



Supplementary Materials for Amphibian Monitoring at Gulf Islands National Seashore: Two-Year Summary through March 2024

Prepared by Jane E. Carlson, Ecologist for the Gulf Coast Network, and Olivia Butler, ACE EPIC member

Overview

As part of each Amphibian Monitoring two-year report –currently written as a web article– the ecologist for the Gulf Coast Inventory and Monitoring (I&M) Network also prepares a Supplementary Materials document of background information and ancillary data. The summaries, figures, and data explorations included here should be considered preliminary and informal. Final presentation of these or related results will be in the future trend reports, which are written after three two-year reports, or six years of data collection (i.e., trend report 1 will summarize data for May 2018 – March 2024).

The current Supplementary Materials document for amphibian monitoring at the Naval Live Oaks Area of Gulf Islands National Seashore contains (1) a project timeline that reviews major events during each 2-year reporting period since 2018; (2) an overview of ancillary weather and environmental data; (3) a list of all amphibian species detected on the park during monitoring; (4) a list of reptiles detected during the 2-year monitoring period as well as during previous monitoring years; (5) literature cited and other useful references for amphibians and amphibian monitoring at the park. The first Supplementary Materials document, covering May 2018 to March 2020 (see Supplemental Materials to Carlson et al. 2020) included a section on amphibian life history in relation to cover object occupancy, which is relevant to future trend reports but not necessary to duplicate here. Specific details on study site layout, design, cover object materials, field methods, and the pilot study can be found in the Amphibian Monitoring Protocol Narrative, Standard Operating Procedures (SOP) and associated documents (Carlson et al. 2018a, Carlson et al. 2018b, Carlson 2018).

1. Project Timeline

Since installation of the current monitoring design, the Gulf Coast Network has collected data for six monitoring years (MY), with the first spanning May 2018 through March 2019 (MY2018; see full list of MY in Table SM-1). Findings from the first two monitoring years were summarized individually in the network’s first two-year amphibian monitoring report for the park (Carlson et al. 2020), and MY 3 and 4 were covered in Carlson and Toussel (2022). Table SM-1 breaks down the full project timeline by monitoring year, focusing primarily on notable observations, missed sampling events, major changes in personnel, major weather events, and changes to methods. More details on key findings are provided in the main report, past reports, or further below in this document.

Table SM-1. Amphibian Monitoring project timeline at Gulf Islands National Seashore, by monitoring year. Overall, this monitoring effort was led by Gulf Coast Network staff, although the field crew composition changed over time. From midway through the pilot study through May 2023, fieldwork was led by Sarabeth Uriz and her assistants from the University of West Florida. After May 2023, fieldwork transitioned to Gulf Coast Network staff, led by Billy Finney. In the event descriptions below, amphibian and reptile species are mentioned using common names only (following Crother 2017); full scientific names are provided in Tables SM-2, SM-3 and SM-4.

Monitoring Year	Relevant Events or Changes
Prior to current study: pilot study March 2011-Dec 2017	Once per month for over 6 monitoring years, crews checked an array of 30 coverboards and 24 pairs of PVC pipes at the Brown's Pond site. These cover objects were deployed in locations similar to those used currently at Brown's Pond. Twenty-five minnow traps were also deployed overnight in a nearby waterbody, to be sampled during each event. The pilot array was disassembled in Dec. 2017.
Installation of current design in March 2018	A crew of Gulf Coast Network staff and cooperators installed 64 coverboards total, divided evenly between the Brown's Pond and Maintenance sites. Coverboards were arranged in clusters of four along a transect in each site. The crew also installed 64 PVC pipes at the Brown's Pond site and 60 at the Maintenance site. Finally, the crew installed one continuous data logger for barometric pressure, one logger per site for water level, and one logger per site for air temperature and relative humidity. Data were, and continue to be, downloaded from loggers during each sampling event and stored on the network server.
(1) MY2018: May 2018-March 2019	Six of six sampling events were completed. Tropical storm Gordon brought significant rainfall in early September 2018, but this did not impact sampling. There was also a government shutdown that delayed the January 2019 event into early February 2019. Eastern Spadefoot Toads were detected during monitoring for the first time in September 2018 and have been recorded a few times since.
(2) MY2019: May 2019-March 2020	Six of six sampling events were completed. Shields were installed over continuous loggers for temperature and relative humidity in July 2019 to reduce the impact of direct sunlight. Also in July and September of 2019, some tampering of coverboards was noted in Brown's Pond and 11 pipes were found off trees, most likely due to hurricane Barry earlier in the month. In November 2019, a non-native Brown Anole was recorded under a coverboard in Maintenance Pond for the first time during monitoring. This species has been known from the park's visitor center as early as 2016. The reporting interval for the first 2-year report (Carlson et al. 2020) ended after the March 2020 event.
(3) MY2020: May 2020-March 2021	Six of six sampling events were completed. Some tampering of coverboards was observed at Brown's Pond in May 2020. Hurricane Sally, making landfall on September 16, 2020, brought over 406 mm [16 inches] of rainfall to the area over two days and caused substantial damage throughout the park, including fallen trees in Naval Live Oaks Area. Beginning in September 2020 with Hurricane Sally, water levels in Maintenance Pond were unusually high, and they remained that way for much of the following year. Three of six events for MY2020 had at least one coverboard at Maintenance Pond underwater and unsampleable. The last time Maintenance Pond was as high was December 2018-February 2019. From April 2019 to May 2020, water levels were generally low, including periods with little water in the Maintenance Pond.
(4) MY2021: May 2021 to March 2022	Six of six sampling events were completed. There were some changes in field personnel for the January 2022 and March 2022 events, but fieldwork continued to be led by participants from the University of West Florida. Hurricanes Ida and Nicholas passed through the region in fall 2021, but with minimal impacts to the park. Water levels at Maintenance Pond remained high throughout much of the sampling year, with four of the 6 events having at least one board unsampleable due to flooding. The network's first capture of a Brown Anole at a Brown's Pond coverboard was in January 2022. The network also recorded Barking Treefrog for the first time in June 2021. This initial record was outside a sampling event, but this species was later detected several times during monitoring in both study sites. This species' presence was already known to park staff since it had been resting during the day on buildings in the maintenance area. During this MY, there had been increasing evidence of a black bear within the Maintenance Pond site, including boards that were potentially

Monitoring Year	Relevant Events or Changes
	damaged by the bear. The water logger PVC pipe in the pond was also found out of its normal upright orientation in January 2022, although it had been under water in September and November 2021 events. Park staff reported having seen the bear several times around the maintenance compound in 2022-2024. The reporting interval for the second 2-year report (Carlson and Toussel 2022) ended after the March 2022 event.
(5) MY2022: May 2022 to March 2023	Six of six sampling events were completed. The first occurrence of Scarletsnake in I&M sampling was recorded under a coverboard at Maintenance Pond in May 2022, and it has also been seen since at Brown's Pond. The network's first Eastern Diamondback Rattlesnake during monitoring was recorded as a casual observation in July 2022 at Brown's Pond. Barking Treefrog tadpoles were also observed in the Maintenance Pond for the first time in July 2022. In March 2023, the network recorded its first Mole Skink under a coverboard at Maintenance Pond. The most notable species record for MY2022, however, was the first (and so far only) detection of the invasive Cuban Treefrog in a PVC pipe at Maintenance pond in September 2022. Only one individual was found, and it was turned over to park staff and euthanized. The arrival of this species into the park was unsurprising, and USGS scientists that study Cuban Treefrogs had already been working in the Naval Live Oaks Area. Well before March 2018, these scientists placed an auditory recording device at Brown's Pond, and they downloaded the data six times a year for analysis. No Cuban Treefrog calls were detected on USGS recordings during MY2022 or in subsequent monitoring years.
(6) MY2023: May 2023 to March 2024	Six of six sampling events were completed. In May 2023, crew leadership changed from University of West Florida staff to Gulf Coast Network staff, and sampling equipment was turned over during that event. This is the second year in a row when no Dwarf Salamanders were recorded under I&M coverboards. This species has been recorded at least once per year at Brown's Pond since 2015, although always in low numbers. Throughout the first six monitoring years of the current study, the Gulf Coast Network's field methods remained unchanged, although minor changes were made to datasheets to improve data recording practices (in SOP03, Carlson et al. 2022). The reporting interval for the current 2-year report ended in March 2024. The network's first status and trends report for amphibian monitoring at the park will be based on these first six years of data.

2. Ancillary Weather and Environmental Data

The Gulf Coast Network collects a wide range of environmental measurements in association with each amphibian monitoring event. These ancillary data are necessary because amphibian occupancy of monitored cover objects is highly variable and may be influenced by current and past weather conditions. This variability creates a statistical challenge for the network because weather-driven fluctuations in cover occupancy may mask declines or increases in amphibian abundance caused by anthropogenic stressors, which is of primary interest to the network and park. By using ancillary data in models predicting amphibian occupancy and abundance, the network has a better chance of detecting problematic changes in amphibian abundance during the 6-year trend analyses for focal amphibian species.

The environmental variables currently measured or assembled by the network are as follows:

- Air temperature and relative humidity at the start and end of each sampling event in each site.
- Ground surface temperature under each coverboard and interior surface temperature inside each PVC pipe at the time of sampling.

- Continuous air temperature and relative humidity measured at half-hour or hourly intervals for all days of the year, recorded by a datalogger located at a central location in each study site.
- Continuous on-site air pressure measured at hourly intervals for all days of the year, recorded by a data logger located at the Maintenance Pond site. A single pressure logger for both sites is acceptable because cross-site variability is low.
- Continuous on-site sensor depth of an underwater logger, to approximate relative water depth of the waterbody nearest each of the two study sites (Brown's Pond and Maintenance Pond). Measurements are hourly, every day of the year.
- Daily rainfall from the nearby Pensacola airport (12 km away).
- Documentation of major weather events, including hurricanes, tropical storms, and prolonged droughts.

These data are assembled and organized into several datasets on the network server. Water level and rainfall data are visualized to better understand their relationships in each of the two monitoring pond sites (Figure SM-1). Several derived variables are calculated from the raw environmental data, to create covariates that should more directly relate to patterns of amphibian activity and reproduction. For example, relevant variables could include total cumulative rainfall over the three months prior to an event (Figure SM-2A), number of days in the three months before an event when toad breeding activity is likely (i.e., warm days [$>20^{\circ}\text{C}$] that also had significant rainfall [>3 cm in the past three days]; Figure SM-2B), or the mean air temperature during an event, which would likely influence an amphibian's need for thermal refuges like coverboards (SM-2C). Because 2-year reports are focused on the status of amphibians, rather than trends over time, there are no statistical comparisons between weather data and amphibian relative abundance in the current report. Even so, visual comparisons suggest meaningful associations will likely be found.

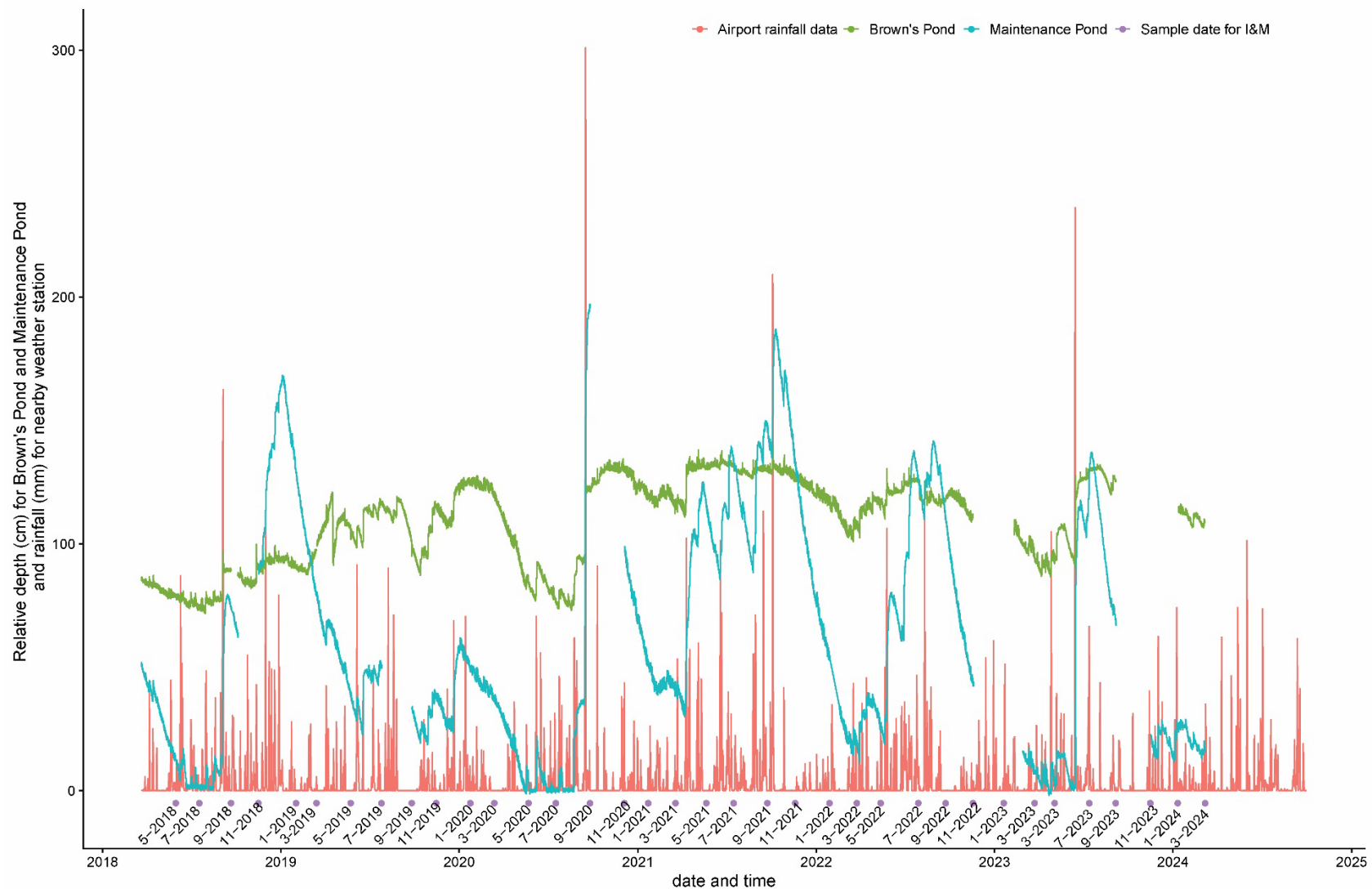


Figure SM-1. Daily rainfall at the nearby airport weather station and hourly water level data for the Brown's Pond and Maintenance Pond amphibian monitoring sites at Gulf Islands National Seashore for 2018-2024. Amphibian monitoring events are shown as purple dots and labeled with the start date of the 2-day event.

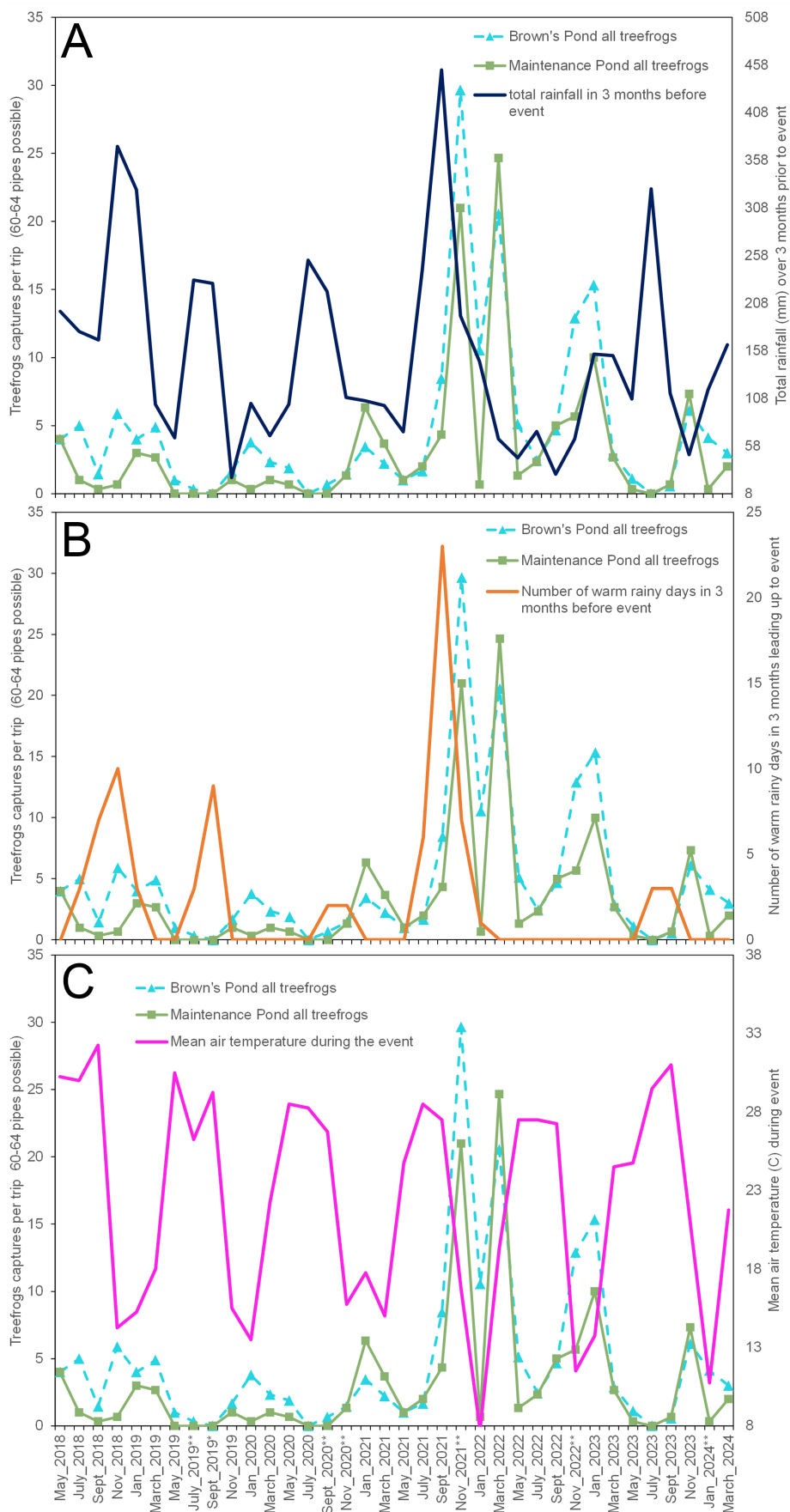


Figure SM-2. Derived environmental variables in relation to amphibian sampling events and amphibian captures for Gulf Islands National Seashore from May 2018–March 2024. (A) Total cumulative rainfall (mm) over 3 months prior to a sampling event; (B) the number of warm ($>20^{\circ}\text{C}$) rainy (>3 cm rainfall in past 3 days) days in the 3 months prior to a sampling event; and (C) the average air temperature during a sampling event.

3. List of Amphibian Species Detected During Monitoring

Over the current 2-year reporting period, a total of 13 amphibian species were recorded through monitored refuges and supplemental visual observations. The names of these species are provided in the web article. The cumulative list of amphibian species observed since monitoring began (Table SM-2) adds six species, bringing the total species observed over the duration of this study to 19. This includes the pilot study at Brown's Pond from 2011-2017, during which minnow traps were deployed overnight for each sampling event to detect tadpoles and adults of aquatic amphibians.

There were two additional species documented in the amphibian inventory by Mohrman and Qualls (2008) that have yet to be recorded during I&M monitoring. These are the Southern Two-lined Salamander (*Eurycea cirrigera*) and the Ornate Chorus Frog (*Pseudacris ornata*). The only non-native amphibian species at Naval Live Oaks Area are the Cuban Treefrog and the Greenhouse Frog, both of which have been recorded by I&M crews.

Table SM-2. Amphibian species recorded by I&M crews under coverboards, in PVC pipes, or out in the open during monitoring events at Gulf Islands National Seashore since the I&M project began at the park (March 2011- March 2024). *Species with an encounter rate high enough for long term monitoring by I&M. Scientific and common names follow Crother (2017) with the exception of *Dryophytes*, which replaced *Hyla* in network records in 2023 due to widespread acceptance in the scientific literature.

Group	Common Name	Scientific name	Most Recent I&M Record
Frogs and Toads	Southern Cricket Frog	<i>Acris gryllus</i>	3/8/2024
Frogs and Toads	Oak Toad	<i>Anaxyrus quercicus</i>	3/8/2024
Frogs and Toads	Southern Toad	<i>Anaxyrus terrestris</i>	3/25/2023
Frogs and Toads	Green Treefrog*	<i>Dryophytes cinereus</i>	3/7/2024
Frogs and Toads	Pine Woods Treefrog*	<i>Dryophytes femoralis</i>	3/8/2024
Frogs and Toads	Barking Treefrog	<i>Dryophytes gratiosus</i>	9/24/2022
Frogs and Toads	Squirrel Treefrog*	<i>Dryophytes squirellus</i>	3/8/2024
Frogs and Toads	Greenhouse Frog*	<i>Eleutherodactylus planirostris</i>	3/8/2024
Frogs and Toads	Eastern Narrow-mouthed Toad	<i>Gastrophryne carolinensis</i>	3/7/2024
Frogs and Toads	American Bullfrog	<i>Lithobates catesbeianus</i>	2/18/2016
Frogs and Toads	Bronze Frog	<i>Lithobates clamitans</i>	1/24/2018
Frogs and Toads	Pig Frog	<i>Lithobates grylio</i>	3/7/2024
Frogs and Toads	Southern Leopard Frog	<i>Lithobates sphenocephalus</i>	9/24/2022
Frogs and Toads	Cuban Treefrog	<i>Osteopilus septentrionalis</i>	9/24/2022
Frogs and Toads	Eastern Spadefoot	<i>Scaphiopus holbrookii holbrookii</i>	1/22/2021
Salamanders	Two-toed Amphiuma	<i>Amphiuma means</i>	9/19/2017
Salamanders	Southeastern Dwarf Salamander	<i>Eurycea quadridigitata</i>	1/28/2022
Salamanders	Eastern Newt	<i>Notophthalmus viridescens</i>	1/13/2024
Salamanders	Southeastern Slimy Salamander	<i>Plethodon grobmani</i>	12/13/2016

4. List of Reptile Species Detected During Two-Year Reporting Period and Since Monitoring Began

When reptiles are encountered during monitoring, the species name and number of individuals are always recorded, even though reptiles are not the targeted taxonomic group for the project. Table SM-3 lists all reptile species encountered in each monitoring site during the current reporting interval (MY2022-2023), including the most recent encounter date.

Since I&M began amphibian monitoring in 2011, 23 reptile species have been detected at Gulf Islands National Seashore (Table SM-4). During this current two-year monitoring period, 15 of those species were observed. Brown Anole is the only non-native species on the list and was first recorded in I&M studies in 2019.

Table SM-3. Reptile species detected under coverboards (CB), in PVC pipes (PVC), or by visual observation (VS) during sampling events in the 2022 and 2023 monitoring years (May 2022 – March 2024). BP is for Brown's Pond site and MP is for Maintenance Pond site.

Group	Common Name	Scientific name	Most recent	Site	Count	Method of detection
Lizard	Green Anole	<i>Anolis carolinensis</i>	3/7/2024	BP	25	CB, PVC, VS
Lizard	Green Anole	<i>Anolis carolinensis</i>	3/8/2024	MP	29	CB, PVC, VS
Lizard	Brown Anole	<i>Anolis sagrei</i>	11/19/2022	MP	2	CB, VS
Lizard	Six-lined Racerunner	<i>Aspidoscelis sexlineatus</i>	5/14/2022	MP	1	VS
Lizard	Eastern Fence Lizard	<i>Sceloporus undulatus</i>	3/25/2023	MP	1	VS
Lizard	Ground Skink	<i>Scincella lateralis</i>	3/7/2024	BP	12	CB, VS
Lizard	Ground Skink	<i>Scincella lateralis</i>	3/8/2024	MP	16	CB, VS
Lizard	Mole Skink	<i>Plestiodon egregius</i>	3/8/2024	MP	2	CB
Lizard	Broad-headed Skink	<i>Plestiodon laticeps</i>	5/4/2023	BP	9	CB, VS
Snake	Scarletsnake	<i>Cemophora coccinea</i>	5/14/2022	MP	1	CB
Snake	Scarletsnake	<i>Cemophora coccinea</i>	5/4/2023	BP	1	CB
Snake	North American Racer	<i>Coluber constrictor</i>	3/8/2024	MP	6	CB, VS
Snake	North American Racer	<i>Coluber constrictor</i>	5/4/2023	BP	1	VS
Snake	Coachwhip	<i>Coluber flagellum</i>	5/5/2023	MP	2	CB
Snake	Coachwhip	<i>Coluber flagellum</i>	7/14/2023	BP	1	CB
Snake	Eastern Diamond-backed Rattlesnake	<i>Crotalus adamanteus</i>	7/29/2022	BP	1	VS
Snake	Banded Watersnake	<i>Nerodia fasciata</i>	1/13/2024	MP	4	CB
Snake	Southeastern Crowned Snake	<i>Tantilla coronata</i>	3/7/2024	BP	1	CB
Snake	Eastern Ribbonsnake	<i>Thamnophis sauritus</i>	3/24/2023	BP	1	VS
Snake	Eastern Ribbonsnake	<i>Thamnophis sauritus</i>	9/7/2023	MP	2	VS
Snake	Common Gartersnake	<i>Thamnophis sirtalis</i>	9/7/2023	MP	3	CB, VS
Snake	Common Gartersnake	<i>Thamnophis sirtalis</i>	5/4/2023	BP	1	CB

Table SM-4. Reptile species recorded by I&M crews since the amphibian monitoring project began at Gulf Islands National Seashore (2011-2024). Individuals were either under coverboards, in PVC pipes, or seen out in the open during monitoring events. The original inventory by Morhmann and Qualls (2008) documented 44 reptile species at the park, but some records may have only been from the park's beachfront properties on Santa Rosa Island or Perdido Key. Scientific and common names follow Crother (2017).

Group	Common Name	Scientific Name
Lizard	Green Anole	<i>Anolis carolinensis</i>
Lizard	Brown Anole	<i>Anolis sagrei</i>
Lizard	Six-lined Racerunner	<i>Aspidoscelis sexlineatus</i>
Lizard	Eastern Glass Lizard	<i>Ophisaurus ventralis</i>
Lizard	Mole Skink	<i>Plestiodon egregius</i>
Lizard	Five-lined Skink	<i>Plestiodon fasciatus</i>
Lizard	Broad-headed Skink	<i>Plestiodon laticeps</i>
Lizard	Eastern Fence Lizard	<i>Sceloporus undulatus</i>
Lizard	Ground Skink	<i>Scincella lateralis</i>
Snake	Scarletsnake	<i>Cemophora coccinea</i>
Snake	(Southern) Black Masked Racer	<i>Coluber constrictor (latrunculus/priapus)</i>
Snake	Coachwhip	<i>Coluber flagellum</i>
Snake	Eastern Diamondback-backed Rattlesnake	<i>Crotalus adamanteus</i>
Snake	Coralsnake	<i>Micrurus fulvius</i>
Snake	Banded Watersnake	<i>Nerodia fasciata</i>
Snake	Cornsnake	<i>Pantherophis guttatus</i>
Snake	Pygmy Rattlesnake	<i>Sistrurus miliarius</i>
Snake	Southeastern Crowned Snake	<i>Tantilla coronata</i>
Snake	Eastern Ribbonsnake	<i>Thamnophis sauritus</i>
Snake	Common Gartersnake	<i>Thamnophis sirtalis</i>
Turtle	Spiny Softshell	<i>Apalone spinifera</i>
Turtle	Common Cooter	<i>Pseudemys floridana</i>
Turtle	Eastern Box Turtle	<i>Terrapene carolina (major)</i>

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