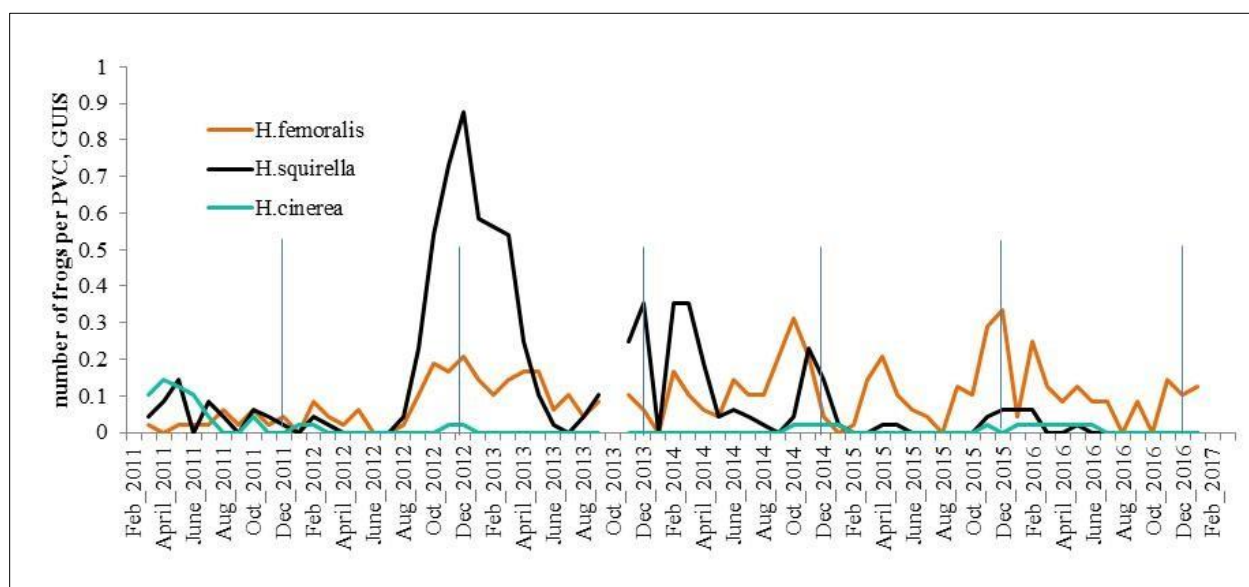


Figure 7. Trends in treefrog counts over time at GUIS. Vertical lines mark transitions between years.

Conclusions

Based on these findings, both pipe sizes should be retained because there is a small but significant tendency for *Hyla cinerea* to preferentially occupy the larger pipes and *H. squirella* to occupy the small pipes. There was an additional, unanalyzed tendency for *H. cinerea* to occupy pipes over water and *H. squirella* to occupy pipes over land, such that both land and water pipes are valuable as well. Finally, it is recommended the results of the recent power analyses be viewed with caution, given the potential trends in Figures 6 and 7.

Analysis of Coverboard Materials

Pilot Study Arrangement

In all study sites, coverboards were 3 × 4 foot (0.9 × 1.2 m) panels arranged flat on the ground in small clusters of 6–10 panels. Within each cluster, there were equal numbers of panels made of roofing tin versus three-quarter-inch plywood. All panels in a site were checked during a single morning once per month, with one crew member lifting the panel from one side and the other crew member calling out the species seen beneath it and the number of individuals per species. Tin panels are generally considered better habitat for reptiles and wooden panels are generally considered better habitat for amphibians, but the deployment of either is not necessarily taxon specific. The analyses in this section address whether the number of amphibians or reptiles encountered depended on the coverboard material.

Coverboards were checked each month from mid-2011 to January 2017 in Jean Lafitte NHP&P, Gulf Islands NS and San Antonio NHP-Missions. Natchez Trace Parkway and Vicksburg NMP also were monitored for five-plus years, but sampling stopped in February 2016 because of very low yields under coverboards. Big Thicket NP, Palo Alto Battlefield NHP and the Rancho parcel at San Antonio Missions were also sampled with coverboards for less than three years and then abandoned due to low yields. Turkey Creek and Big Sandy at Big Thicket were monitored during six months only (June, August, September, November, December of 2014 and February of 2015). Palo Alto was monitored from May 2011 to August 2013, and the San Antonio Missions-Rancho parcel was monitored from June 2011 to April 2014. The effort (number of boards flipped) and number of individuals counted for each park are listed in Table 2. Because San Antonio Missions had arrays that were relatively far apart, each array is considered individually as well. The most amphibians at San Antonio Missions were in array F, which had 20 boards. The total number of amphibians recorded there was 1,412, with 421 *Incilius nebulifer* and 985 *Eleutherodactylus cystignathoides*. The other arrays had only 10 boards each. Array E had 1,215 amphibians total, with 354 *Incilius nebulifer* and 850 *Eleutherodactylus cystignathoides*. Array C had 996 amphibians total, with 502 *Incilius nebulifer* and 494 *Eleutherodactylus cystignathoides*. Array D had the least, at 486 total, 271 *Incilius nebulifer* and 193 *Eleutherodactylus cystignathoides*.

Table 2. Overview of coverboard effort and amphibians and reptiles found since 2011. The number of coverboards multiplied by the number of site visits does not equal the number of boards checked because on some visits, not all boards could be checked because they were missing or incorrectly placed.

Park	Cover boards	Site visits	Boards checked	Individuals encountered	% boards checked with 1+ individual
JELA	30	69	2,066	664 amphibians 378 reptiles	32% for amphibians 18% for reptiles
GUIS	30	71	2,087	421 amphibians 123 reptiles	20% for amphibians 6% for reptiles
SAAN-Missions	30-60 ¹	66	3,527	1525 amphibians 220 reptiles	43% for amphibians 6% for reptiles

Park	Cover boards	Site visits	Boards checked	Individuals encountered	% boards checked with 1+ individual
SAAN-Rancho	40	34	1,354	27 amphibians 57 reptiles	1% amphibians 4% reptiles
VICK	60	55	3,290	131 amphibians 96 reptiles	4% for amphibians 3% for reptiles
NATR: Rocky Springs	40	56	2,239	142 amphibians 135 reptiles	6% for amphibians 6% for reptiles
NATR: Jeff Busby	40	57	2,214	134 amphibians 128 reptiles	7% for amphibians 6% for reptiles
BITH: Turkey Creek	40	6	200	20 amphibians 14 reptiles	9% amphibians 6% reptiles
BITH: Big Sandy	40	6	200	4 amphibians 0 reptiles	2% amphibians 0% reptiles
PAAL	80	40	2,219	3 amphibians 149 reptiles	0.01% amphibians 7% reptiles

¹Boards were added and removed over time. There were 30 boards from 6/2011 to 10/2011, 35 in 11/2011, 55 from 12/2012 to 5/2013, 60 from 6/2013 to 2/2015, and 50 from 3/2015 to 1/2017.

Methods for Comparing Coverboard Types

Three parks were included in the analysis of coverboard types: Jean Lafitte NHP&P, Gulf Islands NS and San Antonio Missions NHP. The data set analyzed for Jean Lafitte and Gulf Islands had the same timespan as for PVC pipes (JELA: 24 February 2011 to 2 February 2017; GUIS: 23 March 2011 to 17 January 2017). For San Antonio Mission, the timespan was 9 November 2011 to 11 January 2017. The same months were missing for PVC pipe data at Jean Lafitte and Gulf Islands (JELA: December 2014 and October 2015; GUIS: October 2013). For San Antonio Missions, only October 2013 was missing.

Two types of comparisons were made for coverboard types, with each park compared separately. First, the average number of amphibian individuals and the average number of reptile individuals were compared between wood and tin coverboards. These comparisons were repeated on a separate dataset excluding *Eleutherodactylus* species, because they were by far the most common species under coverboards in all parks. No statistics were performed on these data. Second, counts were compared between coverboard types using chi-square tests to analyze contingency tables. The tables were constructed for each species separately, and they consisted of (1) a count of wooden coverboard flips that revealed at least one individual, (2) a count of wooden coverboard flips that revealed none, (3) a count of tin coverboard flips that revealed at least one individual, and (4) a count of tin coverboards flips that revealed none. The expectation was that if there was no tendency for an amphibian species to occur under wood more than under tin, or vice versa, the proportion of flips to reveal an amphibian should be 50:50 between wood and tin.

Results

More amphibian individuals were recorded under wooden coverboards than under tin coverboards across all parks, whether or not *Eleutherodactylus* species were included (Figure 8). Also across all

parks, more amphibian individuals were recorded than reptile individuals, regardless of coverboard type (Figure 8, left, Table 2). When *Eleutherodactylus* species were excluded, the pattern of more amphibian encounters persisted in San Antonio Missions, but not in other parks (Figure 8, right). For reptiles, there was no major difference in numbers encountered under tin versus wood. Note that reptile data are the same in the left and right panels of Figure 8.

When the actual number of amphibians encountered under wood and tin was compared to an expected proportional difference of 50:50, several significant differences were observed. Eight amphibian species were encountered under wood more often than under tin, but no amphibian species were encountered more often under tin than under wood (Table 3). Not all species showed the same pattern across parks, however. For example, *Incilius nebulifer* was found under wood more often than under tin in San Antonio Missions NHP but not in Jean Lafitte NHP&P. For reptiles, one lizard species was encountered more often under wood than under tin (*Anolis carolinensis* at SAAN), and two snake species were encountered under tin more often than under wood (Table 3). *Scincella lateralis* was under tin more often than wood at San Antonio Missions NHP and Gulf Islands NS, but there was no difference between coverboard types for that species at Jean Lafitte NHP&P. It should be noted that the low yields under coverboards for most reptiles and some amphibians makes it unlikely that significant differences would be detected.

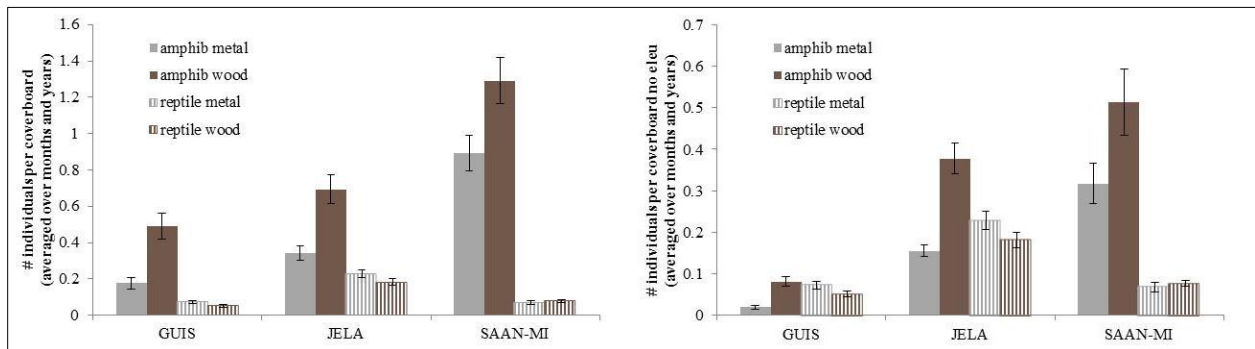


Figure 8. Left, individuals of reptiles and amphibians beneath coverboards. Error bars = 1 SE. Right, Individuals of reptiles and amphibians excluding *Eleutherodactylus* spp. Error bars=1 SE.

Table 3. The number of amphibians and reptiles by coverboard type in three parks. Counts represent the number of times at least one member of that species was present when a coverboard was flipped. Results are similar if using the total number of individuals of that species. Counts that are bolded and marked with a superscript ^a were significantly higher for that coverboard type.

Park	Species name	Tin count	Wood count	p-value
GUIS—Amphibian	<i>Acris gryllus</i>	5	3	NS
	<i>Anaxyrus quercicus</i>	3	1	NS
	<i>Anaxyrus terrestris</i>	2	17^a	0.000551
	<i>Eleutherodactylus planirostris</i>	120	225^a	<0.0001
	<i>Eurycea quadridigitata</i>	0	8^a	0.00462
	<i>Gastrophryne carolinensis</i>	6	29^a	<0.0001

Park	Species name	Tin count	Wood count	p-value
	<i>Hyla femoralis</i>	2	8^a	0.0574
	<i>Hyla squirella</i>	0	3	NS
	<i>Plethodon grobmani</i>	2	5	NS
GUIS—Reptile	<i>Anolis carolinensis</i>	3	2	NS
	<i>Aspidoscelis sexlineata</i>	1	0	NS
	<i>Coluber constrictor</i>	6	3	NS
	<i>Plestiodon fasciatus</i>	1	2	NS
	<i>Plestiodon laticeps</i>	7	7	NS
	<i>Plestiodon sp.</i>	5	7	NS
	<i>Coluber flagellum</i> (was <i>Masticophis</i>)	3	8	NS
	<i>Micrurus fulvius</i>	1	1	NS
	<i>Sceloporus undulatus</i>	5	2	NS
	<i>Scincella lateralis</i>	40^a	13	0.00017
	<i>Tantilla coronata</i>	1	4	NS
JELA—Amphibian	<i>Acris blanchardi</i>	4	8	NS
	<i>Eleutherodactylus planirostris</i>	143	199^a	0.00101
	<i>Eurycea paludicola</i> (was <i>quadridigitata</i>)	6	33^a	<0.0001
	<i>Gastrophryne carolinensis</i>	80	199^a	<0.0001
	<i>Hyla cinerea</i>	0	2	NS
	<i>Hyla squirella</i>	1	0	NS
	<i>Incilius nebulifer</i>	41	39	NS
	<i>Lithobates clamitans</i>	6	21^a	0.00360
	<i>Notophthalmus viridescens</i>	2	23^a	<0.0001
JELA—Reptile	<i>Agkistrodon contortrix</i>	18^a	2	0.00033
	<i>Anolis carolinensis</i>	2	1	NS
	<i>Coluber constrictor</i>	16	7	0.0598
	<i>Elaphe obsoleta</i>	0	2	NS
	<i>Plestiodon fasciatus</i>	3	6	NS
	<i>Plestiodon laticeps</i>	1	3	NS
	<i>Plestiodon sp.</i>	0	2	NS
	<i>Nerodia erythrogaster</i>	17^a	6	0.0213
	<i>Nerodia fasciata</i>	2	0	NS
	<i>Liodytes rigida</i>	1	0	NS
	<i>Scincella lateralis</i>	139	119	NS

Park	Species name	Tin count	Wood count	p-value
	<i>Storeria dekayi</i>	0	1	NS
	<i>Thamnophis proximus</i>	13	20	NS
	<i>Thamnophis sirtalis</i>	1	1	NS
SAAN-MI—Amphibian	<i>Eleutherodactylus cystignathoides</i>	550	663^a	0.000321
	<i>Gastrophryne olivacea</i>	0	9^a	0.002919
	<i>Incilius nebulifer</i>	312	400^a	0.000648
	<i>Lithobates berlandieri</i>	0	1	NS
	<i>Lithobates sp.</i>	0	1	NS
SAAN-MI—Reptile	<i>Anolis carolinensis</i>	6	19^a	0.01038
	<i>Aspidoscelis sexlineata</i>	0	1	NS
	<i>Hemidactylium scutatum</i>	0	1	NS
	<i>Pantherophis guttatus</i>	0	4	NS
	<i>Pantherophis obsoletus</i>	0	3	NS
	<i>Hemidactylus turcicus</i>	7	23^a	0.00394
	<i>Coluber schotti</i> (was <i>Masticophis</i>)	1	5	NS
	<i>Coluber taeniatus</i> (was <i>Masticophis</i>)	0	1	NS
	<i>Micrurus tener</i>	0	2	NS
	<i>Sceloporus olivaceus</i>	1	0	NS
	<i>Scincella lateralis</i>	79^a	49	0.00500
	<i>Tantilla gracilis</i>	1	4	NS
	<i>Thamnophis marcianus</i>	2	2	NS
	<i>Thamnophis proximus</i>	0	1	NS
	<i>Thamnophis sirtalis</i>	0	1	NS

Conclusions

It is recommended that only wooden coverboards be used for the finalized protocol, because of their higher amphibian yields. Although a few reptile species may be less frequently encountered following this change, their encounter rates would be low, regardless. Because the primary focus of the protocol is to monitor amphibians as a key vital sign for park health, reducing the number of reptiles encountered during monitoring should not be a central concern.

Gulf Coast Network Responses

As summarized above, the reports by Cheng (2016, 2017) indicate that unless the design is modified, the Gulf Coast Network will have little hope of detecting true changes in amphibian abundance, richness, or diversity, especially over less than 10-year timespans. In response to these reports and to its own internal analyses, the network implemented seven major changes to its amphibian sampling efforts in three parks (JELA, GUIS, and SAAN-Missions). In the two sections below, the Gulf Coast Network first outlines the changes and the recommendations they are based on. Second, the network describes and justifies decisions that are inconsistent with Cheng's approach and recommendations.

Suggestions from Cheng (2016, 2017) That Have Been Implemented

The Gulf Coast Network now measures more covariates to improve statistical trend analysis of amphibian abundance over time. This change was suggested by Cheng (2017). Prior to the change, the network could already account for time of year, time of day for each board or pipe, air temperature for each board or pipe (with some gaps in time sequence), relative humidity for each board or pipe (with some gaps), rainfall from nearest weather station and additional variables derived from the daily rain and temperature data.

The network has made three major additions to this list of covariates measured: (1) measure surface temperature under or in each board or pipe, respectively, while sampling, (2) upgrade the continuous data loggers to include barometric pressure, and (3) deploy a data logging water-level gauge in the waterbody nearest to each site. Several additional variables are available without any equipment purchases, such as recording whether the cover object is in the shade or sun, whether it is affected by floodwater, and whether the PVC pipe contains an occupant that may deter amphibians (e.g., wasps). Finally, the network will add a photopoint photograph at each cluster of four boards and six pipes, taken on each sampling visit. These decisions are consistent with variables deemed important in other protocols (e.g., Dodd 2003). The network considered several more changes that were ultimately viewed as impractical or too labor intensive. The main rejected changes were (1) measuring percent vegetation cover from fish-eye photo over coverboard and pipe, two times per year; (2) measuring coarse woody debris transects, two times per year, with several transects per site; (3) adding co-located vegetation plots with stem counts and/or percent cover; (4) using a soil moisture probe at each coverboard.

Provided below are some additional details on the new covariates being measured:

- At the same time that each board or pipe is checked, the network measures temperature of ground surface beneath each coverboard or on the inside of each pipe. Surface temperature is measured with an infrared laser sensor in a hand-held unit. The network is implementing this during a trial period of one year and will reassess its utility after that year.
- Associated with each site's continuous data logger, the network has added a sensor for barometric pressure.

- The network has purchased and deployed a sensor that monitors water level in the waterbody nearest to each site, recorded multiple times per day.
- The network can consider the role of moon brightness in predicting amphibian relative abundance in each pipe or board. These data can be obtained from moon phase data plus cloud cover records from the nearest airport or using global cloud cover products from NASA (e.g., OMI/Aura Cloud Pressure and Fraction; recorded hourly at a resolution of 13 × 24 km)
- The network records whether pipes or boards are (1) in sun or shade at checking; (2) affected by floodwater at checking (coverboards only); or (3) occupied by another organism that could deter amphibian occupancy at checking (pipes only).
- The network takes a photopoint photograph at each cluster of four boards and 6 PVC pipes prior to checking the cover objects. This allows for qualitative comparisons over time, particularly for changes in detectability.

The Gulf Coast Network has improved the quality of data for existing covariates, as suggested by Cheng (2017). The network has now installed a high-quality data logger in each site, with a battery life-span of at least four months. A plan for inspecting, refurbishing, and/or replacing units has been put in place. To lengthen battery life, loggers are now set to record measurements every hour rather than every 10–30 minutes. Next, the network has purchased a higher quality hand-held device for measuring air temperature and relative humidity at the start and end of the sampling event. Finally, data from a newly installed weather station near the Jean Lafitte NHP&P site will be used instead of the nearest weather station outside the park. Detailed below are the specifics on how data quality for existing covariates has been improved:

- Temperature and relative humidity were previously measured with a black, pen-sized device. This device's accuracy was in question because it potentially absorbs heat. When the data from the hand-held device were compared with data from the temperature logger on-site (every 30 min) and the nearest airport, the pen's inaccuracy was confirmed. The continuous logger and airport data were very similar to each other, but the pen was three degrees off, on average, with readings especially high on cooler days. Thus, the network has purchased a more accurate device for temperature and relative-humidity measurements at the site level.
- Weather station data should be obtained from inside the park whenever possible. Jean Lafitte NHP&P recently installed a weather station, but nothing similar exists for other parks. For Jean Lafitte NHP&P, the nearest hourly weather data are from the airport, 30 kilometers (18.6 mi) away. For San Antonio Missions NHP, the airport weather station is less than 3 kilometers (1.8 mi) from any study site. For Gulf Islands NS, the airport weather station is 12 kilometers (7.4 mi) from the Naval Live Oaks site.
- The network will inspect and refurbish the continuous data logger at every site and replace those with insufficient battery life. There is also now a schedule for switching out existing units for refurbishment or replacement on a semi-annual basis.

- To increase battery life, continuous loggers have been set to record hourly rather than 10–30 minutes.

The Gulf Coast Network now samples each site every other month, rather than every month of the year. This change follows the advice of Cheng (2017), which indicated that sampling in alternate months would not majorly reduce statistical power. Cheng (2017) also suggested that sampling could be restricted to three winter months for green and squirrel treefrogs, but the network is interested in capturing more than just these two species. So the network will sample in January, March, May, July, September, and November for Jean Lafitte NHP&P and Gulf Islands NS. San Antonio Missions NHP will be sampled in February, April, June, August, October, and December. To increase annual yields, the network retains the option of making extra sampling trips to Jean Lafitte NHP&P and Gulf Islands NS during the winter months of December and February. A third piece of advice was that more than 10 years of data are required to draw solid conclusions about changes in species richness or relative abundance. The network agrees, and expects to continue its effort indefinitely into the foreseeable future.

The Gulf Coast Network has increased the number of sites in the same habitat within each park. Increasing the number of sites was suggested in Cheng (2017) and is also supported internally (see “Spatial Sampling Design”).

The Gulf Coast Network has changed sampling effort within sites to standardize effort, increase the use of productive techniques (per effort required) and eliminate unproductive techniques in each park. These changes were based on analyses and discussions internal to the network. Cheng (2017) suggested that increasing the number of PVC pipes and boards per site at Jean Lafitte NHP&P would not improve power for *Hyla mix* or *Eleutherodactylus planirostris*. Thus, the network has primarily added more pipes and boards at new sites, but within sites, they have rearranged and replaced current cover objects to improve spatial coverage and use the most productive materials. Listed below are the specific changes to the current sampling effort:

- The network has eliminated minnow traps from Jean Lafitte NHP&P and Gulf Islands NS because these techniques were not productive, and waterbodies were not reliably water-filled. There were 1,376 trap-checks at Gulf Islands NS, and 1,219 contained no amphibians (89%). The greatest number captured for any species at Gulf Islands NS was 114 for *Acris gryllus*, followed by *Lithobates sphenoccephalus* at 23. For Jean Lafitte NHP&P, there were 1,728 trap-checks and 1,012 contained no amphibians (59%). The most individuals captured were *L. clamitans* at 1,301, followed by 145 of *Notophtalmus viridescens*.
- The network removed all pipes at San Antonio Missions NHP (percent of pipes with at least one treefrog individual was 0.3%; see “Analysis of PVC pipes”).
- The network removed all tin coverboards and replaced them with wood coverboards. Amphibian encounters are much higher under wooden boards (see section “Analysis of Coverboard Materials”). In the pilot design, there were 30 boards at Jean Lafitte NHP&P and Gulf Islands NS in one site each. San Antonio Missions NHP had 50 boards: 20 in one site,

and 10 each in three additional sites. The original wooden coverboards in each site were rearranged slightly within the same general area, as described directly below. The total number of boards was increased to 32 per site in Jean Lafitte NHP&P and Gulf Islands NS, and 20 per site in San Antonio Missions NHP.

- Within each site (new or pilot), the 20–32 wooden coverboards were arranged into clusters of four, along an approximately 80–140 meter (262–459 ft) transect. Within each cluster, the boards were placed 1–2 meters (3.2–6.5 ft) apart in a quartered-square formation. Each cluster is now 20 meters (65.6 ft) or more apart. Associated with each cluster of four boards are three pairs of pipes at Jean Lafitte NHP&P and Gulf Islands NS, with each pipe pair on a different hardwood tree.
- The total effort per park is now set at two replicate sites in Gulf Islands NS, two replicate sites in Jean Lafitte NHP&P and three replicate sites at San Antonio Missions NHP. To achieve this, one site was dropped from San Antonio Missions NHP (array D), one new site was established in the Naval Live Oaks section of Gulf Islands NS, and one new site was established in the Barataria unit of Jean Lafitte NHP&P. In Jean Lafitte NHP&P and Gulf Islands NS, each site was allocated 32 boards and 64 pipes. Forty-eight pipes (24 pairs) were associated with the coverboards, and 16 pipes (eight pairs) were placed over water. At San Antonio Missions NHP, each of the three sites now has 20 coverboards and no PVC pipes.

The Gulf Coast Network no longer expects to test for trends in species diversity across years and recognizes the limitations of its chosen monitoring approach. The report by Ellen Cheng on amphibian richness and diversity (Cheng 2016) showed that the network is unlikely to obtain reliable diversity estimates, due to low detection probabilities of most species (see section “Cheng (2016): GRAMP Amphibian Diversity Summary for 2011–2015”). Therefore, the network has removed “trends in species diversity” from the GULN monitoring objectives for amphibians. For richness, an increase in effort (more pipes and boards plus more replicate sites per park) may stabilize the dynamics index and provide more reliable estimates over time. If not, “trends in richness” may also eventually be removed from monitoring objectives.

For both community indices and data on individual species, the network has taken care to match its monitoring objectives to what is actually measured. Each objective is directed toward individuals that use the monitored pipes and boards and not the amphibian community as a whole. For relative abundance data in particular, the network further recognizes the relationship between pipe or board use and population size is unknown.

The Gulf Coast Network can track individual species using frequency or occupancy (yes/no detected) as well as relative abundance (counts). The original approach was focused on relative abundance data, but when counts are so low, yes/no data on detection may be more appropriate for analyses. Frequencies based on detection across multiple cover objects would restrict the variability going into the models, under the assumption that the network cannot (and need not) explain all of the species-level variation present. The UGA consultant (Cheng 2017) took this approach for two species at Vicksburg NMP that were infrequently encountered. Although the data were coarser, the power to

detect trends was higher. The network will benefit from this approach when power and occupancy remain low, and unexplained variability high, despite the changes to the final design.

Suggestions from Cheng (2016, 2017) That Have Not Been Implemented

The Gulf Coast Network does not collect data on breeding cycles for each species. Cheng (2017) suggested that frog counts were low during the summer because frogs were breeding. Statistical models may explain variance better if actual breeding season dates were known and included as covariates. The network does not assume that low counts and breeding activity are linked, however, and would prefer to see evidence of this before collecting breeding data on-site. There are other reasons frogs may be absent from pipes in the summer, including the increased availability of vegetation cover in the summer or dangerously high summertime temperatures within the pipes. If the network later decided that breeding data are important, we would first seek out published estimates of breeding timing and duration of these frogs in the Southeast. We would also request information from biologists studying these frogs before beginning our own study. If a network study was performed, it would most likely use frog loggers, although night-time frog call surveys are also possible.

The Gulf Coast Network has not changed its sampling plan to estimate detection probabilities of each species. We believe current sampling is frequent enough for reasonable estimates, if they are desired for models that account for estimate uncertainty (e.g., occupancy models as in Fiske and Chandler (2011)). Estimating detection probability is not currently among the primary goals of the amphibian protocol, however. Thus, these approaches and techniques will not be described in the narrative or SOPs.

The Gulf Coast Network views the results of the power analysis with caution. In particular, we question the assumption that cross-year variation for 2011–2015 represents the normal baseline changes in relative abundance over time for all species. For example, it seems likely that *Eleutherodactylus planirostris* first arrived at the Jean Lafitte NHP&P sampling site after pilot data collection began. The first detection of this species was in July 2012, before which there were 19 months of sampling with no detections. Following the first detection, an average of 10 individuals per month were encountered at the park, with only one period of six months with no encounters of this species (March 2014–Aug 2014). *Hyla squirella* abundance also appeared to peak and then decline during the pilot study, as described in section “Analysis of PVC Pipe Sizes.” Although either of these trends could be false, as often occurs in short time-series data (see Cheng [2017], page 9), the network prefers to make no such assumption. If true trends exist in the pilot data, the network may have more power to detect change than Cheng (2017) suggests.

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