



Biscayne National Park Colonial Nesting Bird Monitoring

Protocol Narrative—Version 1.1

Natural Resource Report NPS/SFCN/NRR—2022/2343



ON THE COVER

A Great White Heron (*Ardea herodias occidentalis*) stands guard over its eggs. This bird was photographed nesting on a mangrove island within Biscayne National Park.

Photograph courtesy of National Park Service South Florida / Caribbean Network

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Revision Log

The Revision Log table below provides a brief description of the changes made to each published version of this protocol over time.

Revision Log Table. Shows the revision date (approval), authors, changes made, reasons for change, and version number for all published versions of this protocol. Please add new rows to this table as need for each new published version.

Revision Date	Author	Changes Made	Reason for Change	New Version #
4/15/2020	Robert Muxo Kevin Whelan Judd Patterson	Updated Sampling frequency and timing section. Updated Quality Assurance/ Quality Control section. Appendix C was updated. Minor editorial changes. The details of Appendix C were moved to SOP CNB06.	Sampling and frequency section updated to reflect current methodology. Quality Assurance/ Quality Control section updated to reflect current standards. Updated Appendix C shows the changes made to the database. Editorial updates reflect current naming convention for SOPs and grammatical corrections.	1.1

Abstract

Breeding colonies of wading birds (orders *Ciconiiformes*, *Pelecaniformes*) and seabirds (orders *Suliformes*, *Pelecaniformes*) serve as important indicators of aquatic ecosystem health, as they respond to changes in food abundance and quality, contaminants, invasive species, and disturbance. The Comprehensive Everglades Restoration Plan, Restoration Coordination & Verification program (CERP-RECOVER) has identified wading-bird colonies as an important ecosystem restoration indicator. The National Park Service South Florida/Caribbean Inventory & Monitoring Network (SFCN) ranked colonial nesting birds eighth out of 44 vital signs of park natural resource conditions for ecological significance and feasibility. However, while large-scale monitoring efforts are occurring in the rest of the Greater Everglades Ecosystem, only minimal historic data collection and no extensive ongoing monitoring of wading bird and seabird nesting have occurred in Biscayne National Park. Consequently, due to their high importance as biological indicators and because they are a gap occurring in regional monitoring efforts, the network has initiated a monitoring program of colonial nesting birds in Biscayne National Park.

This protocol provides the rationale, approach, and detailed Standard Operating Procedures for annual colonial bird monitoring within and close to Biscayne National Park and conforms to the Oakley et al. (2003) guidelines for National Park Service long-term monitoring protocols. The specific objectives of this monitoring program are to determine status and long-term trends in:

- Numbers and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants, Great Egrets, Great White Herons, Great Blue Herons, White Ibises, and Roseate Spoonbills.
- Annual peak active nest counts of colonial nesting birds in Biscayne National Park with a special focus on the species mentioned above.
- An annual nesting index (i.e., sum of monthly nest counts) with a special focus on the species mentioned above.
- Timing of peak nest counts for the focal species.

The protocol involves an annual aerial park-wide survey using a helicopter to locate nesting colonies of wading birds and seabirds within Biscayne National Park, followed by monthly aerial surveys of the nesting colonies. Nesting colonies are photographed, and the photographs are analyzed in the office to identify and count active nests by species. An observer also records counts of both nesting and non-nesting birds observed in the field. The methods used are detailed in seven Standard Operating Procedures (SOPs):

1. Personnel Training
2. Safety Requirements and Procedures to Fly in a Helicopter
3. Camera Use and Setup, GeoTagger use and Setup, and Photography from a Helicopter
4. GPS Track Downloading, Photo Downloading and Archiving, Photo Geotagging, Photo Renaming and Photo Tagging in Thumbs Plus

5. Collecting Data, Circling Nests, and Counting Nests
6. Data Entry, Data Proofing, and Data Reporting
7. Revising the Protocol

The network conducted five years of pilot data collection to facilitate the development of this protocol and some of those early results are provided in support of various aspects of the protocol as well as in a sample data summary report included as an appendix. The methods used are intended to provide the precision and power to detect change at the individual park level while also supplementing the regional colonial nesting bird monitoring occurring throughout the Greater Everglades Ecosystem.

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Acronyms

ANHI:	Anhinga
BAEA:	Bald Eagle
BISC:	Biscayne National Park
CAEG:	Cattle Egret
CERP:	Comprehensive Everglades Restoration Plan
DCCO:	Double-crested Cormorant
DPL:	Data Processing Level
EVER:	Everglades National Park
GBHE:	Great Blue Heron
GPS:	Global Positioning System (device)
GREG:	Great Egret
GWHE:	Great White Heron
IHOG:	Interagency Helicopter Operations Guide
LBHE:	Little Blue Heron
NPS:	National Park Service
OAS:	Office of Aviation Safety
OSPR:	Osprey
PPE:	Personal Protective Equipment
QA/QC:	Quality Assurance / Quality Control
QAP:	Quality Assurance Plan
REEG:	Reddish Egret
ROSP:	Roseate Spoonbill
SFCN:	South Florida/Caribbean Network
SNEG:	Snowy Egret
SOP:	Standard Operating Procedure
TRHE:	Tricolored Heron
WHIB:	White Ibis

Background and Objectives

The National Park Service (NPS) defines vital signs as a small set of characteristics that, when consistently monitored, represent the overall status or condition of a national park. Vital signs are physical, chemical, or biological components that are expected to respond to known environmental stressors or are characteristics highly valued by people. The South Florida/Caribbean Inventory & Monitoring Network (SFCN) systematically monitor vital signs for seven national parks. The information collected is used to support the management of natural resources in those national parks. The Colonial Nesting Bird vital sign ranked 8th in the SFCN Vital Signs Monitoring Plan due to ecological significance and monitoring feasibility (Patterson et al. 2008). The Colonial Nesting Birds Protocol was written and will be updated by SFCN staff. The South Florida/Caribbean Inventory & Monitoring Network will also perform the monitoring duties. This document describes the process used to monitor active bird nests in Biscayne National Park.

Rational for Selecting this Resource

Colonial nesting birds (e.g., wading birds and seabirds) are an important component of the Biscayne National Park ecosystem. A nesting bird colony is defined as a large congregation of individuals of one or more species of birds that nest in close proximity at particular locations. Nesting colonies on islands are very common among seabirds, as nearly 95% of seabird species are colonial (Danchin and Wagner 1997). Herons, egrets, and other species of wading birds also nest communally with other seabirds in Biscayne National Park. The prominent trophic level these birds have is evidence of the important role they serve as indicators of local and regional ecosystem health (Sadoul 1997, Browder et al. 2005, Ogden et al. 2014). Colonial nesting birds have a moderate foraging range (Figure 1) and are affected by both local and regional scale ecosystem changes. This suggests that the long-term monitoring of colonial nesting birds will provide insight to overall ecosystem health at these scales (Erwin et al. 1993).

Colonial nesting birds require a suitable environment for completing reproductive processes. Reproductive requisites include good hydrological conditions that provide an abundance of prey, predator-free roosting, nesting locations close to feeding areas, and safe areas for juveniles and fledglings. Nesting success requires the ability to acquire food for the establishment of reproductive condition, egg production, and to feed chicks and fledgling young. Thus, successful nesting at Biscayne National Park would suggest the environment adequately supports avian reproductive effort. Double-crested Cormorants have been reported to forage between 1.5 miles (Custer and Bunk 1992 as reported in Duffy 1995) and between 18 to 50 miles (Ainley et al. 1990) from the colony. As a conservative foraging distance estimate, we chose a five-mile radius to overlay on a map of the park, thus providing a visual reference of possible foraging grounds relative to park boundaries. Using a 5-mile foraging radius, approximately 66% of Biscayne National Park is supporting the known colonies (Figure 1). If a ten-mile radius is used, 100% of the park would be in the foraging area. Significant variations in nest counts may indicate that birds are encountering changing environmental conditions (Sadoul 1997). Reproductive needs of these animals also include subtle environmental factors not immediately apparent to managers.

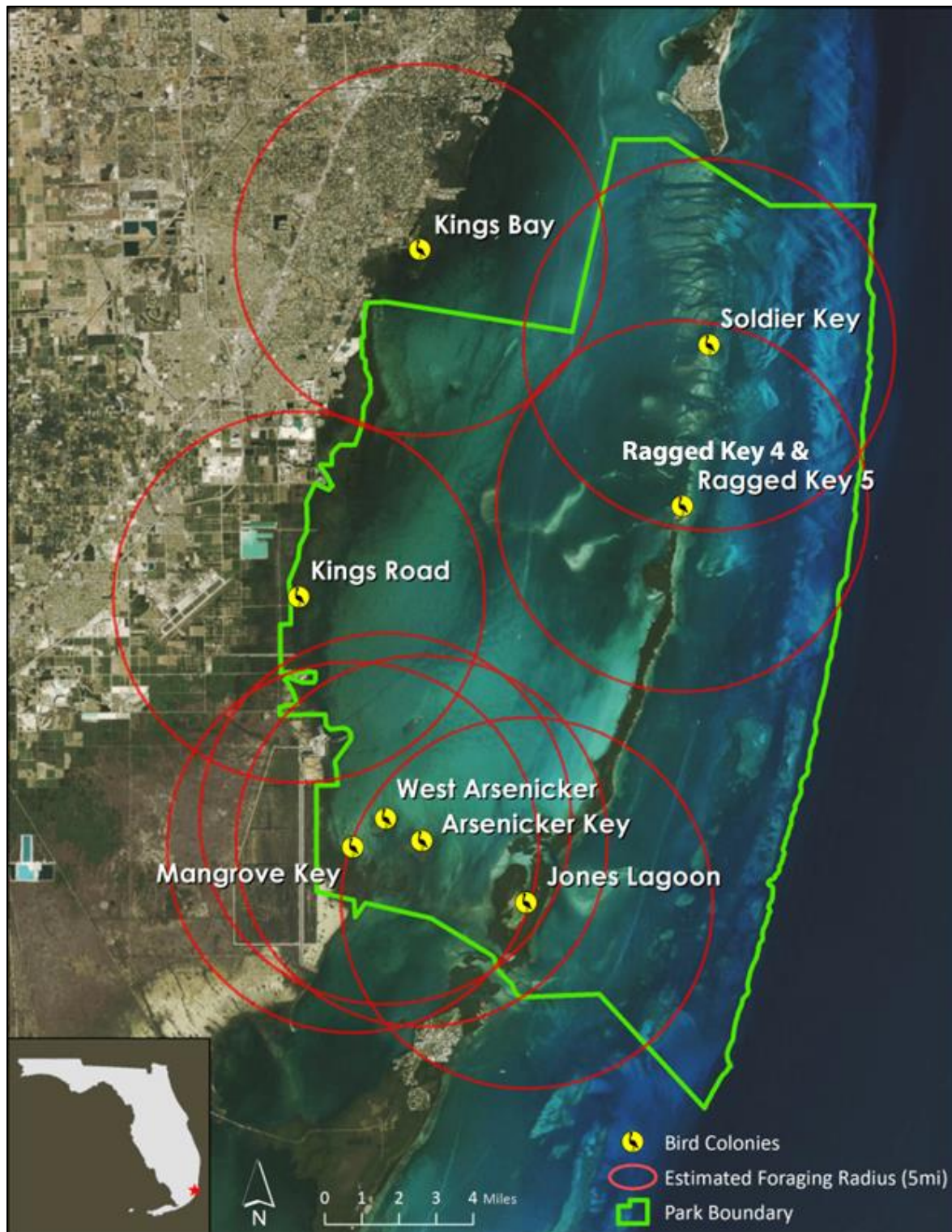


Figure 1. The nine known island sites near and within Biscayne National Park with colonial nesting bird colonies and assumed foraging radius. The circles around each colony are five miles in radius and represent common foraging grounds for birds nesting or roosting at a colony. Ragged Keys 4 & 5 are close to each other and represented by one marker.

The presence of nesting bird colonies as well as colony size and nesting success indicate the ecosystem's ability to support these energy intensive activities.

Evidence suggests that seabird and wading bird reproductive success is linked with ecosystem ecology and hydrology at several spatial and temporal scales (Frederick and Ogden 2003). Consequently, in South Florida, colonial wading birds including Wood Storks (*Mycteria americana*), Roseate Spoonbills (*Platalea ajaja*), egrets and ibises have been identified as important performance measures for the Comprehensive Everglades Restoration Plan (CERP) in order to track the success of the ecosystem restoration. Much of wading bird foraging success relies on the quality, quantity, and timing of water flow draining from the Everglades (Browder et al 2005). Specifically, colonial bird nesting success is being used as a measure of success regarding water flow into Biscayne Bay. The Comprehensive Everglades Restoration Plan aims to influence the path and timing of water delivery as well as levels of contaminants entering the bay. Changes in the quantity and quality of freshwater entering Biscayne Bay affect salinity and turbidity levels and in turn affect mangroves, oysters, and seagrass communities. One of the 14 research questions addressed in the CERP Biscayne Bay Conceptual Ecological Model is: "Will wading bird nesting activity, nesting success, and foraging activity be improved by the reestablishment of more natural hydro-patterns in Biscayne Bay's coastal wetlands?" (Browder et al. 2005). The Biscayne Bay Conceptual Ecological Model and the SFCN Vital Signs Monitoring Plan provide more comprehensive descriptions of these processes. Estuarine communities serve as foraging grounds for several species of birds (Browder et al. 2005), including the Double-crested Cormorant (*Phalacrocorax auritus*), Great Blue Heron (*Ardea herodias*), and Roseate Spoonbill. Many authors (Frohring et al. 1988, Crozier and Gawlik 2003, Cook et al. 2010, and Ogden et al. 2014) consider monitoring of colonial bird population status and trends vital to a greater understanding of ecosystem decline, the potential for recovery, and overall ecosystem health. Long-term monitoring of Biscayne National Park bird nesting can be used to understand impact of short-term events such as oil spills or hurricanes and of long-term progressive events such as sea-level rise resulting from climate change, fisheries management, seagrass health, effects of invasive species, and water quality in Biscayne Bay. Data collected will provide species-specific nesting information separate from community level trends, which is an important consideration (Crozier and Gawlik 2003). The State of Florida considers several of the bird species nesting, roosting and/or foraging in Biscayne National Park to be imperiled. State-listed species of special concern include the Little Blue Heron (*Egretta caerulea*), Reddish Egret (*Egretta rufescens*), Roseate Spoonbill (*Platalea ajaja*), Tricolored Heron (*Egretta tricolor*), and White Ibis (*Eudocimus albus*) (FWC 2013). The Least Tern (*Sternula antillarum*) and White-crowned Pigeon (*Patagioenas leucocephala*) are listed as threatened by the state, and the Wood Stork (*Mycteria americana*) is listed as federally threatened (Florida Fish and Wildlife Conservation Commission 2020).

Colonial nesting birds can in turn have an influence on their surroundings. Added nutrient loads from guano factor into determining which species of seagrass will grow in the area. Changes in seagrass species affect species richness and density of demersal fish and invertebrates (Fourqurean et al. 1992). Thus, knowledge of colony locations and size may assist interpretation of other environmental variables.

Long-term monitoring will provide useful information on the status and trends of these natural resources and may detect environmental problems before severe damage occurs (Sadoul 1997, Bennetts et al. 2007). Monitoring colonial nesting birds can be a powerful tool in understanding the ecology of the birds and their ecosystem (Frederick and Ogden 2003). Monitoring Biscayne National Park colonial bird populations in association with other environmental monitoring programs is expected to provide further understanding of the birds' ecology and that of their surrounding ecosystem. This can be particularly useful for managers to make informed decisions about habitat threats, species protection, resource use, and restoration needs (Gibbs et al. 1999, Parrish et al. 2003).

Existing Monitoring Programs

Bird monitoring efforts in South Florida began long ago, prior to the formation of Everglades National Park. Early records were gathered by wardens and biologists of the National Audubon Society in the 1930s.

Many of today's monitoring programs include performance measures related to the Everglades restoration efforts. Specifically, surveyors monitor birds and nests in Everglades National Park (EVER), Big Cypress National Preserve (BICY), and the Water Conservation Areas (WCAs) north of EVER. Monitoring methods used today include flying aerial transects to spot nesting colonies. These systematic aerial surveys of the Water Conservation Areas began in 1986 followed soon after by aerial surveys of EVER (Frederick and Ogden 2003). Ground surveys assist in locating small colonies and dark birds possibly missed by aerial surveys. Aerial surveys also provide data on wading bird distribution.

The southernmost portion of Everglades National Park is Florida Bay. This bay area supports a significant population of wading birds and has been monitored for decades. Aerial counts for birds in the bay date back as far as 1935 (Powell et al. 1989). Roseate Spoonbills have been a species of interest for several years after nearly being extirpated by hunters seeking meat and plumage. These charismatic birds are still monitored today and are considered an indicator species for the Comprehensive Everglades Restoration Plan RECOVER program.

Multiple agencies, universities, and non-governmental monitoring programs report their results in the South Florida Wading Bird Report and the reader is referred to this resource for a more complete description of wading bird monitoring in South Florida (Cook 2013). A version of this protocol's summary data report is currently published in the South Florida Wading Bird Report.

Although various agencies have measured the numbers of colonial nesting birds and their reproductive success in South Florida for years, few data are available for Biscayne National Park. There were limited surveys that occurred during the 1970s and sporadic surveys by the State of Florida. A consistent monitoring program in Biscayne National Park can serve as an early warning to park management to detect declines in ecosystem integrity and species viability before irreversible loss occurs (Kushlan 1993). In addition, monitoring in Biscayne National Park will help complete a regional wading bird picture. When combined with data from other nesting areas (e.g., Florida Bay), a more comprehensive understanding can be achieved for species which nest in Florida Bay, Everglades National Park, Water Conservation Areas, and Biscayne Bay.

Implementation Park: Biscayne National Park

The South Florida/Caribbean Inventory & Monitoring Network will implement this colonial nesting protocol at Biscayne National Park. Biscayne National Park was established first as a monument in 1968 and then as a national park in 1980. Biscayne National Park islands, waters, and surrounding areas currently provide suitable habitat for bird reproduction. Biscayne National Park covers an area of 173,000 acres, approximately 95% of which are submerged marine environments. Birds utilize the bay and the approximately 42 islands protected within the park boundary year-round. Mangroves cover 74% of the terrestrial environments, hammock/hardwoods cover 23%, marshes 0.4%, and beaches <0.1% (Whelan et al. 2013). The shallow waters surrounding Biscayne National Park mangrove islands are suitable habitat for foraging and offer protection for nesting colonies from most land predators. These islands, which serve as refuge to colonial nesting birds, will be the focus of SFCN monitoring efforts.

Urbanization has reduced the mangrove wetlands and other habitats on the western boundary of the park and modified the natural tidal creeks. These creeks historically mixed freshwater flows with the marine system during the wet season, but these areas are now dominated by canal discharges and unnatural pulses. The modified hydrology of the bay has affected the seasonal salinity patterns and the bay ecology and is one of the targets of the Comprehensive Everglades Restoration Plan. The park receives approximately a half million visitors each year, many of which come to boat, fish, snorkel, and dive within the park.

Focal Species

Though many colonial nesting bird species utilize Biscayne National Park, this protocol focuses on monitoring nesting trends and patterns of five focal species: Double-crested Cormorant (*Phalacrocorax auritus*), Great Blue Heron (*Ardea herodias*) and its subspecies Great White Heron (*Ardea herodias occidentalis*), Great Egret (*Ardea alba*), Roseate Spoonbill (*Platalea ajaja*), and White Ibis (*Eudocimus albus*). For the purposes of this document, the Great White Heron is considered a subspecies.

These bird species are either top-canopy or highly visible upper sub-canopy nesters. All except the cormorants are monitored in other parts of South Florida such as Everglades National Park, both mainland and Florida Bay, the Water Conservation Areas, and Big Cypress National Preserve. The results of these monitoring efforts are published in the South Florida Wading Bird Report (Cook 2013). Monitoring these species allows for inter-regional comparisons to be made. These species cover a variety of feeding techniques, including diving (Double-crested Cormorants), stalk and strike (Great Blue Heron, Great White Heron, Great Egret), and tactile feeding (Roseate Spoonbill, White Ibis), reflecting the complexity of the food web in the park and providing upper trophic-level responses to foraging conditions at different portions of the lower food web.

Double-crested Cormorant

Double-crested Cormorants are a dark to glossy black duck-like bird of medium size (Figure 2). This species feeds by diving and then pursuing prey, primarily fish. Double-crested Cormorants feed in coastal bays, lakes, estuaries, and nearshore open water, including freshwater, brackish, and marine habitats. Cormorants dive below the water surface as deep as 20 ft (Sullivan et al. 2006) and actively

chase fish thereby accessing prey in habitats unavailable to the herons and egrets. The stick nest is built by both the male and female. It takes approximately three months from egg laying to fledged young capable of flying and diving (Nellis 2001). This species is presumed to be sensitive to changes in food supply from local fish populations, contaminants (especially DDT and other organochlorine pesticides), and disturbance of nesting colonies by invasive species (e.g., pythons, rats), native predators (e.g., raccoons), and humans. Historically they were also hunted as fishermen saw them as competition for fish.



Figure 2. Double-crested Cormorant nesting in Biscayne National Park.

Annual censuses of the Double-crested Cormorant population in Biscayne Bay from 1980 to 1986, average as follows: 3,500 in January and February, 2,500 in March, 1,300 from April to September, 2,500 in October, and 3,500 in November and December (Cummings 1987). These results suggest the resident population may be supplemented by a strong winter migration population.

Double-crested Cormorant nests are the most numerous type of nest counted in this monitoring project. Cummings' (1987) findings also indicate peak breeding months of April through August which corresponds with our data (see sample data summary report in Appendix 4).

A banding study reported by Dolbeer (1991) shows that Double-crested Cormorants banded from 1923 to 1988 migrated south from New England, the St. Lawrence River, and the St. Lawrence Gulf region. These northern populations would migrate in October and November and supplement cormorant populations from Texas to Florida, including the Biscayne Bay nesting population. The banding data suggests the majority of cormorants that migrate north eventually return to the

proximity of their natal colony, within a median distance of 25 km (Dolbeer 1991). We consider it unlikely that this migratory population is nesting in Biscayne Bay and note that we are not seeing a large winter-time nesting pulse in our data.

Great Blue Heron

Great Blue Herons are the largest North American heron (Figure 3). The heron's body is gray-blue with the neck having a tan coloration. It feeds using a stalk and strike method, standing still, waiting for unsuspecting prey, and then striking with its beak. Great Blue Herons can be found feeding in freshwater, brackish, and saltwater habitats that are shallow enough for these tall herons to wade in and clear enough to see prey including marshes, sloughs, lakes, open coasts, and riverbanks. They occasionally forage in grasslands and agricultural fields. Their primary diet includes fish, amphibians, reptiles, small mammals, insects and other birds that they can grab using a stalk and strike method. Males gather sticks and the female constructs the nesting platform (Nellis 2001). Nest platforms are sometimes reused. It takes approximately three months from egg laying to fledge young. Gibbs (1991) found a correlation between size of foraging areas and size of colony sites for Great Blue Herons. In general, birds conserve energy by nesting in areas centrally located to food sources. They can be sensitive to changes in hydrology that affect food supplies, contaminants (e.g., DDT and mercury), habitat loss, and disturbance of nesting colonies by invasive species, raccoons, and humans.

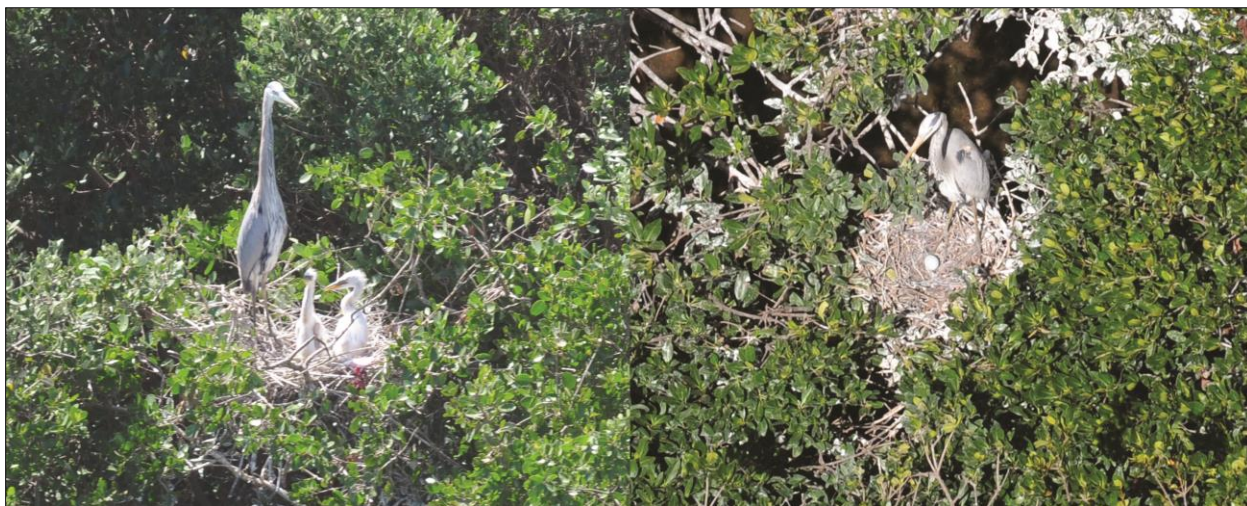


Figure 3. Two examples of Great Blue Herons watching over their nests, one with an egg and the other with two chicks.

Great White Heron

The Great White Heron (Figure 4) is currently considered a subspecies of the Great Blue Heron (Peterson 2010), although they were once considered their own species and debate continues regarding their taxonomic position. They are only found in South Florida and their diet is similar to the Great Blue Heron. They are often seen on seagrass flats and in mangroves. The South Florida/Caribbean Inventory & Monitoring Network has detected the Great White Heron nesting as far north as Soldier Key in Biscayne National Park. Previous reports showed these herons nesting in

the Arsenickers (FWC 2003) in Biscayne Bay, approximately 25 km SSE of Soldier Key. Documentation of Great White Heron nesting in Biscayne National Park is important because they have a limited nesting area that has historically only been reported in the Florida Keys, Florida Bay, and the Sarasota/ Bradenton area (FWC 2003). Increases in freshwater flows that affect estuarine and bay fish communities are expected to affect great white herons (Ogden et al. 2014) along with contaminants (e.g., DDT and mercury), habitat loss, and disturbance of nesting colonies by invasive species, raccoons, and humans.



Figure 4. Great White Heron leaving nest in Biscayne National Park.

Great Egret

The Great Egret is a medium-sized, strikingly elegant all-white heron with black legs (Figure 5). It can be confused with the Great White Heron; however, Great Egrets are slightly smaller and have black legs as opposed to the Great White herons which have yellowish legs. Great Egrets feed using the stalk and strike method. Previously built nests may be reused. It takes just over two months from egg laying to fledge young (Nellis 2001). Great Egrets and Great White Heron nesting times and locations often overlap, making it difficult to distinguish between the two species when a complete view of the birds is not available. Great Egrets can be found feeding in freshwater, brackish, and saltwater habitats that are shallow enough for them to wade in and clear enough to see prey including marshes, sloughs, lakes, open coasts, and riverbanks. They occasionally forage in grasslands and agricultural fields. Their diet is mostly fish but also includes crustaceans, amphibians, and invertebrates and in fields can include insects, rodents, and small birds.



Figure 5. Great Egret at West Arsenicker Key in Biscayne National Park.

Roseate Spoonbill

Roseate Spoonbills are medium-sized pink birds with a uniquely spoon-shaped bill (Figure 6). Roseate Spoonbills are tactile feeders, and they swing their spoonbill through the mud feeding on small fish, shrimp, and aquatic insects. They feed in shallow, estuarine, seasonally flooded wetlands involving a diverse array of habitats including mangrove swamps, tidal ponds, saltwater lagoons, and other areas of brackish water. Males gather sticks and wood materials for the nest and the female builds the nest. It takes approximately two months to lay eggs and fledge young (Nellis 2001). Roseate Spoonbills were once hunted to near extinction for their pink plumage. Roseate Spoonbills were detected nesting in Biscayne National Park by the South Florida/Caribbean Inventory & Monitoring Network in 2009. It is not known exactly when these birds started using Biscayne National Park as a nesting site, but through SFCN monitoring efforts we can follow trends in their nesting effort within the park. Roseate Spoonbills are considered an indicator species for the Comprehensive Everglades Restoration Plan Monitoring and assessment Plan program and are expected to respond positively to restoration of freshwater flows to Florida Bay (Ogden et al. 2014). What impact (if any) this may have on Roseate Spoonbills nesting in Biscayne National Park is unclear. However, one of the lowest nesting seasons in Florida Bay (winter 2010–2011; RECOVER 2014a) coincided with the highest peak nest count recorded to date by the South Florida/Caribbean Inventory & Monitoring Network in Biscayne National Park (12 nests, see Appendix 4). Thus, monitoring Roseate Spoonbills in Biscayne National Park may help complete interpretations of status and trends in Everglades National Park (EVER). Roseate Spoonbills are also sensitive to contaminants and disturbance of nesting colonies by invasive species, raccoons, and humans.



Figure 6. Roseate Spoonbills adult and juveniles in Jones Lagoon.

White Ibis

White Ibises are smaller white birds with a distinctly curving orange-red bill (Figure 7). The White Ibis is a tactile feeder that uses its long slender beak to reach into holes and crannies seeking out prey including crayfish, crabs, insects, snails, frogs, marine worms, snakes, and small fish. They forage in freshwater, brackish, and saltwater shallow habitats and seasonal wetlands including marshes, mudflats, flooded pastures, lake edges, mangrove lagoons, and grassy fields. Males gather sticks and the female builds the nest. Nests are lined with green leaves. It takes almost three months to lay eggs and fledge young (Nellis 2001). In our experience the White Ibis nests lower in the canopy and their nests are small relative to the size of the bird. However, the bird's white coloring, location in the canopy, body posture and well-defined nesting season improve our ability to detect nesting. Thus, detection of White Ibis colonies is fairly easy, however because this is a sub-canopy nester, only a portion of the nests may be visible from the air. Second to the cormorants, White Ibises have the highest peak nest numbers of the species monitored. White Ibises were initially detected at West Arsenicker but subsequently were detected at Arsenicker Key. White Ibises are considered an indicator species for the Comprehensive Everglades Restoration Plan Monitoring and assessment Plan program as nesting colony size and location is expected to respond to regional changes in amount and timing of freshwater hydrology and associated fish productivity. In addition, the timing and length of dry periods is critical as fish are concentrated into small shallow pools that are a potent food source allowing wading birds to complete nesting successfully (RECOVER 2014b). White

Ibises are also sensitive to contaminants and disturbance of nesting colonies by invasive species, raccoons, and humans.



Figure 7. White Ibises nesting in Arsenicker Key in Biscayne National Park.

Other species

Colonies of the smaller egrets and darker herons such as the Tricolored Heron (*Egretta tricolor*), Little Blue Heron (*Egretta caerulea*), Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), Reddish Egret (*Egretta rufescens*) and the Yellow-crowned Night-Heron (*Nyctanassa violacea*) also nest in the sub-canopy. These birds, although present, are not detected well from aerial surveys. Because of lower detection probabilities, these species are not considered focal species of the protocol although colonies, visible active nests, and observed birds are recorded. Species such as Brown Pelicans (*Pelecanus occidentalis*) and Magnificent Frigatebirds (*Fregata magnificens*) have been observed roosting, but not seen nesting in the park.

Measurable Objectives

The specific objectives of this colonial bird monitoring effort are to determine status and long-term trends in:

- Numbers and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants, Great Egrets, Great White Herons, Great Blue Herons, White Ibises, and Roseate Spoonbills.

- Annual peak active nest counts of colonial nesting birds in Biscayne National Park with a special focus on the species mentioned above.
- An annual nesting index (sum of monthly nest counts) with a special focus on the species mentioned above.
- Timing of peak nest counts for the focal species.

The number of colonies and peak nest counts are used as primary metrics by other large-scale colonial nesting bird monitoring efforts (Crozier and Gawlik 2003, Cook et al. 2010). Peak nest counts tend to show similar trends and variability to total nest counts but are more robust with respect to unexpected changes in sampling; for example, cancelled survey flight due to a fire, tropical storm, or a government shutdown. For the purposes of this study, the South Florida/Caribbean Inventory & Monitoring Network is monitoring active nests, whether they are occupied or unoccupied. The rationale for counting non-occupied nests is to provide a more accurate active nest count because birds (especially Double-crested Cormorants) often fly away when the helicopter approaches. For the year 2013, we counted 4,260 active Double-crested Cormorant (DCCO) nests, of these nests 3,950 were occupied and 310 were empty (i.e., non-occupied), therefore, our data indicate that 7.28% of the active DCCO nests were empty. We often observe Double-crested Cormorants leaving their nests when the helicopter approaches and then return to the nests upon our departure. We are specifically clarifying that these non-occupied nests are active nests that experience short-term vacancies and are likely reoccupied shortly after the survey. In our estimation, excluding non-occupied, but actively maintained nests, from the data would provide an inaccurate census of active nests.

A “Nesting Index” is another metric used in our monitoring effort. We define this “Nesting Index” as the annual sum of monthly nests counted across all 12 months. These two metrics bracket the less easily measured but more ideal metric of total nest starts. Using both peak nest counts and the annual nesting index as metrics will provide greater confidence in the analysis if the two metrics coincide. If the two metrics display different trends, this would lead to more analysis and a review of methods. The trends developed using these metrics should be considered as indices of nesting and not true nest counts, because the same nest may be counted in more than one month.

The South Florida/Caribbean Inventory & Monitoring Network also considered using other metrics for monitoring colonial nesting birds such as total nest starts but determined it is not feasible at this time with the technology and NPS resources available. The South Florida/Caribbean Inventory & Monitoring Network will consider other methods and options of monitoring and metrics as new technology emerges.

Link to Management Decision-Making

This protocol does not identify quantitative thresholds to trigger management actions at this early stage in the program. However, abrupt declines or abandonment of nesting colonies and large changes in total number of active nests may trigger an investigation into reasons, e.g., invasive species may be colonizing nesting colony islands (Figure 8), native predators such as raccoons may be able to reach islands via newly formed land bridges, people may be disturbing nesting colonies, bay and marine fish communities may be showing increases or declines due to hydrological changes,

coastal habitat changes and/or implementation of marine protected areas (MPAs); contaminants may be affecting reproductive success; and/or changes may be part of region-wide trends, etc. These in turn may suggest actions for management.



Figure 8. Two non-native Green Iguanas (*Iguana iguana*), circled in blue, occupy a spoil island near the mainland in Biscayne National Park. Iguanas were spotted at nesting colonies during the winter of 2019-2020.

The improved knowledge of where the nesting colonies are located, and the seasonal timing of nesting have already been informative to park planning.

Sampling Design

Overview of Sampling Design

The sampling design chosen for this monitoring protocol at Biscayne National Park is a complete aerial survey of visible colonies within the park and a systematic monthly sample in time of visible active nests by species in located colonies using photographs taken from a helicopter. Our pilot work indicates that monthly sampling is necessary to capture the active nesting season for the colonial birds in Biscayne National Park (Figures 9–10).

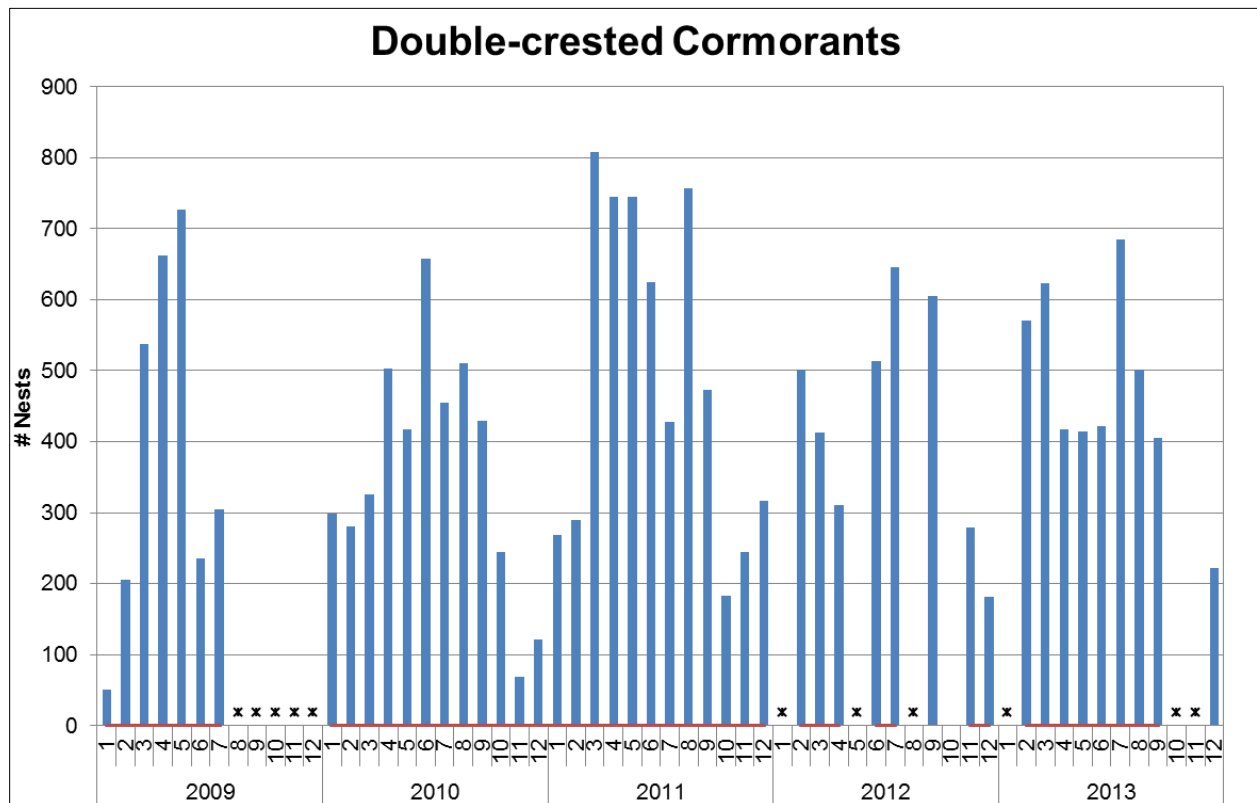


Figure 9. Number of Double-crested Cormorant nests per month and peak nesting periods. * = Months not sampled.

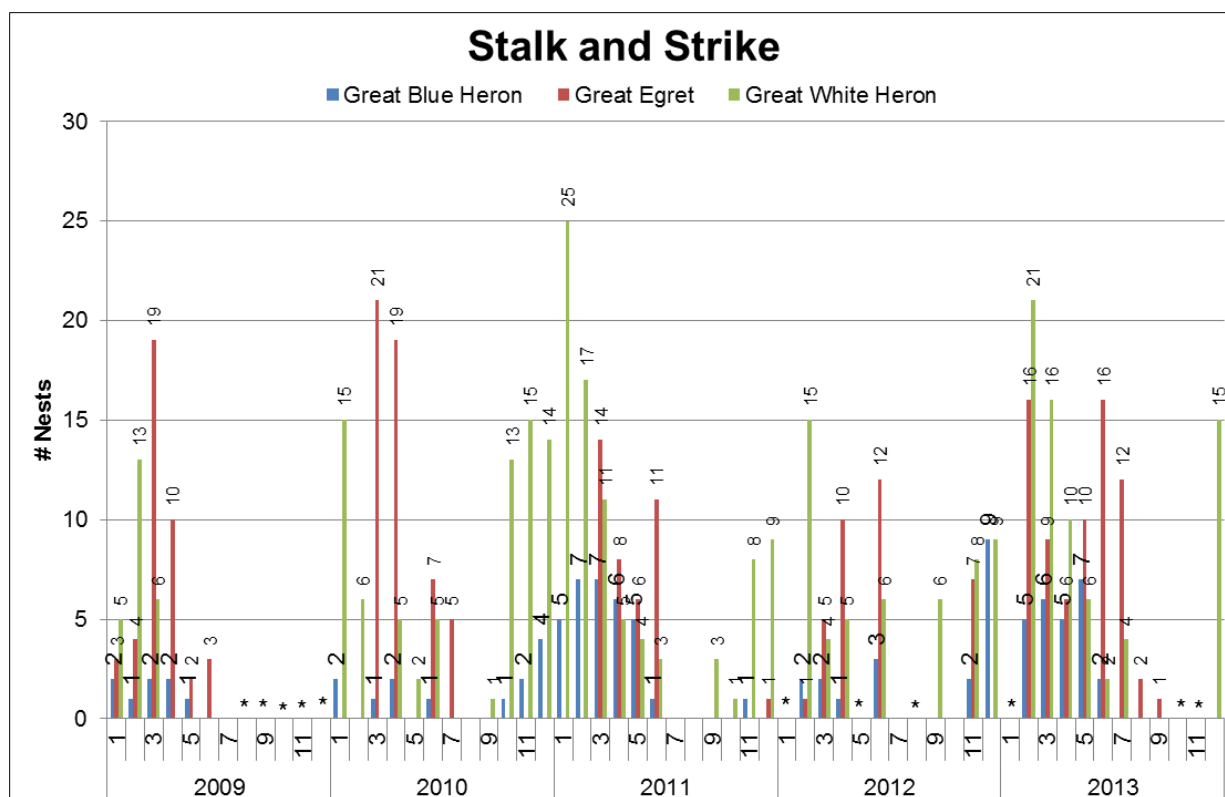


Figure 10. Number of nests and peak nesting periods by month for selected stalk and strike species: Great Blue Heron, Great Egret, and Great White Heron. * = Months not sampled.

Rationale for Selecting This Sampling Design

The South Florida/Caribbean Inventory & Monitoring Network conducted a pilot study to field-test geographically extensive survey techniques within Biscayne National Park. Field tests have shown that the most effective and efficient way to monitor colonies within Biscayne National Park is to conduct an aerial survey from a helicopter. This method provides high detection of a majority of colonies, especially colonies of focal species. Monitoring efforts require identifying colony locations, determining the probable nesting periods, and sampling at monthly intervals for nests which are visible in photographs taken from a helicopter. A complete aerial census that encompasses all the islands, as well as the coastline of the park, is conducted once a year and is spread over two months (January and February) in order to confirm activity at all known colonies and detect any new colonies. Every four years, a summer census is flown instead of a winter census. If resources permit, then there would be both a winter and summer flight in that fourth-year survey. Once colonies are found, monthly flights to these locations (conditions and funding permitting) are conducted to document and monitor nesting activity through photographs. Nest counts from photographs provide a reliable method of data collection (Hutchinson 1979). It is important to limit variability in detection and data collection. The variation in detection must be substantially lower than the variation in the population size being detected (Johnson 2008). The SOPs described in this protocol are designed to ensure consistency and limit variance among personnel performing the tasks.

Detection is the ability to see the subject of interest if it is present in the survey area. Some species are highly visible, nest in the upper canopy, and are more easily detected. These species include the Double-crested Cormorant (*Phalacrocorax auritus*), Great Egret (*Ardea alba*), and the Great Blue Heron (*Ardea herodias*), which are the most prominent examples of visible nesting birds in Biscayne National Park. There are, however, limitations of aerial monitoring – species such as the White Ibis (*Eudocimus albus*) and Roseate Spoonbill (*Platalea ajaja*) tend to nest lower in the tree canopy, but they are still detected with reasonable confidence and are considered focal species of this protocol. Colonies of the smaller egrets and darker herons such as the Tricolored Heron (*Egretta tricolor*), Little Blue Heron (*Egretta caerulea*), Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), and the Yellow-crowned Night-Heron (*Nyctanassa violacea*) also nest in the sub-canopy. These birds, although present, are not detected well from the helicopter or from photographs taken while conducting an aerial census. Nesting for these species is therefore documented incidentally during photograph analysis. Because of minimal detection capabilities, these species are not considered focal species but instead are considered ancillary (Table 1).

Table 1. Nesting location, method of foraging, and target species for some of the bird species identified and monitored in Biscayne National Park.

Species	Location in canopy	Type of forager	Target species for nest counts	Target Species for colony location
Double-crested Cormorant (<i>Phalacrocorax auritus</i>)	Top canopy	Diver	Yes	Yes
Great Egret (<i>Ardea alba</i>)	Top canopy to sub-canopy	Stalk & Strike	Yes	Yes
Great Blue Heron (<i>Ardea herodias</i>)	Top canopy	Stalk & Strike	Yes	Yes
Great White Heron (<i>A. h. occidentalis</i>)	Top canopy	Stalk & Strike	Yes	Yes
White Ibis (<i>Eudocimus albus</i>)	Sub canopy	Tactile	Yes	Yes
Roseate Spoonbill (<i>Platalea ajaja</i>)	Sub canopy to Top canopy	Tactile	Yes	Yes
Tricolored Heron (<i>Egretta tricolor</i>),	Sub canopy	Stalk & Strike	Ancillary	Ancillary
Little Blue Heron (<i>Egretta caerulea</i>)	Sub canopy	Stalk & Strike	Ancillary	Ancillary
Snowy Egret (<i>Egretta thula</i>),	Sub canopy	Stalk & Strike	Ancillary	Ancillary
Cattle Egret (<i>Bubulcus ibis</i>),	Sub canopy	Stalk & Strike	Ancillary	Ancillary

Table 1 (continued). Nesting location, method of foraging, and target species for some of the bird species identified and monitored in Biscayne National Park.

Species	Location in canopy	Type of forager	Target species for nest counts	Target Species for colony location
Yellow-crowned Night-Heron (<i>Nyctanassa violacea</i>)	Sub canopy	Stalk & Strike	Ancillary	Ancillary
Reddish Egret (<i>Egretta rufescens</i>)	Sub canopy	Stalk & Strike	Ancillary	Ancillary

In this protocol the detection of colonial nesting birds differs by species, colony site, time of year, methodology, and observer. We have taken a number of steps to mitigate detection concerns. We have assessed the difference between visual observation from a helicopter and an abundance index from photographs of colonies. Counts from photographs are a better index of abundance, detection of nests is higher and multiple counts can be made along with the advantage of a permanent record being generated. We have compared nest counts from photographs taken from a helicopter to visual counts done from a boat. Boat estimates consistently under count nests high in the canopy whereas the helicopter platform allowed for a more complete colony survey. We have compared nest counts from photos taken from a fixed-wing plane, blimp, and from a helicopter. The helicopter platform is the most stable, repeatable, and cost effective. The ongoing research and inventory efforts at other parks served as a guide to test and streamline field methodologies and analytical approaches. We used pilot datasets to assess the statistical power of the proposed monitoring program.

Sampling Domain

The study area

The 42 islands and the mainland shoreline protected within Biscayne National Park comprise the study area. These islands and shoreline serve as refuge to colonial nesting birds and will be the focus of the monitoring efforts via aerial census. In January and February, in addition to the routine island colonies surveyed, we fly over parts of the park where we don't normally fly. Spreading the aerial census over two months allows us to be more efficient because it allows us to avoid backtracking the length of Elliott Key. If new sites are found, they will be added to our monthly surveys. Between 2015 and 2020 we added three new nesting colonies, bringing us to a total of nine. Since monitoring began the colonies have remained at the same locations with the exception of one colony, Mangrove Key, which showed a drop then stoppage of nesting. Then, after a period of inactivity, nesting resumed and has continued since.

Target population, sampling frame, and sampling units

Each year we perform a complete survey of bird nesting colonies of the focal species. Since the lifetime of a bird nesting colony is multiple months (time to build nest, incubate eggs, and raise young) and we perform monthly sampling, we feel that we are not missing colonies. Since bird nesting colonies are highly visible from the helicopter surveying platform, we again feel that we are not missing colonies during our monthly surveys. The monthly sampling and the complete survey have a very minor difference in total helicopter flight time (1.2 hours compared to 1.5 hours; flight

time ~18 minutes) indicating that there is little area not visually surveyed in the monthly samples. The target population is the number of nesting colonies and peak nest counts for colonial nesting birds (Table 1). Peak nest counts via the photographs are nearly a complete sample (high detection) of the top-canopy focal species but are considered an index of nesting for sub-canopy species. The sampling unit for this protocol is each colony site.

For top-canopy nesters the sampling frame is an aerial census of all colonies and a count of all visible nests on a monthly basis. This is used to determine the peak nest counts by species and timing of nesting. For top-canopy nesters the sampling frame is virtually identical to the target population as nearly all nests are readily visible and identifiable.

For sub-canopy nesters, the location of nesting colonies is the primary metric although visible nest counts are recorded. It is possible that some small nesting colonies of sub-canopy nesters are missed by this protocol, although larger colonies should be located.

Sampling frequency and timing

Monthly flights for counting nests at existing colonies

Three new colonies have been added since the beginning of this monitoring effort: King Bay, Kings Road Island, and Ragged Key 4. Currently nine colonies are monitored. The Kings Bay colony was added on the June flight of 2016, the Kings Road colony July of 2016, and the Ragged Key 4 colony was added on the May of 2018 flight. The monthly survey flights focus on the eight known nesting colonies within and the one colony just adjacent to the northwest boundary of Biscayne National Park. The flight initiates at Homestead General Airport or Miami Executive Airport and monitoring proceeds in the following order: Kings Road Island, Mangrove Key, West Arsenicker, Arsenicker Key, Jones Lagoon, Ragged Key 5, Ragged Key 4, Soldier Key, and Kings Bay. After surveying Kings Bay, the crew returns to the airport. The flight path for a monthly survey is shown in orange (Figure 11).

A typical monthly flight lasts approximately 1.2 hours. The census effort takes place over two months. The census flights are extensions of the routine monthly survey flights. The main differences are that one census flight is flown in the reverse order, allowing the crew to fly on the west coast of Elliott Key. This prevents the crew from having to back track the length of Elliott Key, thus saving time and money. Another difference of the census flights is they include additional coastline along the mainland and additional islands in the southern part of the park. The census flights each take approximately 1.5 hours to fly.

Sampling takes place every month during the year, from January through December. The network will maintain this sampling frequency subject to budget constraints, weather, personnel, flight availability, and other unforeseen circumstances that may arise. Monthly flights need to be conducted throughout the year in order to determine changes in peak nesting periods, which differ by species and location. Reductions in sampling may decrease the ability to detect the peak nesting period for some species in that sampling year. Generally, the time from nesting to fledging takes longer than a month for these species, so monthly flights are considered sufficient to detect peak nest counts.

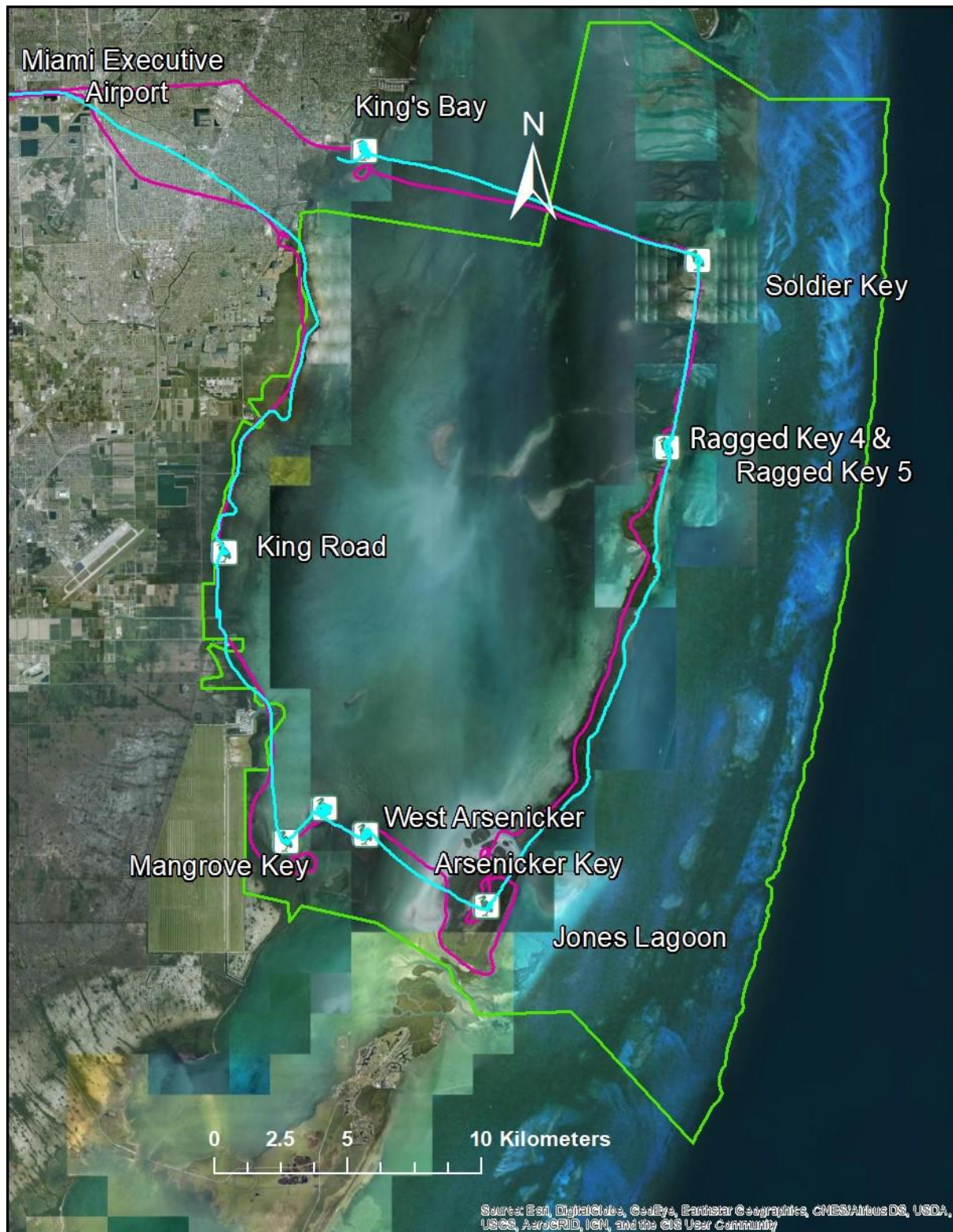


Figure 11. The nine nesting locations displayed along the flight path shown in light blue, the annual survey flight is shown in purple, and the park boundary is in green. This monitoring flight started at Miami General Aviation Airport, west of the park. The flight paths shown were captured from an on-board handheld GPS. Ragged Keys 4 & 5 are close to each other and represented by one marker.

Number and location of sampling sites

Sampling includes all the colony sites found on the islands and coastal fringes within Biscayne National Park. There are currently nine colony sites that have been regularly identified during the execution of the protocol. These nine sites are located on nine different islands within or adjacent to the park. These island colonies are located at Kings Road, Mangrove Key, West Arsenicker Key, Arsenicker Key, Jones Lagoon, Ragged Key 5, Ragged Key 4, Soldier Key, and Kings Bay (Figure 11).

Sampling method

The network has chosen helicopter surveys as the preferred method of gathering data. We have found using a helicopter provides the most stable and functional platform for taking aerial photographs. Helicopter surveys allow for monitoring events to be completed in a timely manner.

For typical monthly monitoring flights, we use a consistent flight path around the colonies and take photographs at an altitude of approximately 150 feet. The altitude can vary slightly depending on needs of the photographer and observer, the pilot's requirements, vegetation density at the colonies, and weather conditions. We try to approach each colony the same way every month (Figures 11 and 12) although changes may be required to accommodate for weather conditions. Upon approach to a colony, an overview photo is taken to help identify and differentiate colonies.

We use two crew members to gather data, an observer in the front seat and the photographer in the back seat. The front seat observer records all the bird species observed while the backseat photographer takes as many overlapping photographs as necessary to capture the nesting areas. Once back at the office, SFCN personnel determine which photographs taken during the helicopter flights will be utilized for counting nests. After each flight is completed, photographs taken during the flight are analyzed and the circled nests are counted from the analyzed photographs. It is important not to count the same nest more than once although it may appear in multiple photographs.

The front seat observer collects species richness data not otherwise captured by photographs. For example, 12 American White Pelicans (*Pelecanus erythrorhynchos*) were observed on 16 February 2012 at Arsenicker Key, but none were photographed nesting. These data indicate birds are using the park for purposes other than nesting, such as roosting or foraging. The photographs provide better data to determine nest quantities. For example, on 23 March 2011, a visually estimated 250 Double-crested Cormorants were observed at Ragged Key 5, while photographs taken during the aerial survey showed 416 Double-crested Cormorant nests. The two data sets together provide a more complete description of birds nesting and using the park.



Figure 12. Flight path around Arsenicker Key with photograph locations geotagged. Yellow arrows show direction camera was pointing.

Alternative sampling methods investigated

In an effort to gather the best data possible and potentially reduce expenses, the network has attempted other methods to gather data. Boat surveys and walking surveys were performed at various islands in Biscayne National Park to check the feasibility of gathering data from below the tree canopy. Both methods may be valuable to supplement the helicopter surveys, though neither provides the visibility needed for a complete survey of an island, as too many canopy nests are not visible from the ground or water surface. In addition, the time required to complete a survey of all nine islands from a boat is not practical. Observations made and photographs taken from these surveys may provide data on sub-canopy nesting birds such as the Little Blue Heron and the Yellow-crowned Night-Heron. Alternate methods of gathering data can be used to supplement helicopter observations and provide information about possible changes in nesting behavior but they are not included as part of this protocol.

In February 2012, both helicopter and boat surveys were performed at Ragged Key 5 and Soldier Key. Active cormorant nests observed from the helicopter were 12 and 10 respectively. The photographs taken from the helicopter were analyzed in the office and nest counts rose to 272 and 78 respectively. Seven days later, a return to Ragged Key 5 and Soldier Key in a boat resulted in nest counts of 55 and 26 respectively. With significantly more nests observed, aerial photography clearly provides the most complete nest count for top-canopy nesters. It should be noted that at locations where all the nests were observable from the water (nests observed from canoe at small mangrove islands in the Jones Lagoon Colony) field observations and helicopter surveys produced the same number of nests.

In December of 2010, the network performed a nesting survey from a blimp to determine whether this could be a practical survey method. The blimp survey did allow for observations and photographs, similar to those taken from a helicopter, and provided similar results to a helicopter survey performed three days earlier. Overall, helicopters provide a better survey method because of better maneuverability and much shorter flight time for a similar cost.

Fixed-wing aircraft may be suitable to fly transects but are not practical for flying over small island colonies. Planes fly too fast and do not afford the ability to hover. Helicopters allow for a more complete set of photographs, providing better precision of nesting area locations. Overall, it is more difficult to photograph and make observations from a fixed-wing airplane. Additionally, it has been shown helicopter surveys are more accurate and cause fewer disturbances to birds than fixed-wing aircraft surveys or ground surveys where observers walk among the birds (Kushlan 1978).

Using unmanned aerial vehicle (UAV) for photography has been considered and will continue to be evaluated in the future as a method to gather data. The benefits of this technology include a higher level of safety, lower costs in the long term, and more control over scheduling. Several other considerations such as: proximity to Homestead Air Reserve Base and Turkey Point Nuclear Power Plant, licensing, changing federal regulations from Federal Aviation Administration (FAA) and NPS Interim Policy Memorandum 14-05 regarding unmanned aircraft, and training requirements, need to be resolved in order for unmanned aircraft data collection to occur.

In June 2014 a comparison was made of the quality of photography and field observations achieved at three different flight altitudes: 150, 250, and 500 ft. The three photographs (Figures 13, 14 and 15) were taken above West Arsenicker and cover approximately the same area. They demonstrate the reduction in detail as the helicopter is flown higher. The inset images are a 100% view to show the maximum detail level available at each altitude.



Figure 13. View of a Great Egret at an altitude of 150 ft. We found this altitude provides the best opportunity to capture good observational and photographic data. The image inserted is blown up 100% and allows for easier species identification and location of nests.



Figure 14. View of a Great Egret at an altitude of 250 ft. The inset is zoomed to 100%. At this altitude it is difficult to see into the canopy and locate nests.



Figure 15. View of a Great Egret at an altitude of 500 ft. with a lens focal length comparable to the previous photos. From this altitude, it is difficult to determine species and see into the canopy. At this altitude, it is impractical to locate nests, locate birds and identify bird species.

An altitude of 150 ft. was determined to provide the best data for the photographer and the observer. When flying too low, it is difficult to completely photograph the colony and birds may be flushed off their nests. When flying too high, it is difficult for the observer to locate nests and birds with the naked eye. At 150 ft., Figure 7 clearly shows the narrow, yellow bill and black legs that are the signature identification characteristics of a Great Egret. In Figure 8 at 250 ft. the yellow bill is distinguishable in this bird, but the clarity is obviously less, and the thickness of the bill and the black legs are not distinguishable. Figure 9, photographed from 500 ft., shows a loss in the ability to distinguish the key characteristics to reliably separate species such as Great Egrets, Great White Heron, Snowy Egrets and White Ibis, even when magnified to fullest extent. It is important to note these photographs are of a bird out in the open, not obscured by branches or in shadows and so provide the best opportunity to capture good observational and photographic data. Without the ability to magnify the birds, the field observer generally loses the ability to distinguish species at 500 ft.

Level of Change Detectable

Any change in the number of colonies for top-canopy nesters is considered a difference as the monitoring completes a census for the park. White Ibis colony counts are also considered a census as White Ibis is a highly visible bird even in the sub-canopy and usually nests in large numbers. However, the range of natural variation is still to be determined.

For peak nest counts (maximum nests counted in any month by colony then summed across colonies) and annual nesting index (annual sum of monthly nest counts; missing months interpolated by

averaging number of nests in months before and after missing month), a very preliminary change detection analysis for regression was conducted for years 2010–2014 data using Gerrodotte's equations (as published in Thompson et al. 1998 and calculated using "Fishmethods" package in the statistical program R) with an $\alpha=5\%$, power=80% and an assumption that variance is proportional to $1/\sqrt{\bar{x}}$. This means we are 95% confident that a trend declared statistically significant will actually be occurring and 80% confident that if a trend is occurring, we will actually detect it. Results for peak nest counts and annual nesting index are summarized in Tables 2 and 3 respectively. Variability in peak nest counts for top-canopy nesters may be associated with annual rainfall, freshwater flows, and/or other factors and future analyses that take these factors into account may further improve the estimates. The equations produce slightly different results for a negative trend (decline) than for a positive trend (increase). The results below show reasonable positive and negative trends should be detectable for four of the six species after 10 years of sampling. However, for Roseate Spoonbills and White Ibises, detection of a negative trend will be difficult as a 100% decline has low power of detection. Instead for these species a negative trend might be better measured using the probability of multiple years with no nesting assuming a Poisson distribution. It should also be noted that if a trend is already occurring in the data set, that these change detectable estimates will be inflated.

Table 2. Preliminary estimates of percent change detectable in peak nest counts with $\alpha=5\%$ and power=80% based upon data collected from 2010–2014. A negative percent change indicates the amount of change detectable as a negative trend or decline and conversely a positive percent change is the change detectable as an increase. Detected peak months includes data from 2009–2013. If a trend is already occurring, then estimated percent change detectable results will be inflated.

Variable	DCCO	GBHE	GREG	GWHE	ROSP	WHIB
Peak Nesting Months for years 2009–2014	Mar–Sep	Dec–Jun	Nov–Jul	Sep–Apr	Nov–Feb	Apr–Jul
Average Annual Peak Nest Count for years 2010–2014	958.0	10.4	18.2	22.2	6.0	54.6
Std. Deviation for years 2010–2014	225.9	2.7	3.8	4.2	3.7	24.6
Coefficient of Variation for years 2010–2014	0.24	0.26	0.21	0.19	0.61	0.45
Maximum Peak Nest Count for years 2010–2014	1294	13	23	29	12	92
Minimum Peak Nest Count for years 2010–2014	746	6	14	18	3	28
Total % change detectable (with $\alpha=5\%$ and power=80% for 5 Years)	-94% (+176%)	-99% (+196%)	-86% (+149%)	-79% (+131%)	<-100% (+690%)	<-100% (+430%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 10 Years)	-63% (+92%)	-67% (+101%)	-57% (+79%)	-52% (+70%)	<-100% (+310%)	<-100% (+201%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 15 Years)	-53% (+71%)	-56% (+78%)	-47% (+61%)	-43% (+54%)	<-100% (+230%)	-86% (+151%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 20 Years)	-46% (+60%)	-50% (+65%)	-41% (+52%)	-38% (+46%)	-96% (+184%)	-77% (+125%)

Table 3. Preliminary estimates of percent change detectable in the annual nesting index with $\alpha=5\%$ and power=80% based upon data collected from 2010–2014. The nesting index is defined as the annual sum of monthly nest counts. Missing months are interpolated. The same nests may be counted in more than one month, so the nesting index does not equal total number of independent nesting starts. A negative percent change indicates the amount change detectable as a negative trend or decline and conversely a positive percent change is the change detectable as an increase. If a trend is already occurring, then estimated percent change detectable results will be inflated.

Variable	DCCO	GBHE	GREG	GWHE	ROSP	WHIB
Months Any Nesting Detected for years 2009–2013	All	Oct–Jun	All except Oct	All except Aug	Oct–Apr	Apr–Aug
Average Annual Nesting Index for years 2010–2014	5421.1	25.0	53.1	83.5	12.4	96.0
Std. Deviation for years 2010–2014	756.3	7.8	16.4	12.7	5.3	44.8
Coefficient of Variation for years 2010–2014	0.14	0.31	0.31	0.15	0.43	0.47
Maximum Nesting Index for years 2010–2014	6320	32	81	104	21	150
Minimum Nesting Index for years 2010–2014	4309	13	40	71	7	40
Total % change detectable (with $\alpha=5\%$ and power=80% for 5 Years)	-63% (+91%)	<-100% (+249%)	<-100% (+249%)	-66% (+98%)	<-100% (+400%)	<-100% (+460%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 10 Years)	-40% (+50%)	-77% (+125%)	-77% (+125%)	-43% (+54%)	-98% (+189%)	<-100% (+213%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 15 Years)	-33% (+39%)	-65% (+95%)	-65% (+95%)	-35% (+42%)	-83% (+142%)	-89% (+159%)
Total % change detectable (with $\alpha=5\%$ and power=80% for 20 Years)	-29% (+33%)	-57% (+80%)	-57% (+80%)	-30% (+36%)	-75% (+118%)	-80% (+132%)

Observer Bias

The network examined differences in nest detection by five different observers (Table 4). Sixty-seven photographs were used from three colonies. While there were some differences among observers, generally this represented about 2–4% of the variation. As such, observer bias is not included in calculations of the number of nests. Instead, every effort is made to train new observers until their nest identification is not statistically different from the trained observers using standardized photograph sets. An example is observer 5 who was trained and then her results were compared with the other observers. Her nest counts are in the middle of the range of the Observers 1–4. None of the five observers was statistically different from the others in an ANOVA test where observer and photograph number were used as factors, thus there was not a consistent bias detectable among the observers.

Table 4. Total Active Nests detected by five different observers.

Colony	Observer 1	Observer 2	Observer 3	Observer 4	Observer 5	Average	Std. Dev.	CV
Arsenicker	169	155	163	169	161	163.4	5.9	3.6%
Jones Lagoon	57	57	58	57	55	56.8	1.1	1.9%
West Arsenicker	150	144	144	149	147	146.7	2.7	1.8%
Grand Total	376	356	365	375	363	366.9	8.3	2.3%

Field Methods

The field methods section is intended to ensure consistent methodology and repeatability in light of changing personnel (Beard et al. 1999). Aspects of field methodology that must be repeated consistently are written in the form of Standard Operating Procedures (SOPs). SOPs provide detailed instructions intended to ensure uniformity and consistency in the performance of a given procedure within the protocol. This section describes general methods for gathering data. For more information, please refer to the SOPs associated with this document.

Field Season Preparations and Equipment Setup

The Colonial Bird Monitoring in Biscayne National Park has a year-round operational season; hence no additional preparation or equipment is necessary (See SOPs). Monitoring flights are scheduled approximately one week in advance of the flight with the goal of flying in the middle of the month. All participants are responsible for complying with flying authorization requirements.

Field equipment includes a Nikon D300s SLR camera with a Nikon AF-S 70–300mm f/4.5–5.6 VR zoom lens, Garmin 60CSx GPS unit, personal protective equipment (See SOP CNB02 *Safety Requirements and Procedures to Fly in a Helicopter* (SFCN 2021), and field data sheets. The network will be responsible for verifying that participants conform to requirements and are equipped with all necessary gear.

Sequence of Events During Field Season

Network personnel perform an aerial reconnaissance of the park at the beginning of each calendar year. If any new nesting colonies are observed during the reconnaissance flights, they will be added to the routine monthly monitoring flights. The network then determines which sites within Biscayne National Park will be sampled through the year based on the bi-annual reconnaissance flights and the historical nesting locations. Once a new location is found to have active bird nests, it will be included in the monthly monitoring process. Monthly sampling schedules may vary due to weather, helicopter availability, and budgetary concerns. Flights are usually scheduled in the middle of the month (in the second or third week) allowing time to reschedule the flight in the same month if there is a delay. Timing is important because we try to space the monitoring flights approximately one month apart.

A single monitoring event, from planning to data storage may take approximately two weeks (Table 5).

Table 5. Sampling timeline for a single monitoring event.

Personnel	Timetable	Task
Team leader	One week prior to flight	- Consult with team members for their availability - Contact helicopter contractor for helicopter/ pilot availability
Team leader	Friday prior to flight	- Submit ENP 9400 to EVER aircraft dispatcher - Submit ENP 9400 & mission requirements to helicopter contractor - Notify Biscayne National Park management and FPL of flight details by email - Check expected weather conditions for flight date
Team leader/ team member	One day prior to flight	- Organize required personal protective equipment, camera, GPS, data sheets, & personal locator beacon - Verify operation with helicopter contractor - Fill out SFCN office safety sheet - Check expected weather conditions for flight date
Team leader/ team member	Day of flight	- Monitor weather conditions - Post SFCN office safety sheet - Follow all required safety protocols pre/during/post flight - Ensure pilot & helicopter are certified for mission - Review mission with pilot and flight services personnel
Team leader/ team member	Day of flight (upon returning to office)	- Store & secure gear - Send completed flight paperwork to EVER Aviation Manager - Download camera & GPS - Burn CD of photos & GPS tracklines - Rename & place photographs on Z drive
Team leader/ team member	Post flight	- Analyze & process photographs - Enter observed & photographic data into Access data base - Perform QA/ QC processes - Scan & store data sheets

Pre-flight Preparations

Certain preparations must be made prior to the actual flight (SOP CNB02). The helicopter must be reserved with the contractor. Notifications with the flight date, helicopter tail number, and pilot information are sent to Florida Power & Light (local power utility), Everglades flight following (park service flight monitoring), and Biscayne National Park management.

Specific gear is required to perform the monitoring flights. Much of the gear is required to be worn for flight safety. The personal protective equipment (PPE) includes leather boots, Nomex flight gloves, flight suit, personal flotation devices, and helmet. The PPE is designed to protect the user from flames and impacts in case of a crash. For a complete list of safety gear see SOP CNB02. A handheld park radio and personal locator beacon are part of the safety geared carried on each mission.

A Nikon camera and GPS are used to collect data. For more detailed information see SOP CNB02 *Safety Requirements and Procedures to Fly in a Helicopter* (SFCN 2021) and SOP CNB03 *Camera Use and Setup, Geosetting/Geotagger Use and Setup, and Photography from a Helicopter* (SFCN 2021). The data sheets are carried in a notebook along with a pen and the SFCN Helicopter Go/No-Go Checklist (SOP CNB02). We also carry a map of the park as an aid for a pre-flight briefing with the pilot.

Helicopter Crew Roles and Data Collection

A helicopter crew consists of three people for each flight: the pilot, an observer seated next to the pilot, and a photographer seated in the rear on the port side. The pilot is responsible for safely flying to nesting colonies and maneuvering into position for photographs to be taken. The observer assists the pilot in navigating by using a track plotting GPS loaded with a pre-determined flight path. The observer also scans the horizon for other aircraft and birds, searches the target islands for nesting bird colonies, and records observations on field data sheets (SOP CNB02). The photographer sits behind the observer and visually scans the islands and the sky. Using a Nikon camera equipped with a vibration-reducing zoom lens, the photographer attempts to capture the entire nesting areas of the islands (SOP CNB03 *Camera Use and Setup, Geosetting/Geotagger Use and Setup, and Photography from a Helicopter* [SFCN 2021]). It is imperative to systematically photograph as many nests as possible, since digital photographs provide the data used to determine the quantity of occupied and non-occupied active nests. A single flight lasts approximately one hour and fifteen minutes, but may vary slightly because of weather conditions, new colonies observed, or other unforeseen circumstances.

Data Handling, Analysis and Reporting

The colonial bird monitoring vital sign creates several types of data at different points in the monitoring process. The survey flights generate field data sheets and a large number of digital photographs. In the office these photographs are analyzed and processed using photo processing data sheets. Ultimately all of these data are entered and linked together in a Microsoft Access geodatabase. The outline below summarizes the process:

1. Survey activities (Previous section)
 - a. Complete pre-flight data sheet
 - b. Fill out field data sheet
 - c. Photograph nesting bird colonies
2. Post-Flight Survey Activities
 - a. Download photographs
 - b. Burn DVD with photographs and GPS tracklines
 - c. Geotag photographs (optional)
 - d. Rename photographs
 - e. Tag photographs in ThumbsPlus
3. Photograph Processing
 - a. Circle nests in the photographs as described in SOP CNB05 *Collecting Data, Circling Nests, and Counting Nests* (SFCN 2021)
 - b. Print the analyzed photographs
 - c. Compare photographs sequentially so you do not count the same nest more than once
 - d. Total the nest counts on each photo sheet
 - e. Fill out photo processing data sheet
 - f. 5% check of circling on raw photographs
4. Data entry, QA/QC, and Reports
 - a. Enter field and photo data sheets into database
 - b. 100% verification of all database entries; change DPL to “Provisional”
 - c. 10% random check of database entries
 - d. Run reports and analyses
 - e. Change DPL to “Certified” if a Quality Assurance Plan (QAP) exists or “Accepted” without a QAP
 - f. Scan and archive field / photo processing data sheets

Table 6 provides a guide to all file locations and naming conventions.

Table 6. Critical field and data management file locations. Note: Z:\SFCN\Vital_Signs\Colonial_Nesting_Birds\ is replaced by "...\".

File type	Folder	Filename
Flight and safety documents	• Z:\Helicopter\Colonial_birds\Forms\ • Z:\Helicopter\Colonial_birds\Post_flight_forms\ • Z:\SAFETY\SFCN Safety Program\Section 3A - SFCN Standard Operating Procedures - SOP's\Colonial_Birds\	• 20140319_HMC_Bird_Aircraft_Daily_Diary_HCM-1_Use.xls • SFCN_Helicopter_Go_No_Go_Checklist_Mod_USE.docx • GAR_Risk_Assessment_Model_Birds_USE.doc • Flight_Request_Form_9400_blank_use_this.pdf • Aviation_Risk_Assessment.docx • HAZARDOUS_MATERIALS_MANIFEST.docx
Blank data sheet	• ...data\BISC\Blank_data_sheets\	• 20130213_data_sheet_BISC.xlsx
Photos	• ...images\BISC\YYYY\ YYYYMMDD _BISC_BirdFlight\ YYYYMMDD _ISLANDCODE\	• YYYYMMDD_BISC_BirdFlight_ISLANDCODE_Photonumber.jpg
Geotag file	• ...spatial_info\BISC\YYYY\gpx\	• GPSUnitName_YYYYMMDD.gpx • (e.g., GPSUnitName=Garmin60Unit3)
Flight tracklines	• ...spatial_info\BISC\YYYY\	• GPSUnitName_YYYYMMDD_tracklines.shp
Scanned field sheets	• ...data\BISC\Scanned_data_sheets\YYYYMMDD_BISC_DataSheets\	• Flight_Info_Sheet • ISLANDCODE _OBS • ISLANDCODE _PHO • OBS = Observed, PHO = Photographed
Database	• ...data\	• SFCN_ColonialBirds.mdb
Exports	• ...data\BISC\Exports\	• YYYYMMDD_ColonialBirds.csv
Graphing Template	• ...data\BISC\Graphs\	• Colonial_Birds_Graphing_Template.xlsx

Table 6 (continued). Critical field and data management file locations. Note: Z:\SFCN\Vital_Signs\Colonial_Nesting_Birds\ is replaced by "...\".

File type	Folder	Filename
Data Summary Reports	...documents\summaries_reports\SFCN_data_summaries\YYY_BISC_ - ColBirds_Summary_Report\	- YYYYMMDD_YYYY_BISC_ColonialBirds_Summary_Report.docx (YYYYMMDD=draft date) - YYYY_BISC_ColonialBirds_Summary_Report..pdf
Backup Templates	...documents\protocol\backup_templates\	Backup of graphing template
Protocol	...documents\protocol\	YYYYMMDD_BISC_ColonialBirds_v1.docx, *.pdf

Post Flight Survey Activities

Several steps occur as soon after the flight as possible to reduce errors. Each survey generates a large number of digital photographs. These photographs should be downloaded, geotagged (optional), and renamed immediately upon return from the field (SOP CNB04 *GPS Track Downloading, Photo Downloading and Archiving, Photo Geotagging, Photo Renaming, and Photo Tagging in ThumbsPlus* [SFCN 2021]). These photographs should also be tagged in ThumbsPlus with the “FlightDate” and “SiteName” user fields (SOP CNB04). These user fields allow the photographs to be linked to information in the database, and they also allow the photographs to be displayed in the database.

Photograph Processing

Data from one flight requires a minimum of one-week processing time, during which data from the monitored colonies can usually be processed and analyzed. Photos are processed before the next flight in case anything unusual needs to be verified or investigated on subsequent flights. Processing of photographs at each site consists of circling and counting all visible nests by a trained technician.

The nests are categorized by type, i.e., active nests may contain eggs, juveniles, adult birds, or are non-occupied but appear maintained. Overlapping photos are evaluated to ensure the same nests are not counted twice. Nest counts are recorded on photo processing data sheets (one per colony) which are then used for data entry.

Additional details on nest circling are provided in SOP CNB05. Once a photo processing sheet has been filled out for each site, it should be scanned along with the field data sheet and a copy placed in the following folder for archiving:

Z:\SFCN\Vital_Signs\Colonial_Nesting_Birds\data\BISC\Scanned_data_sheets

Database

The colonial bird database (Figure 16) is located in:

Z:\SFCN\Vital_Signs\Colonial_Nesting_Birds\data\SFCN_ColonialBirds.mdb

The SFCN colonial bird database is designed as a Microsoft Access personal geodatabase and was designed from the Natural Resource Database Template (NRDT) format. Individual table and field descriptions can be found in SOP CNB06. The database stores four general types of data:

1. Primary field/photo processing data
2. Colony locations feature class controlled by ArcGIS
3. Photo data entered via ThumbsPlus
4. Lookup tables with commonly referenced values and metadata tables

Data entry should occur as soon as photo processing is complete. The field data sheet and all the photo processing sheets should be entered following the methods detailed in SOP CNB06 *Data Entry, Data Proofing, and Reporting* (SFCN 2021). Additionally, all bird colony photographs should be tagged in ThumbsPlus using the steps in SOP CNB04.

SFCN Colonial Bird Monitoring Database
database last modified 08/22/2017

Which task would you like to perform?

[Add Survey](#)
[View/Edit Survey](#)
[View Reports](#)
[Open Graphing Template](#)

Database Summary:
 Number of Surveys: 134 Latest Survey: 12/5/2019

	Double-crested Cormorant Observed nesting on 111 surveys High nest count: 1047 (Apr 2014)		Roseate Spoonbill Observed nesting on 33 surveys High nest count: 12 (Jan 2011)
	Great Blue Heron Observed nesting on 71 surveys High nest count: 12 (Apr 2015)		Reddish Egret Observed nesting on 14 surveys High nest count: 2 (Apr 2019)
	Great White Heron Observed nesting on 85 surveys High nest count: 41 (Jan 2018)		White Ibis Observed nesting on 31 surveys High nest count: 93 (Jul 2016)
	Tricolored Heron Observed nesting on 9 surveys High nest count: 5 (May 2018)		Osprey Observed nesting on 5 surveys High nest count: 2 (Mar 2010)
	Great Egret Observed nesting on 52 surveys High nest count: 25 (Feb 2018)		Bald Eagle Observed nesting on 19 surveys High nest count: 2 (Feb 2009)

Figure 16. Startup form for the SFCN Colonial Bird Monitoring Database.

Quality Assurance / Quality Control

The database is designed with lookup lists for species, island names, and observer names to reduce data transcription errors.

Quality assurance and control begin before the flight takes place. Personnel training and the use of the available SOPs are the first steps to provide consistent and accurate data. Measures are in place to ensure consistency of personnel circling nests. A paired *t*-test (two-tailed) is performed to compare results of personnel who will perform the circling process.

Once a technician has analyzed the photographs from a flight, a trained second technician will perform an additional 5% check of un-circled, raw photographs as part of the QA/QC process. This will consist of the project leader and another technician comparing one another's work. One person will analyze and circle all photos for a flight, and the other person will analyze 5% of those same

photos (e.g., if 260 photos are used in the circling process, 13 photos will be reviewed, hence forth referred to as QA/QC photographs). These QA/QC photographs will be chosen with an R script that loads all image files from a specified directory and uses the sample() function to pull a random 5%. The second technician will analyze and circle these QA/QC photographs. The project leader will print out and compare both sets of photographs and note:

- Missing nests—nests that were not circled
- False nests—nests that were circled in error
- Discrepancies in determining occupied vs. non-occupied nests
- Discrepancies in species identification

If this check reveals a large number of discrepancies, the protocol lead or data manager may search for the source of the discrepancy, require additional training for technicians or require additional images to be reviewed.

The data from the photo processing data sheet compiled from the bird survey photographs is entered into the Microsoft Access database. Once all photograph data have been processed and entered, the SFCN data management plan (Witcher 2008) requires 100% verification of the data entry. This is completed by first printing out a report of the data and manually comparing the printout to the original data sheets. Any discrepancies are marked in red so the project leader can review and correct them in the database. The project leader initials and dates the printouts when the corrections have been entered. When data verification has been completed for each site, the “Checked?” box on the data entry form in the database is then checked indicating the verification process is complete and the DPL is changed to “Provisional”. The name of the person who did the verification is then selected from the drop-down menu that appears. This provides an easy way to track the progress of data verification.

Additionally, the SFCN data management plan requires a 10% check of the verified data as an additional safeguard against data errors. This 10% check starts by running a query that randomly selects 10% of the flight date/colony pairs between two given dates. Each chosen flight date and colony is viewed within the database and the data is checked against the original data sheets. If any errors are found that particular flight must go through 100% verification again.

Observed data are entered into the data base and verified for accuracy of entry. The entered observed data are compared to the field data sheet directly. The nature of the observed data is better suited to show presence of species versus quantitative results; therefore, we do not use the observed data for statistical analysis.

Data Reporting and Analysis

After data entry and verification is complete, the database can run several reports to summarize the data. Three basic types of reporting occur from this protocol:

- Basic quick look reports can be produced directly from the database

- Nesting reports: Number of nests counted by species and month during a specific year and location.
- Observation reports: Number of field observed birds by species and month during a specific year and location.
- Species report: Number of nests counted for a specific species during a specific year.
- Percentage empty nests report: This calculates the % empty nests by species, location, year and month.
- Graphing template: The database exports all the routine and annual census photo and field observation data into a Microsoft Excel document which contains pre-set graphs and tables that automatically update upon opening. The same export for the graphing template is saved as a *.csv file for archiving and for responding to data requests.
- Data Summary Report: An annual summary report is published in the South Florida Wading Bird Report, which is published by the South Florida Water Management District (SFWMD). If there is time and need an NPS annual summary report can be published that contains basic graphs and tables summarizing the results through the current year.

Below are some of the fundamental metrics produced from this monitoring protocol:

- List of species detected nesting or visually observed as adults in field
- # colonies by species
- # colonial nesting species detected nesting at each colony (species richness)
- Peak nesting by focal species and colony
- Peak nesting by focal species summed across all colonies
- Annual nesting index by focal species summed across all colonies (annual sum of monthly active nests counted)
- Months nesting occurs and proportion of nesting by focal species
- Printout of total active nests and field observed birds by month and colony for all species

The South Florida Wading Bird Report is a comprehensive report of nesting birds (many of which are our focal species) throughout specific south Florida areas such as Everglades National Park and the water conservation areas. The summary data report produced by the network provides data from Biscayne National Park that otherwise would not be included in the South Florida Wading Bird Report.

The data provided to the South Florida Wading Bird Report cover a nesting year that spans from July 1 of one year to June 30 of the following year (e.g. July 1, 2019 to June 30, 2020). This time frame coincides with the other data provided to the District for their report. The summary data report is sent to the SFWMD in September, thus allowing the network time to verify and validate data collected through June.

Reporting is focused on the five focal species and one subspecies: Double-crested Cormorant, Great Blue Heron, Great White Heron (subspecies), Great Egret, Roseate Spoonbill, and White Ibis. In 2013, these represented 98% of the visible nests recorded in the park with cormorants alone representing 92%. Graphing of these species is organized into the three types of feeding behavior: diver, stalk and strike, and tactile. Double-crested Cormorants are divers, and the most abundant bird in Biscayne National Park. Data collection has already shown that different nesting seasonality is evident for the various species, including species with similar feeding methods, e.g., Roseate Spoonbills and White Ibises are both tactile feeders, yet each nest during different seasons.

The data summary report format will be cumulative, allowing each year of data to be added to the existing tables and graphs. The automated graphing template is designed to allow easy update of tables and graphs to reduce the time to create annual reports. Details for compiling the report using the graphing template are provided in SOP CNB06 and an example data summary report is included in Appendix 4. Additional summary tables and/or information can be added to the summary data report as needed. Data are summarized park-wide and by colony. Figures 18–20 provide examples from data collected. For more complete results, see Appendix 4.

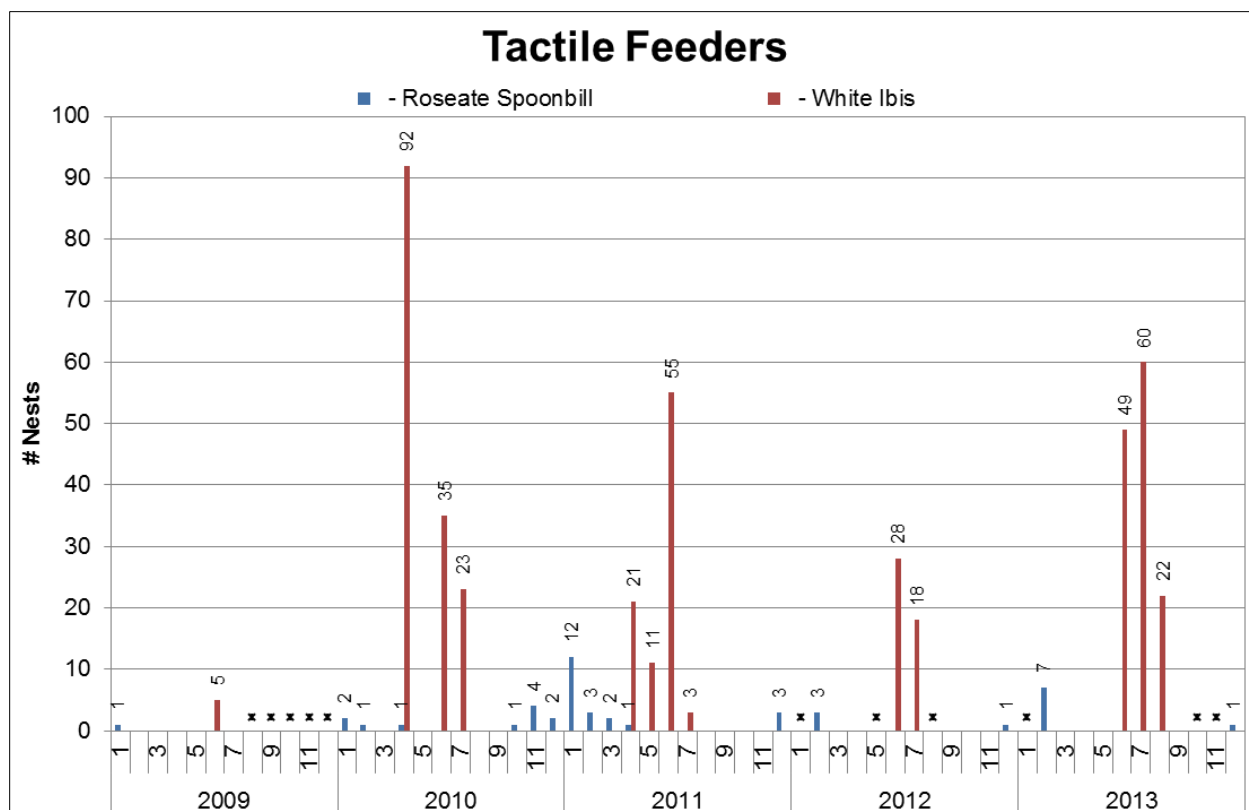


Figure 18. The number of nests and peak nesting periods by month for selected for two tactile feeder species: Roseate Spoonbills and White Ibis. This graph shows Roseate Spoonbills nest in the dry season and White Ibis nest in the wet season. * = Months not sampled.

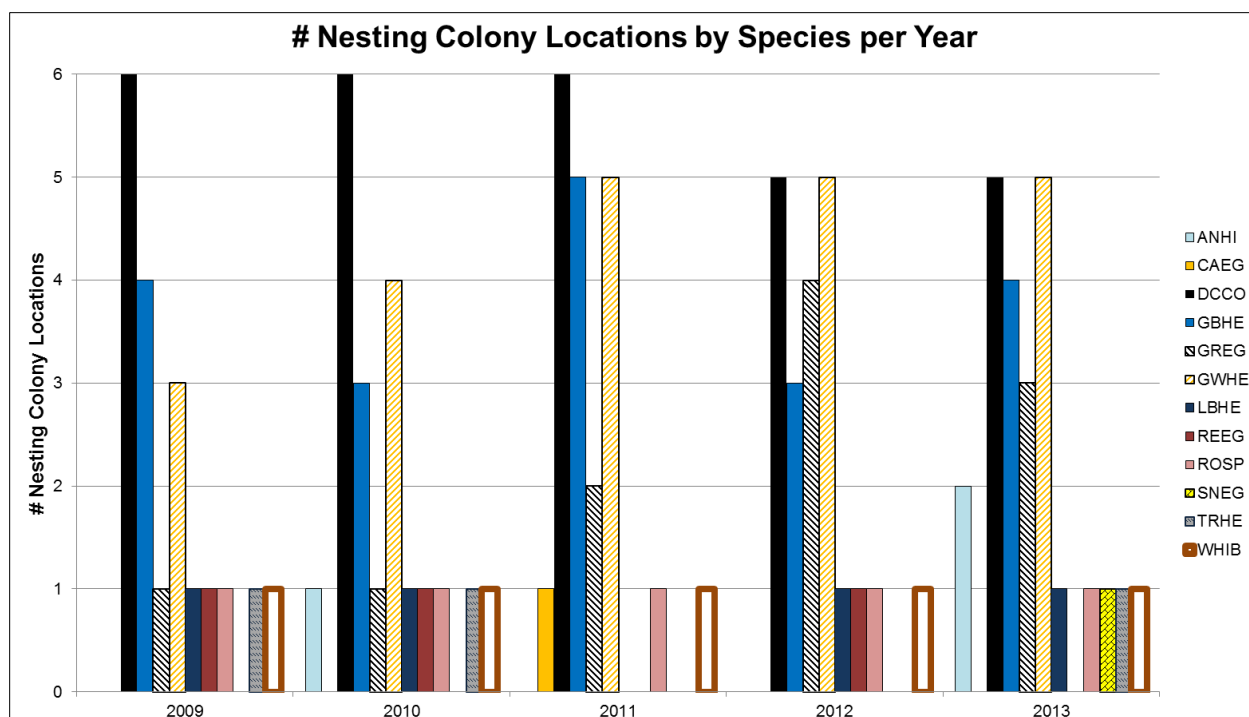


Figure 19. Sample graph showing number of nesting colony locations by species per year. Includes all egrets, ibis, and herons.

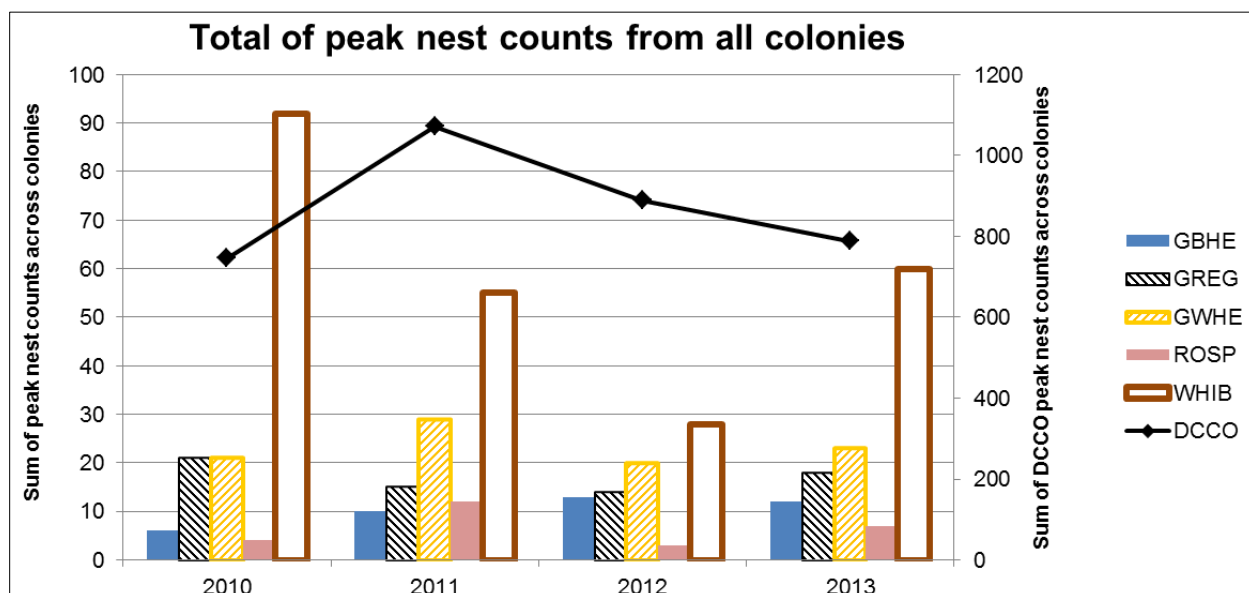


Figure 20. Sample graph showing how the peak number of nests detected per colony vary through time. Peak nest counts by colony were summed to create a total of peak nest counts across all colonies for the six focal species.

Presently there is not enough data to determine the natural range of variability that should be expected within BISC in numbers of colonies, locations of colonies, peak nests, peak nesting periods,

and the annual nesting index. These are expected to vary with annual rainfall, amount and timing of freshwater flows into the bay, and how they in turn affect food availability within and outside the park. Separating natural background variability from actual trends will be difficult at first and will be approached cautiously and with common sense. In general, the first years of data collection will be used to establish a cautious baseline for comparison as more data is collected (Table 7).

The number of colonies will be reported and graphed by species. Any change in the number of colonies for top-canopy nesters is considered a difference as the monitoring completes a census for the park. The number of colonies of White Ibis is similarly considered a census as it is a highly visible bird even in the sub-canopy, and typically nests in large groups. The simplest approach at this time is to note whether a current year's number of colonies is outside the range seen from years 2010–2013 and whether new colonies have developed or colonies have been abandoned as the locations of colonies have been fairly stable through the development phase of this protocol. For other sub-canopy nesters this protocol is still experimental and generally their numbers are only adding to the number of species detected nesting by colony.

For focal species, trends in peak nest counts are determined by colony and then across all colonies to provide a park-wide estimate. Similar to the colony count, peak nest numbers can be compared to the range detected in 2010–2013. In addition, once five or more complete years of data have been gathered, a regression analysis may be used to evaluate trends (SOP CNB05). For species with small whole numbers (i.e., all species except cormorants) which may violate the assumption of normally distributed data, a Poisson regression analysis may be used. Different statistical thresholds may be used to indicate a “caution/change possible/warning” threshold (e.g., $\alpha=10\%$) versus a “change likely occurring” threshold (e.g., $\alpha=5\%$) but the network will be looking at the data in total against the backdrop

of climatic and regional changes. The network will interpret results cautiously during the early years of this program rather than using absolute thresholds.

A similar analysis will be conducted of the annual nesting index. The nesting index is calculated as the sum of monthly active nest counts. If a month is missing (e.g., helicopter is unavailable because firefighting takes priority), then the nest count for the missing month will be interpolated by taking the average nest count from the month before and the month after the missing month. In general, peak nest counts and the annual nesting index should bracket the preferred metric of number of nest starts.

This annual report will be presented to Biscayne National Park Managers. Together, these patterns and trends provide indicators of conditions in the park that support nesting behavior and can be used as part of a comprehensive approach to resource decisions within the park. The report and data will also be available on the SFCN website and irma.nps.gov. The network will also produce a more in-depth trend report every five years.

Table 7. Initial baseline ranges from 2010–2013 of number of colonies, peak nest counts, and annual nesting index for focal species. The nesting index is the annual sum of monthly active nest counts. New data outside this range may be noted as worth watching as a trend may be developing.

Range	Variable	DCCO	GBHE	GREG	GWHE	ROSP	WHIB
Colonies	Colony locations where nested at least once	All	All except Mangrove Key	All except Mangrove Key	All except Mangrove Key	Jones Lagoon	Arsenicker, West Arsenicker
	Maximum # Colonies	6	5	4	5	1	1
	Minimum # Colonies	5	3	1	4	1	1
Peak Nest Counts	Maximum Peak Nest Count	1072	13	21	29	12	92
	Minimum Peak Nest Count	746	6	14	20	3	28
	Average Annual Peak Nest Count	874.0	10.3	17.0	23.3	6.5	58.8
	Std. Deviation	145.0	3.1	3.2	4.0	4.0	26.2
	Peak Nesting Months	Mar–Sep	Dec–Jun	Nov–Jul	Sep–Apr	Nov–Feb	Apr–Jul
Nesting Index	Maximum Nesting Index	5880	32	81	104	21	150
	Minimum Nesting Index	4309	13	40	76	7	69
	Average Nesting Index	5196	25	56	87	13	110
	Std. Deviation	653	9	18	12	6	37
	Months Any Nesting Detected	All	Oct–Jun	All except Oct	All except Aug	Oct–Apr	Apr–Aug

Additional Analyses

After implementation of five or more complete years of data collection, a regression analysis will be run. If no trend is detected, the maximum and minimum of the data can be updated to include 2014 as initial “Control Limits”. As more data is collected the range can be replaced with 90% and 95% calculated “Control Limits” (Montgomery 2001) which provide a quick way of evaluating whether a current year of data is outside what is expected given the initial baseline data. This process can be repeated as time moves forward (see SOP CNB06 for details). A switch to non-parametric regression may be considered once at least 10 years of data are accumulated as this approach involves even fewer assumptions. Before / after analyses using *t*-tests or Poisson confidence limits may be considered if events cause a sharp decline in numbers.

The Double-crested Cormorant is a year-round nester with what appears to be multiple peak nesting events. Incorporating this behavior into a better estimate of total peak nesting is worth investigating as more data is acquired.

Further research into historical studies and datasets is needed. Our surveys show the Double-crested Cormorant (DCCO) as the dominant nesting species in BISC for which there are few comparable studies. Some earlier surveys from 1980 to 1986 actually suggested a strong DCCO winter nesting period from October to March and reduced nesting in spring and summer from April to September (Cummings 1987, cited in Brugger 1995) which varies from our data that shows increased nesting in the summer months, but further monitoring will be needed to determine whether the current nesting patterns represent a change or whether this is part of the background variability. Research into this data set and other regional datasets for the other focal species are a task for the near future and tentatively may be useful for putting the status of current populations in BISC into a historical and regional context.

The effectiveness of the sampling design may be revisited in the future, e.g., evaluating the frequency and timing of the monthly sampling; whether some months can be dropped from sampling to reduce costs; development of additional metrics or indices; and/or development of methods to augment surveying of deep sub-canopy nesters such as with complimentary boat surveys. After perhaps ten or more years, linkages to freshwater flows, rainfall and other factors may be tested to better refine the expected baseline and interpretation in “wet” and “dry” years.

Protected Data

Currently, data collected from these monitoring efforts are not considered protected, therefore no special accommodations are required to limit access. All data exports will follow the latest park protected data agreement.

Metadata and Archiving

Each year the network will archive the database together with associated metadata, summary report, and scanned datasheets on the NPS Data Store (<https://irma.nps.gov/DataStore/>). The 100% verification process for data entry will be completed as the monitoring is completed. The additional 10% check will be completed annually, and each colony visit will be set to ‘Certified’ or ‘Accepted’

within one year of the flight date. Metadata requirements are further discussed in section 8.3 of the SFCN data management plan (Witcher 2008).

Personnel Requirements and Training

Roles and Responsibilities

Two people are required to fulfill the field monitoring portion of this project. Additional support comes from the data management team and other personnel by assisting with the processing and analyzing of photographs. The Community Ecologist or Biological Technician is responsible for scheduling flights and completing the necessary paperwork for each flight, but these tasks can be shared with other staff members when needed. Training of new personnel involved in the vital sign and maintenance of physical records are responsibilities of the project coordinator. The participants for Biscayne National Park colonial bird monitoring are SFCN personnel. The network has cross-trained personnel making it possible for a variety of people to fulfill the mission. At least one of the two SFCN crew members on any given mission will have previously been on several bird monitoring flights and will be able to provide guidance. One person sits in the front of the helicopter assisting the pilot, while the other takes photographs from the back seat. It is the responsibility of the crew to download data promptly upon their return. Analysis of photographs is performed by technician(s), usually including a member of the flight crew.

The Community Ecologist or Biological Technician is responsible for completing the data summary report. The SFCN Data Manager in cooperation with the Biological Technician oversees the database design, building in adequate quality control procedures into the database, maintaining data security and archiving. The Quantitative Ecologist is responsible for assisting with analyses, updating the graphing template and/or converting the same to R code, and with editing of the data summary report to ensure it meets NPS Natural Resource Publications Management guidelines. The Data Management / Outreach Technician is responsible for updating the colonial nesting birds resource brief, IRMA.gov, and the SFCN web site.

The Community Ecologist's duties include but are not limited to; ensuring all safety protocols are followed, assisting in data collection when needed, helping to determine data to be published, and supervising and providing guidance for the project coordinator.

Qualifications and Training

SOPs CNB01 *Personnel Training* (SFCN 2021) and CNB02 discuss the training needed for this protocol in greater detail. Personnel will thoroughly review this protocol, associated Safety SOPs, and associated Job Hazard Analyses (JHA's) before implementing procedures. All DOI personnel participating in helicopter flights for this monitoring project are required to complete the following helicopter training courses: A-107, Aviation Policy and Regulations I (online); A-100, Basic Aviation Safety; S-271, Interagency Helicopter Crewmember; A-110, Aviation Transport of Hazardous Material (if applicable and online); A-200, Aviation Mishap Review; and A-312, Water Ditching and Survival. For more information on currency requirements visit the Interagency Aviation Training website at: <https://www.iat.gov/training/searchcourses.asp>.

Personnel must acquire the ability to complete flight data sheets and take photographs from a helicopter. The project leader and the SFCN Community Ecologist will determine when new personnel have acquired proficient abilities to participate on flight missions.

When bringing a new technician into the project, it is necessary to perform approximately one to two weeks of on-the-job training using this protocol as an aid. Much of the training for photo analysis and data downloading occurs on-the-job, but familiarity with Biscayne Bay and local bird species are beneficial. Identifying characteristics of various bird species and knowing their nesting times will aid in identifying one species versus another. Using available resources such as *Smithsonian Field Guide to the Birds of North America* (Floyd 2008) and *Common Coastal Birds of Florida & the Caribbean* (Nellis 2001) are invaluable. These books aid in identifying adult birds, their eggs, and juveniles as well as providing descriptions of their nesting habits. The SOPs associated with this protocol address the training requirements to complete required tasks.

We have specific photos that are used for training new personnel in the analysis portion of gathering data from photos. Using training photographs allows us to check for consistency between personnel analyzing photographs. Inter-observer variability is evaluated to determine if there is significant difference between photo processors. Any difference in photo analysis results will be reviewed by the project leader and the SFCN Community Ecologist to determine when new personnel have acquired proficient abilities to analyze photos.

Operational Requirements

Annual Workload and Field Schedule

This protocol is implemented once a month throughout the year. Pre-flight requirements include scheduling the flight trip, notifying flight following and appropriate facilities of the flight plan, packing gear, and donning flight gear. The actual flight lasts approximately 1.20 hours and is performed by two people plus the pilot. Post-flight duties include, removing gear from the helicopter, completing paperwork, and stowing gear for the return drive to the SFCN office. Upon returning to the office, the tasks of sending post-flight paperwork, downloading pictures and GPS flight tracks onto a computer, burning a hard copy of the photos and flight tracks onto a DVD-R are completed. The majority of time spent for a monitoring event is spent analyzing and processing the photographs. The analyzing and processing of photos includes nest circling, printing, counting, and entering the data. These tasks take approximately 42 hours to complete. Flight conditions may affect the number of photographs and possibly affect photo analysis times (Table 8).

Table 8. Project time estimates per monthly monitoring event.

Personnel	Tasks	Approximate time per person	Approximate crew time
Team leader (1 person)	Phone calls, flight related paperwork & notification emails	2.0 hours	2.0 hours
Team leader, team member (2 people)	Prep, pack & load gear	1.0 hour	2.0 hours
Team leader, team member (2 people)	Drive to airport	0.75 hour	1.50 hours
Team leader, team member (2 people)	Pre-flight safety briefing, check certifications for pilot & helicopter don flight gear	0.75 hour	1.50 hours
Team leader, team member (2 people)	Store/ secure gear & flight time	1.5 hours	3.0 hours
Team leader, team member (2 people)	Post flight – remove flight gear & complete paperwork	0.50 hours	1.0 hour
Team leader, team member (2 people)	Return drive to office	0.75 hour	1.50 hours
Team leader (1 person)	Complete and send post-flight paperwork	1.0 hour	1.0 hour
Team leader (1 person)	Download camera, burn CD with camera & GPS data	1.0 hour	1.0 hour
Team leader (1 person)	Rename photos and place in folders	1.50 hours	1.50 hours

Table 8. Project time estimates per monthly monitoring event.

Personnel	Tasks	Approximate time per person	Approximate crew time
Team leader, team member (2 people)	Analyze, process, enter data	21.0 hours	42.0 hours
Team leader (1 person)	Attach digital images to database using Thumbsplus	1.0 hour	1.0 hour
Total time	–	–	59.0 hours

Additional time is required during the year for writing the colonial nesting birds portion of the SFCN Annual Report and to submit paperwork for flight contract management. These tasks may take approximately 16 hours. Tables 9 and 10 provide an approximate annual schedule.

Table 9. One-time costs for bird monitoring helicopter flights. (*) indicates used per person. Note: These costs are approximate based upon 2013 estimates. Costs of vehicles, computers, software, etc. are not included.

Equipment	Cost
* Leather Boots	\$ 100
* Nomex Flight Gloves	\$ 24
* Flight Suit	\$ 142
* Helmet	\$ 726
* Helmet Bag	\$ 16
Garmin GPS 62s HandheldCSx	\$ 350
Nikon D 300s camera with vibration-reducing lens	\$ 1,560
BK DPHX5102X Radio	\$ 2,035
ACR ResQLink Personal Locator Beacon	\$ 290
Total charges	\$ 5,243

The initial Colonial Nesting Bird database took approximately 120 hours to construct. The outreach program consisting of the resource brief and annual report required approximately 60 hours to complete. The data management team spends an additional 10–20 hours throughout the year in report writing and database modifications.

Table 10. Monthly and yearly cost estimates for bird monitoring helicopter flights. *Note: These costs are approximate based upon 2013 salary estimates and helicopter costs.*

Expense	Expense per Monitoring Flight	Annual cost @ 12 flights per year
Flight Prep	\$ 41	\$ 492
Approximate salaries actual flight	\$ 250	\$ 3,000
Approximate helicopter cost	\$ 1,290	\$ 15,480
Approximate salaries for post-flight data processing and analysis	\$ 912	\$ 10,944
Report writing and analysis	–	\$ 1,000
Additional data management support	–	\$ 750
Totals	–	\$ 31,666

Schedule

January—First half of annual park-wide census (with routine colony survey)

February—Second half of annual park-wide census (with routine colony survey)

April–May—Update Resource Brief (previous year)

June–August—All QA/QC checks, 100 percent checks, & 10 percent checks will be completed prior to sending the summary data report to SFWMD. A second park-wide survey occurs in July.

September–October—Annual BISC nesting report prepared for SFWMD.

All year—QA/QC checks can be performed throughout the year as monitoring flights are processed

Facility and Equipment Needs

A facility with ample desk space for reviewing photographs is essential, along with a computer capable of running all necessary software. Software currently used include: Adobe Bridge CS3 (or CS4), Adobe Photoshop Elements 15, ThumbsPlus 7, DNR Garmin, GPS-Photo Link, and GeoSetter as a backup. Other software may be used as it becomes available and technology changes.

For each flight, a helicopter is contracted from a local airport close to both our home office and the islands to be flown over. Appropriate flight gear (helmet, leather boots, flight suit, and gloves), camera, GPS, notebook, and data sheets are required for each flight (SOP CNB02 and SOP CNB03).

An SFCN vehicle (for the drive to and from the airport) will be reserved on the calendar in advance of the flight date. We have used two local airports to fly out of for completing our missions. The airports are Miami Executive Airport and Homestead General Aviation Airport. Directions to the airports from the SFCN office can be found in Appendix 8.

Startup Costs and Budget Considerations

Startup costs consist of the equipment mentioned in the SOPs includes a handheld VHF radio, GPS, and flight gear. This equipment costs approximately \$5,243 (Table 9). The B-3, S-271, and A-312 flight training courses are currently provided for no charge, but travel expenses may need to be added depending where the training takes place. The ongoing cost of the helicopter runs approximately \$1,290 per trip or \$15,480 annually (Table 11), and the salary of the flight crew should be factored in as well. Budget constraints may limit the quantity of trips. The combination of data processing, data management, and reporting equals approximately 40% of the budget.

Safety

Flying in helicopters requires considerable safety training and then mission specific caution and care. All personnel are responsible for following the safety rules, regulations, requirements, policies, and procedures of DOI as well as of the park they are working within. In general an attitude of a “culture of safety” and “operational leadership” should prevail in which problems are considered proactively and each person must feel empowered to think about potential problems and speak up early about safety concerns regardless of their position and those concerns must be addressed seriously and respectively by the rest of the flight team and their supervisor(s).

All DOI personnel participating in helicopter flights for this monitoring project are required to complete the necessary helicopter training courses and remain current. The following courses are examples of the coursework:

- A-107, Aviation Policy and Regulations I (online)
- A-100, Basic Aviation Safety
- S-271, Helicopter Crewmember
- A-110, Aviation Transport of Hazardous Material (if applicable and online)
- A-200, Aviation Mishap Review
- A-312, Water Ditching and Survival

All personnel must read and follow:

- SOP CNB02 Safety Requirements and Procedures to Fly in a Helicopter for Colonial Bird Monitoring in Biscayne National Park (SFCN 2021)

SOP CNB02 is dedicated to the required safety precautions, paperwork, equipment, considerations for weather, setting up flight following with Everglades National Park dispatch, notification of Biscayne National Park and Florida Power and Light Turkey Point Nuclear Power Plant, and Homestead Air Reserve Base.

The appendix in SOP CNB02 contains the following documents and forms.

- SFCN_Float_Plan.doc
- Flight_Request_Form_9400_blank_use_this.pdf
- GAR_Risk_Assessment_Model_Birds_USE.doc

- SFCN_Helicopter_Go_No_Go_Checklist_Mod_USE.docx
- Aviation_Risk_Assessment.docx
- Hazardous_Materials_Manifest.docx
- 20140319_HMC_Bird_Aircraft_Daily_Diary_HCM-1_Use.xls

THESE FORMS MAY BE UPDATED AFTER PUBLICATION AND THUS SHOULD BE SEEN ONLY AS EXAMPLES TO HELP PERSONNEL LOCATE THE CORRECT FORMS. The most recent versions of the forms are located in:

- Z:\Helicopter\Colonial_birds\Forms\

With backups in:

- Z:\SAFETY\SFCN Safety Program\Section 3A - SFCN Standard Operating Procedures - SOP's\Colonial_Birds\

Procedures for Revising the Protocol

As time progresses and monitoring techniques evolve, revisions to the protocol narrative and SOPs may be required. It is important to document revisions so data collection and processing will be handled in a consistent manner (SOP CNB07 *Revising the Protocol* [SFCN 2021]).

Considerations for revising the protocol narrative and SOPs include:

1. Staffing and/or budget adjustments do not allow for completion as previously directed.
2. New direction or goals are required.
3. Significant technological advances are made in software or equipment used.
4. There are new contributions from other parks or agencies which need to be considered.

A review of the changes by the participants and supervisors will help ensure they are beneficial and achievable. Modifications must be consistent with the long-term goals of the monitoring program. Any modification in methodology must be made accessible to participants and remain consistent with the goals of this protocol.

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Appendix A. Example Data Summary Report

Introduction

Colonial nesting bird colonies of wading birds and seabirds serve as important indicators of wetland health as they respond to changes in food abundance and quality, contaminants, invasive species, and disturbance. The network is monitoring colonial nesting birds in Biscayne National Park (BISC) and this report summarizes the results.

Methods

The specific objectives of this monitoring program are to determine status and long-term trends in:

- number and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants, Great Egrets, Great White Herons, Great Blue Herons, White Ibises, and Roseate Spoonbills
- annual peak active nest counts of colonial nesting birds in Biscayne National Park with a special focus on Double-crested Cormorants, Great Egrets, Great White Herons, Great Blue Herons, White Ibises, and Roseate Spoonbills
- changes in annual nesting index (sum of monthly nest counts) for the focal species
- changes in the timing of peak nest counts for the focal species

The protocol involves an annual aerial park-wide survey using a helicopter to locate nesting colonies of wading birds and seabirds within Biscayne National Park followed by monthly aerial surveys of the nesting colonies (Figure A-1). Nesting colonies are photographed, and the photographs are analyzed in the office to identify and count active nests by species. An observer also records counts of both nesting and non-nesting birds observed in the field. Peak nest counts are calculated first by colony and then summed across all colonies. The annual nesting index is calculated by summing the nests counted each month by species (note: this number is larger than the true number of nests as the same nest may be counted in multiple months). The nesting index for months with no sampling is calculated as the average of the months before and after the missing month. Complete methods are described in the protocol “Colonial Nesting Bird Monitoring Protocol in Biscayne National Park” (Muxo et al. Draft).

Colony surveys were conducted: 2/25/2013, 3/21/2013, 4/18/2013, 5/15/2013, 6/19/2013, 7/19/2013, 8/14/2013, 9/13/2013, and 12/19/2013. In 2013, the park-wide survey was not performed. Flights were not conducted during the federal government shutdown and subsequent spending restrictions. The six islands surveyed during the monthly flights included: Mangrove Key, West Arsenicker, Arsenicker Key, Jones Lagoon, Ragged Key 5, and Soldier Key. Mangrove Key was surveyed throughout the year as it had been a nesting colony in previous years despite no nests being detected.

The survey data and graphs presented in this report encompasses data collected during the pilot data collection phase through the current monitoring year: 2009 (January–July), 2010 (January–December), 2011 (January–December), 2012 (February, March, April, June, July, September, November, and December), and 2013 (February–September, and December).

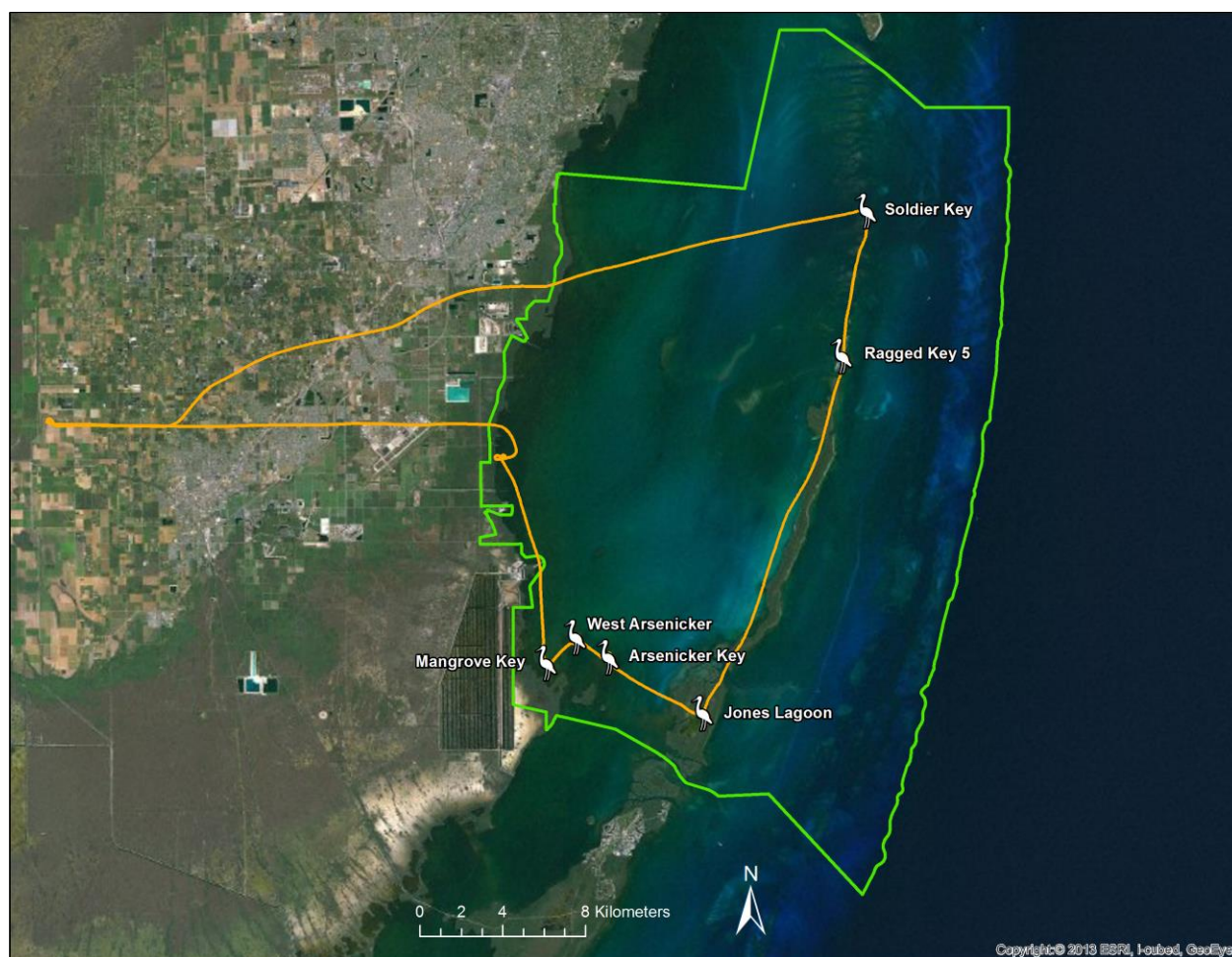


Figure A-1. Nesting colony locations and flight path. The six nesting locations are displayed along the flight path shown in orange, and the park boundary is in green. This monitoring flight started at Homestead General Aviation Airport, west of the park. The flight paths shown were captured from an on-board handheld GPS.

Results and Discussion

The standard results of the colonial nesting bird monitoring are summarized in the following tables and graphs and then discussed further below:

- Table Appendix A-1: Species List
- Figures Appendix A-2 thru 4: Graphs of nests photographed per month by focal species
- Figure Appendix A-5: Number nesting colonies per species by year
- Figure Appendix A-6: Number species nesting by colony and year
- Figure Appendix A-7: Total of peak nest counts across colonies by focal species
- Figure Appendix A-8: Annual nesting index across colonies by focal species
- Figure Appendix A-9: Peak nest counts by colony by focal species
- Figure Appendix A-10: Annual nesting index by colony by focal species

- Table Appendix A-2: Percent nesting by month and focal species
- Table Appendix A-3: All photographed and observed data by year, location, and species
- Table Appendix A-4: Totals and percentages of nests occupied by birds, nests with eggs, nests with chicks, and empty nests

Table A-1. List of species detected in 2013. Numbers in this table should not be used as true abundance estimates as nests and birds were likely observed during more than one sample period.

Common Name	Species Code	Photographed Nests	Field Observed Birds
Anhinga	ANHI	4	9
Bald Eagle	BAEA	1	2
Black-crowned Night-Heron	BCNH	–	5
Brown Pelican	BRPE	–	73
Double-crested Cormorant	DCCO	4,260	3,686
Great Blue Heron	GBHE	25	36
Great Egret	GREG	72	99
Great White Heron	GWHE	74	125
Laridae family gull	LARI	–	3
Laughing Gull	LAGU	–	10
Little Blue Heron	LBHE	1	24
Osprey	OSPR	–	4
Roseate Spoonbill	ROSP	8	34
Royal Tern	ROYT	–	2
Snowy Egret	SNEG	1	21
Tricolored Heron	TRHE	1	144
Turkey Vulture	TUVU	1	35
Unidentified	UNID	30	5
Unidentified Dark Bird	UNDA	3	–
Unidentified White Bird	UNWH	29	64
White Ibis	WHIB	131	170
White-crowned Pigeon	WCPI	–	4
Grand Total	n/a	4,641	4,555

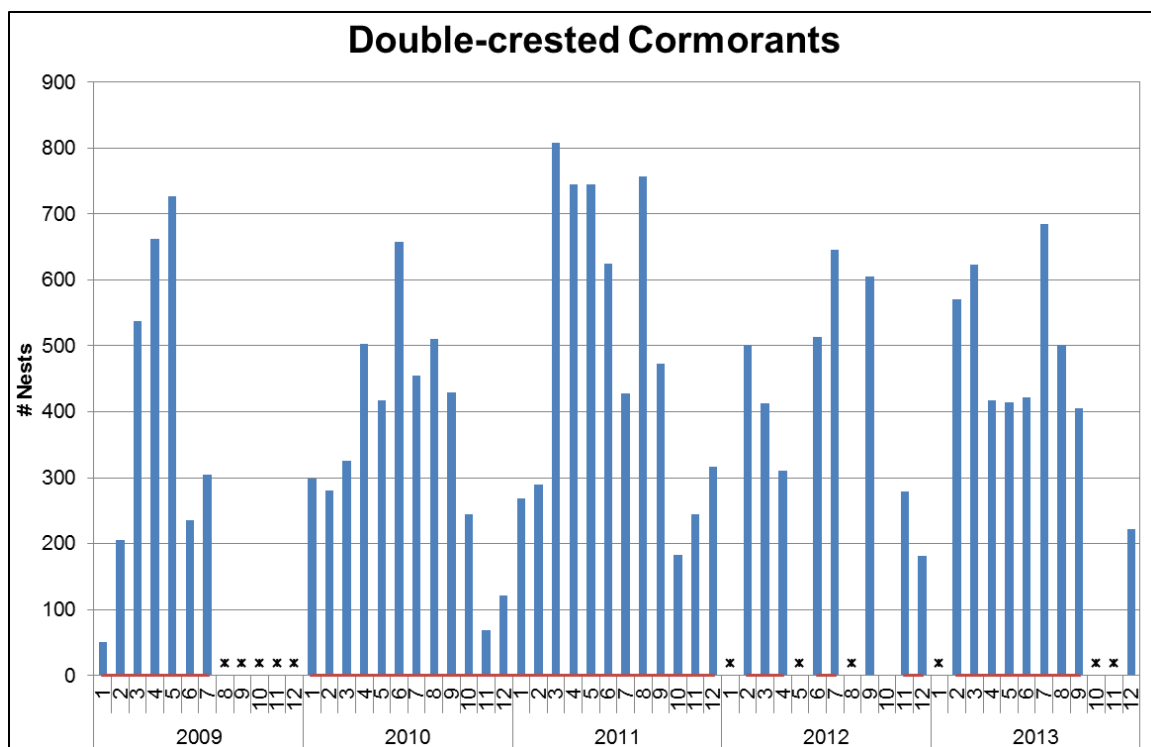


Figure A-2. Number of Double-crested Cormorant nests per month and peak nesting periods. * = Months not sampled.

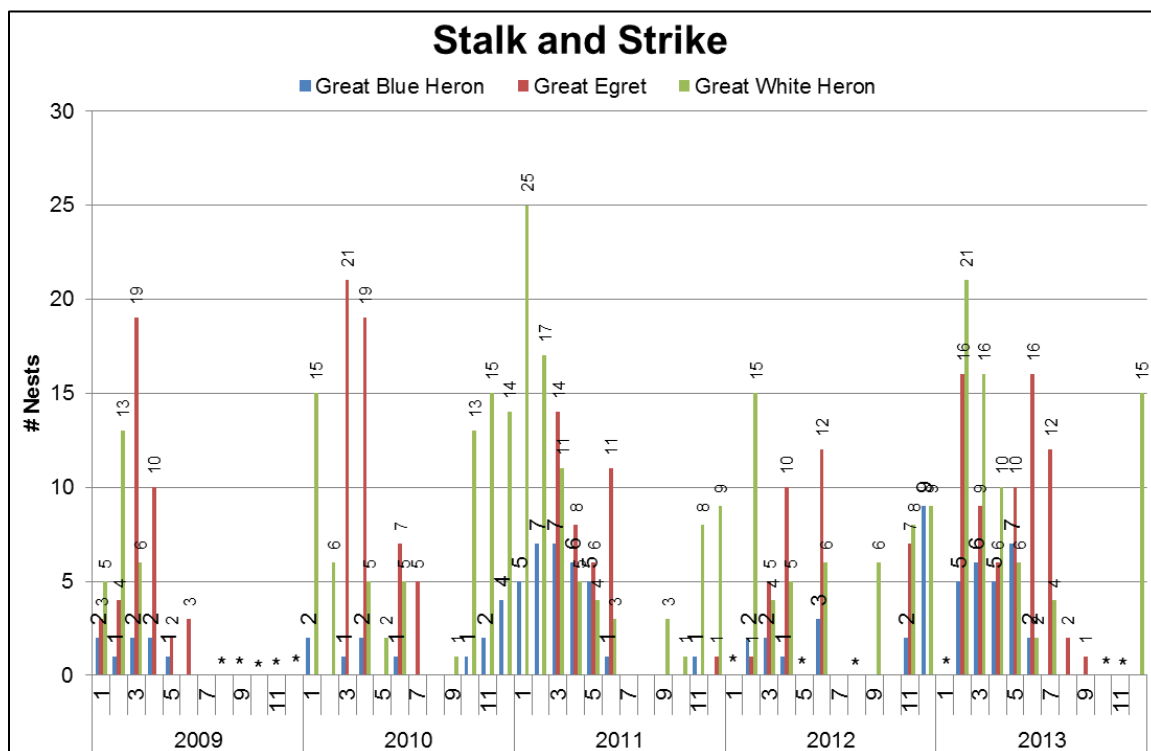


Figure A-3. The number of nests and peak nesting periods by month for selected stalk and strike species: Great Blue Heron, Great Egret, and Great White Heron. * = Months not sampled.

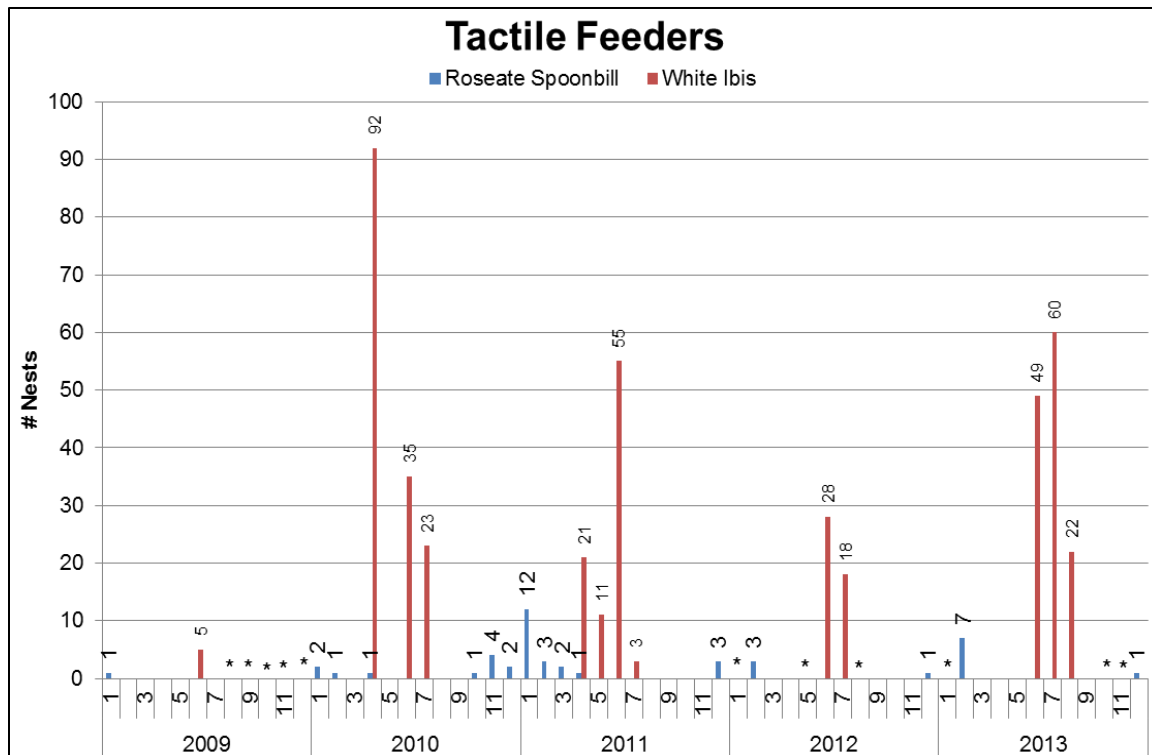


Figure A-4. The number of nests and peak nesting periods by month for selected for two tactile feeder species: Roseate Spoonbills and White Ibises. This graph shows Roseate Spoonbills nest in the dry season and White Ibises nest in the wet season. * = Months not sampled.

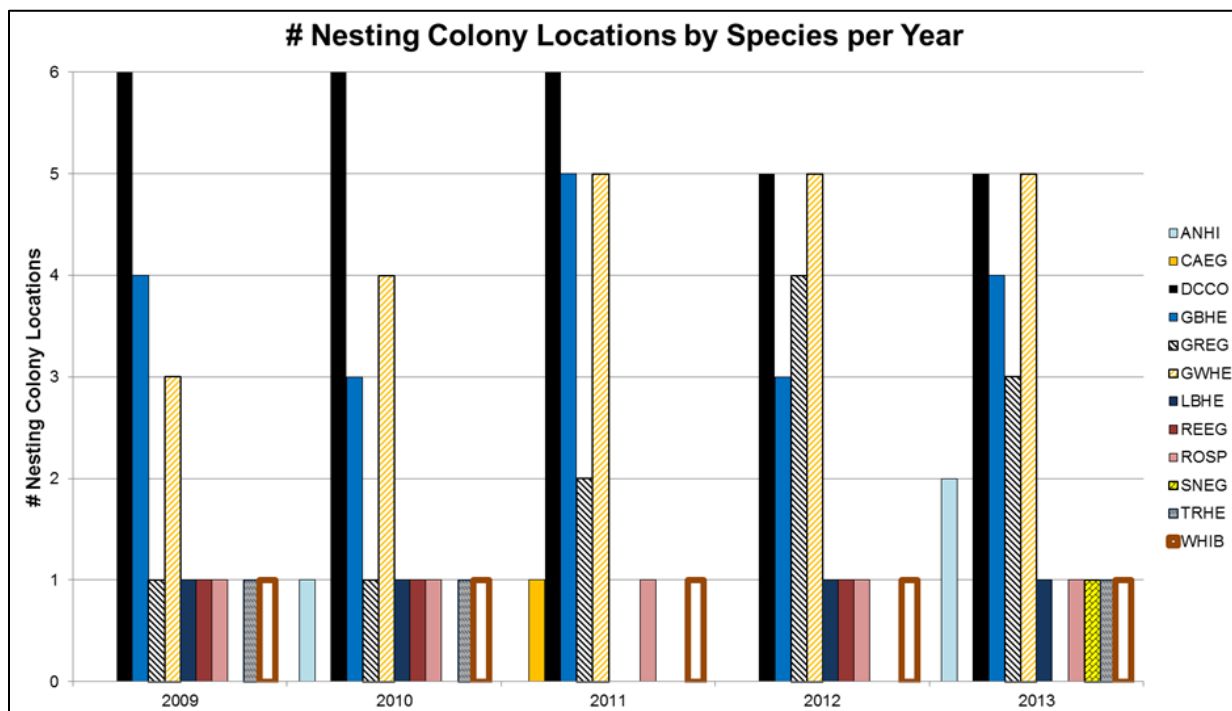


Figure A-5. Number of nesting colonies per species by year. Includes all egrets, ibis, and herons.

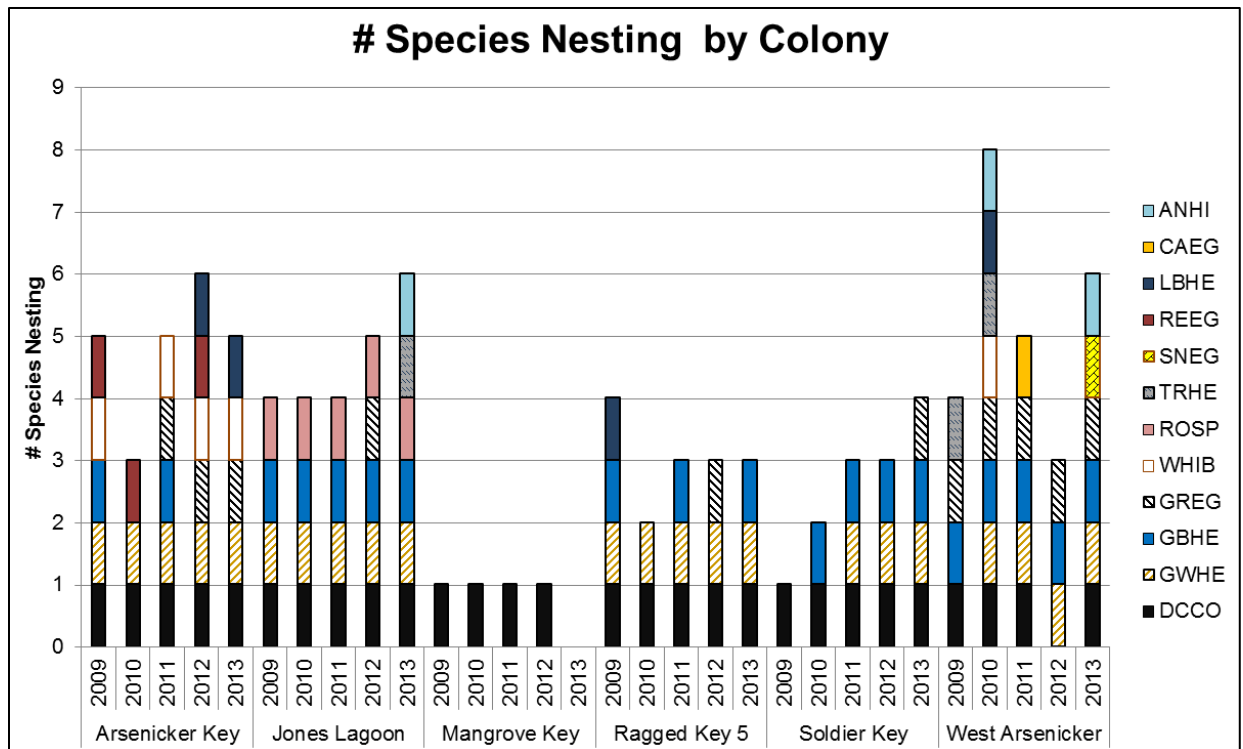


Figure A-6. Number of species detected nesting by colony and year. Includes all egrets, ibis, and herons.

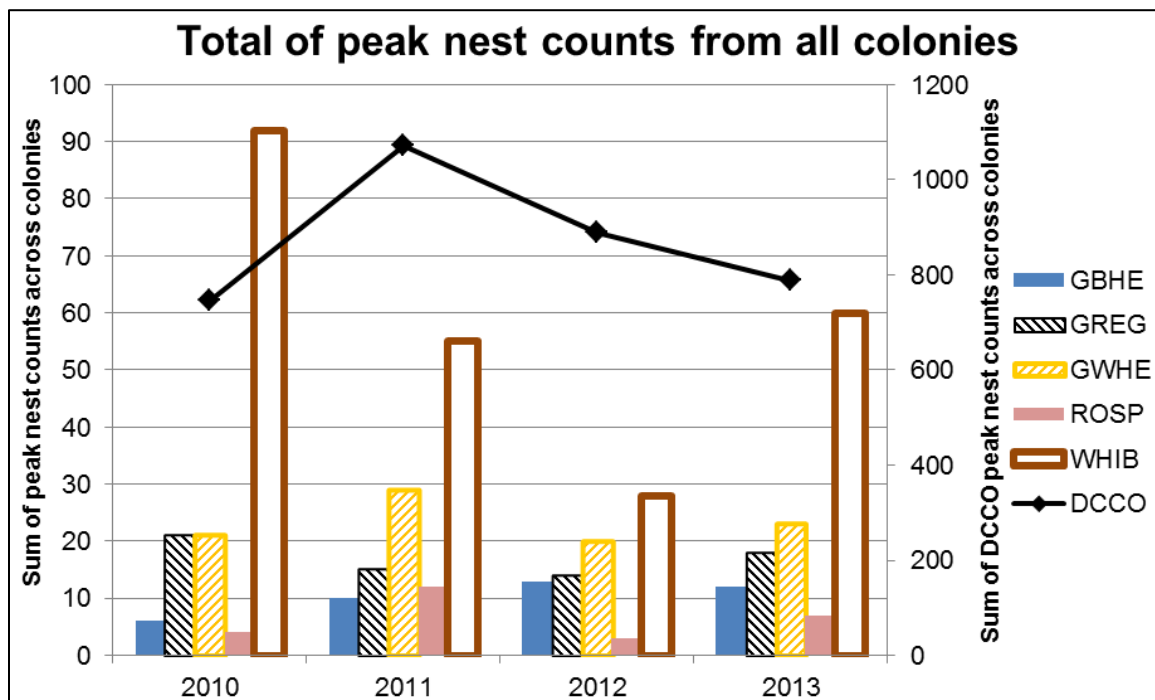


Figure A-7. The maximum number of nests detected per colony were summed to create a total of peak nest counts across all colonies for the six focal species.

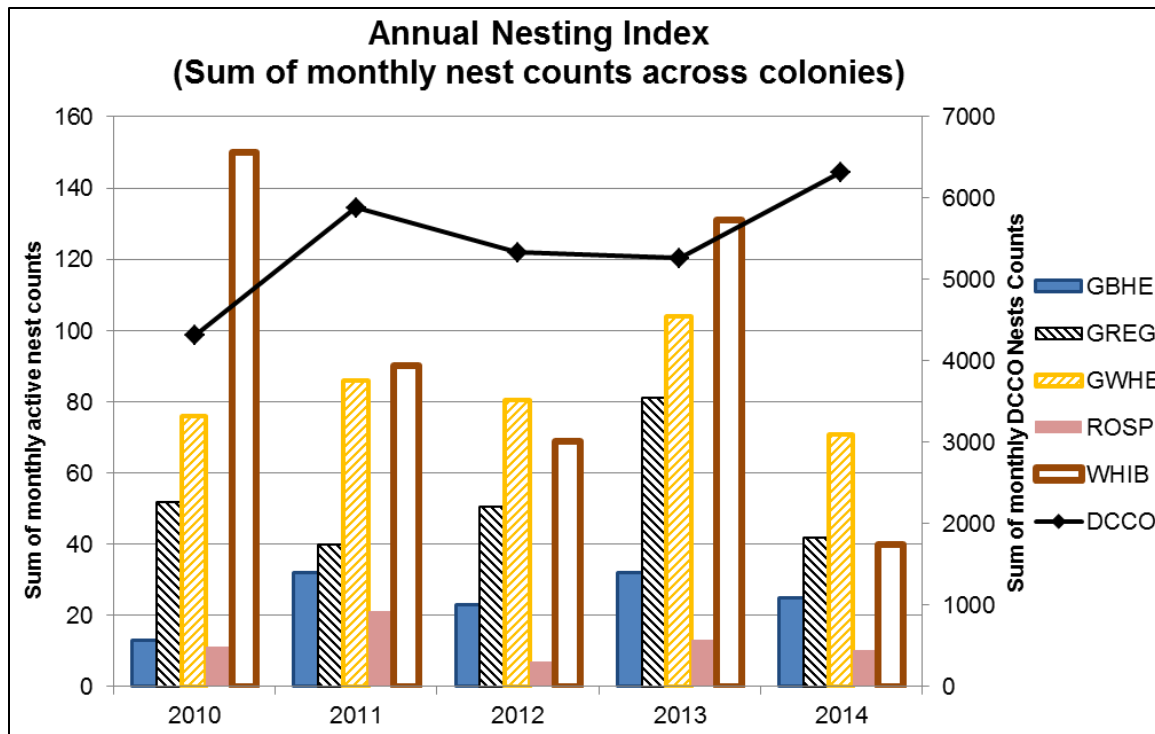


Figure A-8. Annual nesting index across colonies by focal species. The number of nests counted at each colony during each month were summed to create an annual nesting index across all colonies for the six focal species. This number exceeds the actual number of nest starts as a single nest could be counted during two or more monthly visits.

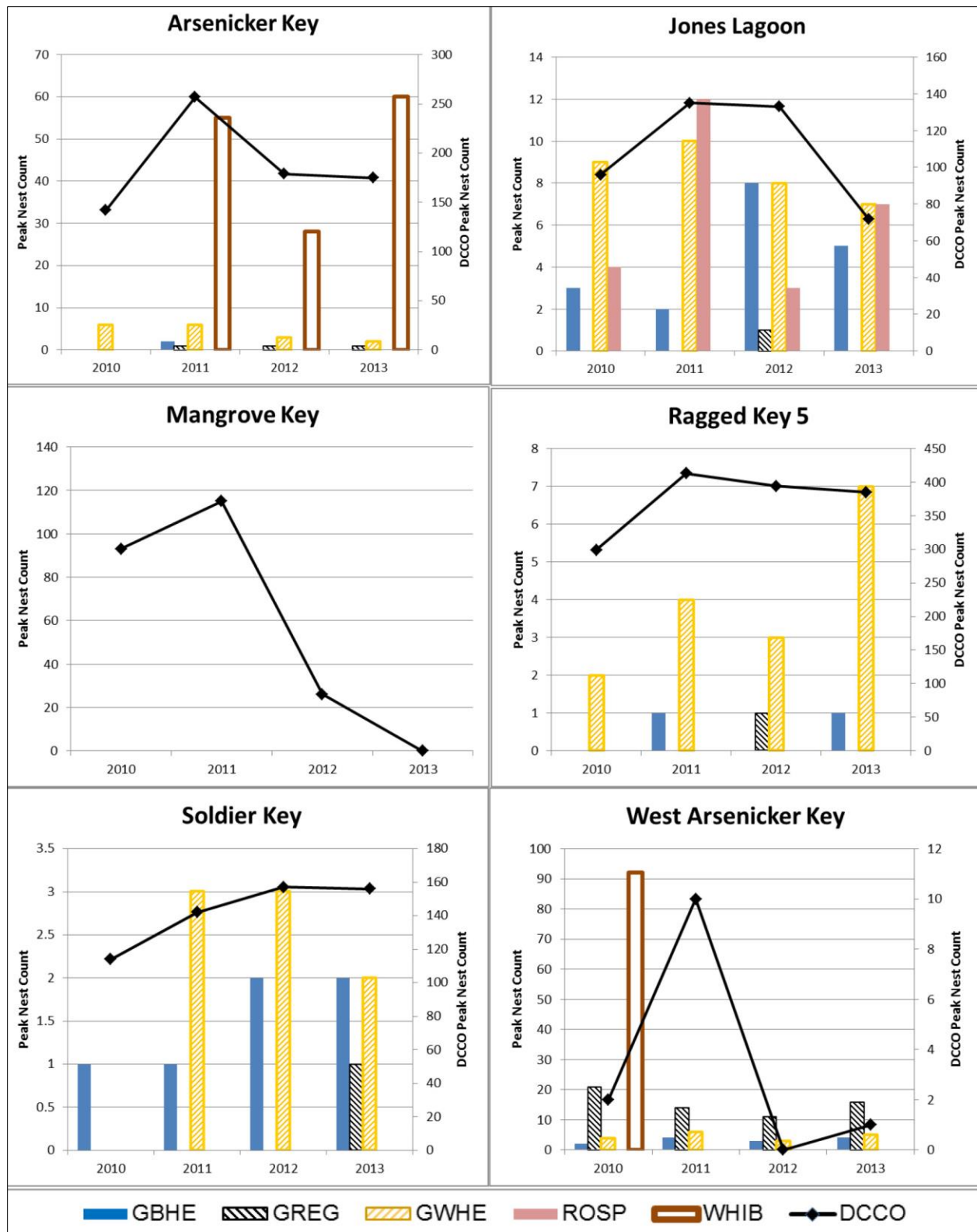


Figure A-9. Peak nest counts by colony for the six focal species.

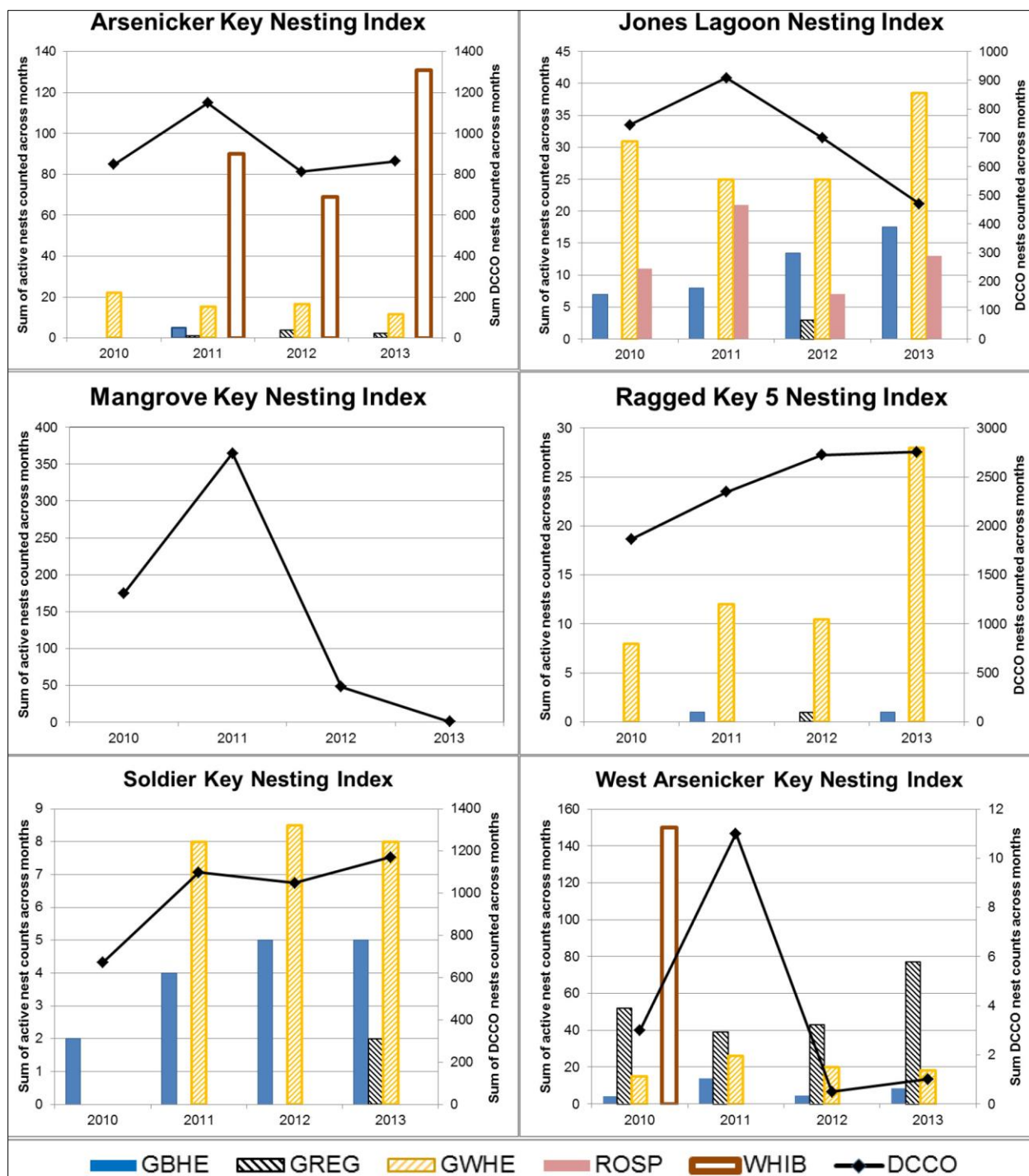


Figure A-10. Annual nesting index across colonies by focal species. The annual nesting index is defined as total nests counted across all months and colonies.

Table A-2. Percent nesting by month and species.

Species	Time Period	Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Double-crested Cormorant	Total for Period	3 ^a	9 ^a	12 ^a	11 ^a	9 ^a	12 ^a	12 ^a	10 ^a	11 ^a	2 ^a	3 ^a	5 ^a
	2010	7 ^a	6 ^a	8 ^a	12 ^a	10 ^a	15 ^a	11 ^a	12 ^a	10 ^a	6 ^a	2 ^a	3 ^a
	2011	5 ^a	5 ^a	14 ^a	13 ^a	13 ^a	11 ^a	7 ^a	13 ^a	8 ^a	3 ^a	4 ^a	5 ^a
	2012	— ^c	15 ^a	12 ^a	9 ^a	— ^c	15 ^a	19 ^a	— ^c	18 ^a	0	8 ^a	5 ^a
	2013	— ^c	13 ^a	15 ^a	10 ^a	10 ^a	10 ^a	16 ^a	12 ^a	10 ^a	— ^c	— ^c	5 ^a
Great Blue Heron	Total for Period	8 ^a	16 ^a	18 ^a	16 ^a	13 ^a	8 ^a	— ^c	— ^c	— ^c	1 ^a	6 ^a	15 ^a
	2010	15 ^a	0	8 ^a	15 ^a	0	8 ^a	— ^c	— ^c	— ^c	8 ^a	15 ^a	31 ^b
	2011	16 ^a	22 ^b	22 ^b	19 ^a	16 ^a	3 ^a	— ^c	— ^c	— ^c	0	3 ^a	0
	2012	0	11 ^a	11 ^a	5 ^a	— ^c	16 ^a	— ^c	— ^c	— ^c	0	11 ^a	47 ^b
	2013	0	20 ^b	24 ^b	20 ^b	28 ^b	8	— ^c	— ^c	— ^c	— ^c	— ^c	0
Great Egret	Total for Period	0	9 ^a	25 ^b	22 ^b	8 ^a	23 ^b	9 ^a	1 ^a	1 ^a	0	4 ^a	1 ^a
	2010	0	0	40 ^b	37 ^b	0	13	10	0	0	0	0	0
	2011	0	0	35 ^b	20 ^b	15 ^a	28 ^b	0	0	0	0	0	3 ^a
	2012	—	3 ^a	14 ^a	29 ^b	— ^c	34 ^b	0	—	0	0	20 ^b	0
	2013	—	22 ^b	13 ^a	8 ^a	14 ^a	22 ^b	17 ^a	3 ^a	1 ^a	— ^c	— ^c	0
Great White Heron	Total for Period	14 ^a	20 ^b	11 ^a	9 ^a	4 ^a	6 ^a	1 ^a	0	3 ^a	5 ^a	11 ^a	16 ^a
	2010	20 ^a	8 ^a	0	7 ^a	3 ^a	7 ^a	0	0	1 ^a	17 ^a	20 ^a	18 ^a
	2011	29 ^b	20 ^a	13 ^a	6 ^a	5 ^a	3 ^a	0	0	3 ^a	1 ^a	9 ^a	10 ^a
	2012	— ^c	28 ^b	8 ^a	9 ^a	— ^c	11 ^a	0	— ^c	11 ^a	0	15 ^a	17 ^a
	2013	— ^c	28 ^b	22 ^b	14 ^a	8 ^a	3 ^a	5 ^a	0	0	— ^c	— ^c	20 ^b

^a Months with any photographed nests (also highlighted in light blue).

^b Months with greater than 20% nesting (also highlighted in darker blue).

^c These months had no flight.

Table A-2 (continued). Percent nesting by month and species.

Species	Time Period	Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Roseate Spoonbill	Total for Period	32 ^b	32 ^b	5 ^a	5 ^a	0	0	0	0	0	2 ^a	9 ^a	16 ^a
	2010	18 ^a	9 ^a	0	9 ^a	0	0	0	0	0	9 ^a	36 ^b	18 ^a
	2011	57 ^b	14 ^a	10 ^a	5 ^a	0	0	0	0	0	0	0	14 ^a
	2012	— ^c	75 ^b	0	0	— ^c	0	0	— ^c	0	0	0	25 ^b
	2013	— ^c	88 ^b	0	0	0	0	0	0	0	— ^c	— ^c	13 ^a
White Ibis	Total for Period	0	0	0	27 ^b	3 ^a	40 ^b	25 ^b	5 ^a	0	0	0	0
	2010	0	0	0	61 ^b	0	23 ^b	15 ^a	0	0	0	0	0
	2011	0	0	0	23 ^b	12 ^a	61	3 ^a	0	0	0	0	0
	2012	— ^c	0	0	0	— ^c	61 ^b	39 ^b	— ^c	0	0	0	0
	2013	— ^c	0	0	0	0	37 ^b	46 ^b	17 ^a	0	— ^c	— ^c	0

^a Months with any photographed nests (also highlighted in light blue).

^b Months with greater than 20% nesting (also highlighted in darker blue).

^c These months had no flight.

Table A-3. Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2009	All locations for 2009	All species for 2009	69	229	571	678	736	243	310	NF	NF	NF	NF	NF	23	219	414	555	457	-	-	NF	NF	NF	NF	NF
	Arsenicker Key	All 2009 species for Arsenicker Key	22	34	169	75	118	60	72	-	-	-	-	-	-	21	109	93	73	-	-	-	-	-	-	-
	Arsenicker Key	Double-crested Cormorant	20	30	167	74	114	55	67	-	-	-	-	-	-	12	100	45	60	-	-	-	-	-	-	-
	Arsenicker Key	Great Blue Heron	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Arsenicker Key	Great White Heron	2	4	1	-	-	-	-	-	-	-	-	-	-	9	3	-	-	-	-	-	-	-	-	-
	Arsenicker Key	Magnificent Frigatebird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	36	1	-	-	-	-	-	-	-
	Arsenicker Key	Reddish Egret	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Arsenicker Key	Unidentified White Bird	-	-	-	-	4	-	5	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-
	Arsenicker Key	White Ibis	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
	Black Point	All 2009 species for Black Point	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Black Point	Bald Eagle	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Elliott Key	All 2009 species for Elliott Key	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Elliott Key	Osprey	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Jones Lagoon	All 2009 species for Jones Lagoon	39	87	129	150	98	20	33	-	-	-	-	-	17	86	86	106	75	-	-	-	-	-	-	-
	Jones Lagoon	Double-crested Cormorant	31	78	126	149	97	20	33	-	-	-	-	-	12	40	80	100	75	-	-	-	-	-	-	-
	Jones Lagoon	Great Blue Heron	2	1	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	Jones Lagoon	Great White Heron	3	8	2	-	-	-	-	-	-	-	-	-	2	9	6	-	-	-	-	-	-	-	-	-
	Jones Lagoon	Magnificent Frigatebird	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	6	-	-	-	-	-	-	-	-
	Jones Lagoon	Roseate Spoonbill	1	-	-	-	-	-	-	-	-	-	-	-	2	24	-	-	-	-	-	-	-	-	-	-
	Jones Lagoon	Unidentified	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Jones Lagoon	Unidentified White Bird	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Mangrove Key	All 2009 species for Mangrove Key	-	-	53	148	217	7	25	-	-	-	-	-	-	-	22	80	40	-	-	-	-	-	-	-
	Mangrove Key	Anhinga	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mangrove Key	Double-crested Cormorant	-	-	53	148	217	7	25	-	-	-	-	-	-	-	22	80	40	-	-	-	-	-	-	-

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2009 (cont.)	Mangrove Point	All 2009 species for Mangrove Point	1	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–
	Mangrove Point	Osprey	1	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–
	Ragged Key 5	All species for Ragged Key 5	–	86	166	217	205	85	74	–	–	–	–	–	–	71	125	200	150	–	–	–	–	–	–	–
	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Double-crested Cormorant	–	84	163	215	205	85	74	–	–	–	–	–	–	60	120	200	150	–	–	–	–	–	–	–
	Ragged Key 5	Great Blue Heron	–			1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Great White Heron	–	1	3	–	–	–	–	–	–	–	–	–	–	1	5	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Little Blue Heron	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Unidentified White Bird	–			1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Sands Key	All 2009 species for Sands Key	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Sands Key	Osprey	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Soldier Key	All 2009 species for Soldier Key	–	14	29	76	90	68	103	–	–	–	–	–	–	30	50	60	101	–	–	–	–	–	–	–
	Soldier Key	Double-crested Cormorant	–	14	29	76	90	68	103	–	–	–	–	–	–	30	50	60	100	–	–	–	–	–	–	–
	Soldier Key	Great White Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
	West Arsenicker	All 2009 species for West Arsenicker	6	6	23	12	8	3	3	–	–	–	–	–	6	11	21	15	18	–	–	–	–	–	–	–
	West Arsenicker	Bald Eagle	1	1	1	–	–	–	–	–	–	–	–	–	1	1	1	3		–	–	–	–	–	–	–
	West Arsenicker	Cattle Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–
	West Arsenicker	Double-crested Cormorant	–	–	–	–	3	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	Great Blue Heron	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
	West Arsenicker	Great Egret	3	4	19	10	2	3	–	–	–	–	–	–	5	10	–	–	4	–	–	–	–	–	–	–
	West Arsenicker	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
	West Arsenicker	Snowy Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
	West Arsenicker	Tricolored Heron	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
	West Arsenicker	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2009 (cont.)	West Arsenicker	Unidentified	2	1	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	Unidentified White Bird	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	20	12	–	–	–	–	–	–	–
2010	All locations for 2010	All species for 2010	318	292	352	641	423	715	485	511	431	262	91	141	–	–	–	–	998	–	–	–	–	–	–	330
	Arsenicker Key	All 2010 species for Arsenicker Key	90	54	50	145	144	124	79	116	53	4	6	13	–	–	–	–	167	–	–	–	–	–	–	54
	Arsenicker Key	American White Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	
	Arsenicker Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	
	Arsenicker Key	Double-crested Cormorant	86	52	50	142	141	122	79	116	52	–	–	9	–	–	–	–	150	–	–	–	–	–	–	36
	Arsenicker Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
	Arsenicker Key	Great Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	
	Arsenicker Key	Great White Heron	4	2	–	1	–	2	–	–	1	2	6	4	–	–	–	–	2	–	–	–	–	–	–	6
	Arsenicker Key	Green Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–
	Arsenicker Key	Laridae family gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	Arsenicker Key	Magnificent Frigatebird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–
	Arsenicker Key	Reddish Egret	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Tricolored Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
	Arsenicker Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Arsenicker Key	Unidentified Dark Bird	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Unidentified White Bird	–	–	–	2	1	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Black Point	All 2010 species for Black Point	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Black Point	Bald Eagle	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Black Point	Jones Lagoon	96	88	96	64	32	64	81	58	83	57	28	51	–	–	–	–	57	–	–	–	–	–	–	37
	Black Point	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Black Point	Double-crested Cormorant	85	85	96	58	29	61	81	58	83	49	17	42	–	–	–	–	50	–	–	–	–	–	–	20
	Black Point	Great Blue Heron	–	–	–	2	–	–	–	–	–	1	1	3	–	–	–	–	–	–	–	–	–	–	–	1
	Black Point	Great White Heron	9	–	–	2	2	2	–	–	–	6	6	4	–	–	–	–	2	–	–	–	–	–	–	6

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2010 (cont.)	Black Point	Magnificent Frigatebird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
	Black Point	Roseate Spoonbill	2	1		1	–	–	–	–	–	1	4	2	–	–	–	–	–	–	–	–	–	–	–	2
	Black Point	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Black Point	Unidentified	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Black Point	Unidentified White Bird	–	2	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Black Point	White-crowned Pigeon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	
	Mangrove Key	All 2010 species for Mangrove Key	–	–	–	–	1	93	27	37	17	–	–	–	–	–	–	–	150	–	–	–	–	–	–	2
	Mangrove Key	Bald Eagle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Mangrove Key	Double-crested Cormorant	–	–	–	–	1	93	27	37	17	–	–	–	–	–	–	–	150	–	–	–	–	–	–	–
	Mangrove Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Mangrove Key	Old Rhodes Key	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Mangrove Key	Osprey	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	All 2010 species for Ragged Key 5	103	86	131	257	190	300	172	183	206	156	35	58	–	–	–	–	203	–	–	–	–	–	–	131
	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
	Ragged Key 5	Double-crested Cormorant	103	84	130	255	190	299	172	183	206	154	35	56	–	–	–	–	200	–	–	–	–	–	–	100
	Ragged Key 5	Great Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Ragged Key 5	Great White Heron	–	2	–	2	–	–	–	–	–	2	–	2	–	–	–	–	3	–	–	–	–	–	–	3
	Ragged Key 5	Laridae family gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
	Ragged Key 5	Snowy Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Ragged Key 5	Unidentified	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Unidentified White Bird	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Sands Key	All 2010 species for Sands Key	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Sands Key	Osprey	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Soldier Key	All 2010 species for Soldier Key	25	59	50	48	56	82	95	114	71	41	17	15	–	–	–	–	153	–	–	–	–	–	–	91

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2010 (cont.)	Soldier Key	Double-crested Cormorant	25	59	49	48	56	82	95	114	71	41	17	14	–	–	–	–	150	–	–	–	–	–	–	70
	Soldier Key	Great Blue Heron	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	
	Soldier Key	Great White Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	
	Soldier Key	Laridae family gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	18	
	Soldier Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	
	Soldier Key	Unidentified White Bird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	
	West Arsenicker	All 2010 species for West Arsenicker	4	3	22	127	–	52	31	3	1	4	5	4	–	–	–	–	268	–	–	–	–	–	–	15
	West Arsenicker	Anhinga	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	West Arsenicker	Bald Eagle	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	West Arsenicker	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	
	West Arsenicker	Cattle Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	75	–	–	–	–	–	–	
	West Arsenicker	Double-crested Cormorant	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	
	West Arsenicker	Great Blue Heron	2	–	–	–	–	1	–	–	–	–	1		–	–	–	–	2	–	–	–	–	–	1	
	West Arsenicker	Great Egret	–	–	21	19	–	7	5	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	2	
	West Arsenicker	Great White Heron	2	2	–	–	–	1	–	–	–	3	3	4	–	–	–	–	10	–	–	–	–	–	2	
	West Arsenicker	Green Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	
	West Arsenicker	Little Blue Heron	–	–	–	–	–	1	1		–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	
	West Arsenicker	Tricolored Heron	–	–	–	3	–	3	1	1	–	–	–	–	–	–	–	–	89	–	–	–	–	–	–	
	West Arsenicker	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	–	–	–	–	–	–	
	West Arsenicker	Unidentified	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	West Arsenicker	Unidentified Dark Bird	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	West Arsenicker	Unidentified White Bird	–	–	–	10	–	3	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	
	West Arsenicker	White Ibis	–	–	–	92		35	23	–	–	–	–	–	–	–	–	–	50	–	–	–	–	–	–	
	West Arsenicker	White-crowned Pigeon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	–	–	

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2011	All locations for 2011	All species for 2011	314	316	845	790	774	695	438	757	477	185	255	336	549	422	616	137	475	516	147	409	182	212	377	335
	Arsenicker Key	All 2011 species for Arsenicker Key	58	26	125	179	192	183	124	257	78	2	17	23	15	5	57	30	73	102	56	99	25	201	73	80
	Arsenicker Key	American White Pelican	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	19
	Arsenicker Key	Bald Eagle	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4		6	–	–	3	10
	Arsenicker Key	Double-crested Cormorant	51	21	121	157	181	127	121	257	77	1	15	20	1	–	55	24	60	16	45	30	20	200	65	45
	Arsenicker Key	Great Blue Heron	1	2	1	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–
	Arsenicker Key	Great Egret	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2	1	1	–	–	–	–
	Arsenicker Key	Great White Heron	6	3	3	–	–	1	–	–	1	–	1	–	7	5	2	–	–	3	–	–	4	1	5	5
	Arsenicker Key	Magnificent Frigatebird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
	Arsenicker Key	Reddish Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
	Arsenicker Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	50	–	–	–	–
	Arsenicker Key	Unidentified	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Arsenicker Key	Unidentified White Bird	–	–	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	White Ibis	–	–	–	21	11	55	3	–	–	–	–	–	–	–	–	6	12	70	10	12	–	–	–	–
	Black Point	All 2011 species for Black Point	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–
	Black Point	American White Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	All 2011 species for Jones Lagoon	134	89	143	91	85	78	40	124	14	8	50	111	32	43	51	13	91	42	15	48	12	5	48	54
	Jones Lagoon	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
	Jones Lagoon	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Jones Lagoon	Double-crested Cormorant	110	82	135	87	83	78	40	124	14	7	47	101	12	15	45	12	90	40	15	48	12	–	40	45
	Jones Lagoon	Great Blue Heron	1	1	1	2	2	–	–	–	–	–	1	–	–	1	–	–	1	–	–	–	–	1	1	1
	Jones Lagoon	Great White Heron	10	3	5	–	–	–	–	–	–	1	2	4	6	3	4	1	–	–	–	–	–	4	7	4
	Jones Lagoon	Roseate Spoonbill	12	3	2	1	–	–	–	–	–	–	–	3	14	24	2	–	–	–	–	–	–	–	–	3
	Jones Lagoon	Unidentified	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2011 (cont.)	Jones Lagoon	Unidentified White Bird	1	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Mangrove Key	All 2011 species for Mangrove Key	–	–	2	42	69	115	32	46	44	2	9	5	–	–	1	24	36	4	14	10	6	–	1	6
	Mangrove Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
	Mangrove Key	Double-crested Cormorant	–	–	2	42	69	115	32	46	44	2	8	5	–	–	1	24	36	4	12	10	6	–	–	6
	Mangrove Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	Mangrove Key	Great White Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	Mangrove Key	Unidentified Dark Bird	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	All 2011 species for Ragged Key 5	34	135	415	309	275	198	138	188	237	120	158	154	292	204	251	36	100	67	7	112	41	4	114	94
	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	40	–	–	–	–	–	–	–	1	4	12	24
	Ragged Key 5	Double-crested Cormorant	29	133	413	309	275	198	138	188	237	120	157	151	250	200	250	36	100	67	6	110	40	–	100	65
	Ragged Key 5	Great Blue Heron	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	Ragged Key 5	Great White Heron	4	2	2	–	–	–	–	–	–	–	1	3	2	4	1	–	–	–	–	2	–	–	2	4
	Ragged Key 5	Ring-billed Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Soldier Key	All 2011 species for Soldier Key	84	57	139	142	136	107	96	142	101	53	17	39	203	154	246	29	152	133	40	50	56	–	124	88
	Soldier Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
	Soldier Key	Cattle Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
	Soldier Key	Double-crested Cormorant	78	53	137	140	136	107	96	142	101	53	17	39	200	150	200	24	150	125	40	50	55	–	120	85
	Soldier Key	Great Blue Heron	1	1	1	1	–	–	–	–	–	–	–	–	–	2	2	–	1	1	–	–	–	–	1	1
	Soldier Key	Great White Heron	3	3	1	1	–	–	–	–	–	–	–	–	3	2	12	5	1	6	–	–	1	–	3	–
	Soldier Key	Ring-billed Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Soldier Key	Unidentified	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Soldier Key	Unidentified White Bird	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Soldier Key	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	–	–	–	–	–	–	–	–	–
	West Arsenicker	All 2011 species for West Arsenicker	4	9	21	27	17	14	8	–	3	–	4	4	7	12	10	5	23	168	15	90	42	2	17	13

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2011 (cont.)	West Arsenicker	American White Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	West Arsenicker	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–
	West Arsenicker	Bald Eagle	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2	1
	West Arsenicker	Black Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–
	West Arsenicker	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	West Arsenicker	Cattle Egret	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	15	–	–	–	–	–
	West Arsenicker	Double-crested Cormorant	–	–	–	10	–	–	–	–	–	–	–	1	–	–	–	–	1	30	–	10	36	–	–	3
	West Arsenicker	Great Blue Heron	1	3	4	2	3	1	–	–	–	–	–	–	1	3	2	1	2	1	–	–	–	–	3	1
	West Arsenicker	Great Egret	–	–	14	8	6	11	–	–	–	–	–	–	–	–	6	–	–	5	–	6	–	–	–	–
	West Arsenicker	Great White Heron	2	6	–	4	4	2	–	–	2	–	4	2	6	9	2	2	20	2	–	–	5	2	12	5
	West Arsenicker	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	–	–	–	–	–	–
	West Arsenicker	Tricolored Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	27	–	12	–	–	–	–
	West Arsenicker	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	50	1	–	–	–
	West Arsenicker	Unidentified	1	–	–	2	4	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	Unidentified White Bird	–	–	2	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	–	–	–	–	–	–
	West Arsenicker	White-crowned Pigeon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	50	–	–	–	–	–	–
2012	All locations for 2012	All species for 2012	NF	525	427	331	NF	574	663	NF	612	NF	303	202	NF	361	38	168	NF	455	351	NF	544	NF	426	479
	Arsenicker Key	All 2012 species for Arsenicker Key	–	109	41	15	–	210	118	–	55	–	16	45	–	109	18	38	–	107	88	–	75	–	40	192
	Arsenicker Key	American White Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	2	–	–	–
	Arsenicker Key	Bald Eagle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
	Arsenicker Key	Belted Kingfisher	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
	Arsenicker Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	1
	Arsenicker Key	Cattle Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–	–	–	–

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2012 (cont.)	Arsenicker Key	Double-crested Cormorant	–	108	37	10	–	179	100	–	52	–	15	44	–	70	12	30	–	45	60	–	60	–	34	180
	Arsenicker Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	10	2	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Great Egret	–	–	–	1	–	1	–	–	–	–	–	–	–	2	–	–	–	5	1	–	4	–	–	–
	Arsenicker Key	Great White Heron	–	1	2	2	–	2	–	–	3	–	–	1	–	5	4	5	–	–	–	–	2	–	6	8
	Arsenicker Key	Little Blue Heron	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–
	Arsenicker Key	Magnificent Frigatebird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
	Arsenicker Key	Reddish Egret	–	–	–	1	–	–	–	–	–	–	–	–	–	3	–	–	–	1	–	–	–	–	–	–
	Arsenicker Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	23	5	–	–	–	–	–
	Arsenicker Key	Unidentified	–	–	1		–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
	Arsenicker Key	Unidentified White Bird	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Arsenicker Key	White Ibis	–	–	–	–	–	28	18	–	–	–	–	–	–	–	–	–	–	28	20	–	5	–	–	1
	Black Point	All 2012 species for Black Point	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Black Point	Osprey	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Jones Lagoon	All 2012 species for Jones Lagoon	–	60	25	18	–	48	133	–	64	–	75	47	–	51	6	30	–	2	36	–	25	–	8	18
	Jones Lagoon	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Jones Lagoon	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Double-crested Cormorant	–	43	23	16	–	47	133	–	63	–	72	33	–	32	–	26	–	–	35		23	–	–	4
	Jones Lagoon	Great Blue Heron	–	2	1	1	–	–	–	–	–	–	–	8	–	1	1	1	–	–	–	–	–	–	3	3
	Jones Lagoon	Great Egret	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–
	Jones Lagoon	Great White Heron	–	8	1	1	–	1	–	–	–	–	2	4	–	8	5	1	–	1	–	–	–	–	5	6
	Jones Lagoon	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–
	Jones Lagoon	Magnificent Frigatebird	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Roseate Spoonbill	–	3	–	–	–	–	–	–	–	–	–	1	–	8	–	–	–	–	–	–	–	1	–	3
	Jones Lagoon	Unidentified	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Unidentified White Bird	–	3	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2012 (cont.)	Jones Lagoon	White Ibis	–	–	–	–	–	–	–	–		–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
	Mangrove Key	All 2012 species for Mangrove Key	–	–	–	–	–	26	–	–	2	–	1	1	–	5	–	3	–	3	–	–	6	–	7	4
	Mangrove Key	Belted Kingfisher	–	–	–	–	–		–	–		–	–	–	–	–	–	–	–	–	–	–	–	2	–	
	Mangrove Key	Double-crested Cormorant	–	–	–	–	–	26	–	–	2	–	1	1	–	5	–	3	–	1	–	–	6	–	2	4
	Mangrove Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	
	Mangrove Key	Great White Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	
	Mangrove Key	Unidentified White Bird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	
	Ragged Key 5	All 2012 species for Ragged Key 5	–	275	297	127	–	141	310	–	394	–	154	66	–	64	5	–	–	149	80	–	257	–	151	80
	Ragged Key 5	Belted Kingfisher	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	
	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	14	–	–	–	–	–	–	–	–	55	
	Ragged Key 5	Double-crested Cormorant	–	272	294	127	–	141	310	–	394	–	151	66	–	39	–	–	–	149	80	–	199	–	150	20
	Ragged Key 5	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	54	–	1	–	
	Ragged Key 5	Great Egret	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Ragged Key 5	Great White Heron	–	3	–	–	–	–	–	–	–	–	3	–	–	3	3	–	–	–	–	–	–	–	–	3
	Ragged Key 5	Laughing Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Ring-billed Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Ragged Key 5	Unidentified White Bird	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
	Soldier Key	All 2012 species for Soldier Key	–	81	59	158	–	122	102	–	94	–	44	39	–	103	9	91	–	84	121	–	136	–	213	173
	Soldier Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	8
	Soldier Key	Double-crested Cormorant	–	78	58	157	–	120	102	–	94	–	40	37	–	90	–	90	–	81	120	–	130	–	200	160
	Soldier Key	Great Blue Heron	–	–	1	–	–	–	–	–	–	–	2	1	–	2	–	–	–	–	–	–	2	–	9	1
	Soldier Key	Great Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	
	Soldier Key	Great White Heron	–	3	–	1	–	1	–	–	–	–	–	1	–	5	1	–	–	–	1	–	2	–	4	2
	Soldier Key	Herring Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
	Soldier Key	Laughing Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2012 (cont.)	Soldier Key	Ring-billed Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Soldier Key	Unidentified	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soldier Key	Unidentified White Bird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	1	-	-	-	-	-	-	-	-
	West Arsenicker	All 2012 species for West Arsenicker	-	-	5	13	-	27	-	-	3	-	13	4	-	29	-	6	-	110	26	-	45	-	7	11
	West Arsenicker	American White Pelican	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	West Arsenicker	Bald Eagle	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
	West Arsenicker	Brown Pelican	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2
	West Arsenicker	Cattle Egret	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	West Arsenicker	Double-crested Cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	-	-	1	-	-	5	-	-	2
	West Arsenicker	Great Blue Heron	-	-	-	-	-	3	-	-	-	-	-	-	-	6	-	3	-	-	-	-	-	-	-	-
	West Arsenicker	Great Egret	-	-	4	9	-	11	-	-	-	-	6	-	-	4	-	1	-	2	-	-	8	-	-	-
	West Arsenicker	Great White Heron	-	-	1	1	-	2	-	-	3	-	3	3	-	4	-	-	-	1	-	-	2	-	6	3
	West Arsenicker	Little Blue Heron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	West Arsenicker	Osprey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	West Arsenicker	Tricolored Heron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	77	12	-	5	-	-	-
	West Arsenicker	Turkey Vulture	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	25	-	-	-
	West Arsenicker	Unidentified	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-	-	1	-
	West Arsenicker	Unidentified White Bird	-	-	-	3	-	11	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
	West Arsenicker	White Ibis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6	-	-	-	-	-
	West Arsenicker	White-crowned Pigeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	6	-	-	-	-	-
	West Arsenicker	Yellow-crowned Night-Heron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
2013	All locations for 2013	All species for 2013	NF	628	667	444	443	500	770	534	406	NF	NF	249	NF	339	529	711	536	515	629	572	340	NF	NF	384
	Arsenicker Key	All 2013 species for Arsenicker Key	-	91	49	16	22	159	239	187	81	-	-	16	-	30	40	87	124	93	64	142	75	-	-	63
	Arsenicker Key	Anhinga	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
	Arsenicker Key	Brown Pelican	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	7

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2013 (cont.)	Arsenicker Key	Double-crested Cormorant	–	89	46	14	21	107	175	160	80	–	–	13	–	1	30	80	120	60	7	100	36	–	–	50
	Arsenicker Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	1	–	1	–	–	–	–	
	Arsenicker Key	Great Egret	–	–	–	–	–	–	–	–	1	–	–	–	–	16	–	4	–	–	2	–	–	–	–	
	Arsenicker Key	Great White Heron	–	2	1	–	1	1	1	–	–	–	–	2	–	6	–	–	1	2	2	–	3	–	–	6
	Arsenicker Key	Little Blue Heron	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	
	Arsenicker Key	Tricolored Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	
	Arsenicker Key	Turkey Vulture	–	–	1	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	4	–	–	–	–	
	Arsenicker Key	Unidentified	–	–	1	–	–	1	–	4	–	–	–	1	–	–	–	–	–	–	5	–	–	–	–	
	Arsenicker Key	Unidentified Dark Bird	–	–	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	Arsenicker Key	Unidentified White Bird	–	–	–	1	–	–	2	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	
	Arsenicker Key	White Ibis	–	–	–	–	–	49	60	22	–	–	–	–	–	–	–	–	–	30	42	40	36	–	–	–
	Arsenicker Key	White-crowned Pigeon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	
	Elliott Key	All 2013 species for Elliott Key	–	–	–	–	–	–	–	–	–	–	–	–	–	–	43	98	–	–	–	–	–	–	–	
	Elliott Key	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14	–	–	–	–	–	–	–	
	Elliott Key	Double-crested Cormorant	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	80	–	–	–	–	–	–	–	
	Elliott Key	Great Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	
	Elliott Key	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	
	Elliott Key	Osprey	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	
	Elliott Key	Tricolored Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	
	Jones Lagoon	All 2013 species for Jones Lagoon	–	35	78	70	84	49	44	56	38	–	–	17	–	79	53	73	108	92	75	53	24	–	–	28
	Jones Lagoon	Anhinga	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	
	Jones Lagoon	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2	
	Jones Lagoon	Double-crested Cormorant	–	13	72	63	72	47	40	56	38	–	–	4	–	60	30	58	100	90	72	50	24	–	–	2
	Jones Lagoon	Great Blue Heron	–	3	1	1	5	2	–	–	–	–	–	–	–	–	1	2	2	1	–	1	–	–	–	3
	Jones Lagoon	Great Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2013 (cont.)	Jones Lagoon	Great White Heron	–	7	4	5	3	–	2	–	–	–	–	6	–	10	1	4	6	–	2	2	–	–	–	5
	Jones Lagoon	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Roseate Spoonbill	–	7	–	–	–	–	–	–	–	–	–	1	–	8	15	4	–	–	1	–	–	–	–	6
	Jones Lagoon	Tricolored Heron	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Unidentified	–	3	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
	Jones Lagoon	Unidentified White Bird	–	2	–	1	2	–	1	–	–	–	–	4	–	–	6	–	–	–	–	–	–	–	–	–
	Jones Lagoon	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
	Mangrove Key	All 2013 species for Mangrove Key	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	13	26	2	4	–	–	5
	Mangrove Key	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
	Mangrove Key	Double-crested Cormorant	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	25	1	2	–	–	5
	Mangrove Key	Great White Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	–	1	–	–	–	–
	Mangrove Key	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–
	Mangrove Key	Unidentified White Bird	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
	Ragged Key 5	All 2013 species for Ragged Key 5	–	356	394	214	165	181	347	194	227	–	–	136	–	118	171	225	153	110	184	150	61	–	–	127
	Ragged Key 5	Anhinga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	3	–	–	–	–	–	–	20
	Ragged Key 5	Double-crested Cormorant	–	350	385	211	165	180	347	194	227	–	–	131	–	100	170	220	150	110	182	150	60	–	–	100
	Ragged Key 5	Great Blue Heron	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Great Egret	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
	Ragged Key 5	Great White Heron	–	6	7	2	–	–	–	–	–	–	–	5	–	10	1	3	–	–	1	–	1	–	–	6
	Ragged Key 5	Laridae family gull	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Royal Tern	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Ragged Key 5	Unidentified	–		1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Unidentified White Bird	–		1	–		1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
	Ragged Key 5	Soldier Key	–	121	122	132	158	88	124	94	60	–	–	78	–	82	168	205	121	102	190	184	110	–	–	155

Table A-3 (continued). Photographed nests and observed bird data by year, location, and species. Note: NF = No Flight.

Year	Location	Species	Sampling month for photographed nests												Sampling month for observed birds											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
2013 (cont.)	Ragged Key 5	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	1	–	–	–	–	2
	Ragged Key 5	Double-crested Cormorant	–	119	120	129	156	87	122	92	60	–	–	74	–	65	160	203	120	100	180	180	100	–	–	150
	Ragged Key 5	Great Blue Heron	–	1	1	–	2	–	–	–	–	–	–	–	–	5	–	1	–	–	–	–	–	–	–	1
	Ragged Key 5	Great Egret	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
	Ragged Key 5	Great White Heron	–	1	–	2	–	1	1	–	–	–	–	1	–	6	8	1	1	2	6	1	3	–	–	2
	Ragged Key 5	Laridae family gull	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
	Ragged Key 5	Laughing Gull	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3	6	–	–	–
	Ragged Key 5	Royal Tern	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
	Ragged Key 5	Unidentified	–	–	–	1	–	–	–	2	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	All 2013 species for West Arsenicker	–	25	24	12	14	23	16	3	–	–	–	2	–	30	53	22	29	105	90	41	66	–	–	6
	West Arsenicker	Anhinga	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	–	1
	West Arsenicker	Bald Eagle	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–
	West Arsenicker	Black-crowned Night-Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3	–	–	–
	West Arsenicker	Brown Pelican	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	3	–	–	–
	West Arsenicker	Double-crested Cormorant	–	–	–	–	–	–	1	–	–	–	–	–	–	20	7	6	4	–	20	–	–	–	–	4
	West Arsenicker	Great Blue Heron	–	1	4	3	–	–	–	–	–	–	–	–	–	–	3	3	2	–	3	–	–	–	–	–
	West Arsenicker	Great Egret	–	16	8	6	10	16	11	2	–	–	–	–	–	6	10	7	12	25	4	–	6	–	–	–
	West Arsenicker	Great White Heron	–	5	4	1	2	–	–	–	–	–	–	1	–	–	5	–	–	4	4	4	1	–	–	1
	West Arsenicker	Little Blue Heron	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	12	–	–	–	–
	West Arsenicker	Snowy Egret	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	21	–	–	–	–	–
	West Arsenicker	Tricolored Heron	–	–	–	–	–	–	–	–	–	–	–	–	–		22	4	10	40	17	20	25	–	–	–
	West Arsenicker	Turkey Vulture	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	5	2	12	–	–	–
	West Arsenicker	Unidentified	–	1	3	1	1	1	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
	West Arsenicker	Unidentified White Bird	–	2	4	1	1	4	1	1	–	–	–	–	–	–	5	–	–	30	–	–	15	–	–	–
	West Arsenicker	White Ibis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–
	West Arsenicker	White-crowned Pigeon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–

Table A-4. Totals and percentages of nests occupied by birds, nests with eggs, nests with chicks, and empty nests. Occupied nests number includes nests with chicks and nests with eggs. Total active nest is comprised of occupied nests plus empty nest. Blanks are zero.

Species Code	Sample Year	Occupied Nests	Nests With Chicks	Nests With Eggs	Empty Nests	Total Active Nests	% Occupied Nests	%Nests With Chicks	% Nests With Eggs	% Empty Nests
DCCO	2010	3995	672	118	314	4309	93%	16%	3%	7%
DCCO	2011	5274	507	159	606	5880	90%	9%	3%	10%
DCCO	2012	3030	222	79	416	3446	88%	6%	2%	12%
DCCO	2013	3950	321	108	310	4260	93%	8%	3%	7%
GBHE	2010	13	–	–	–	13	100%	–	–	–
GBHE	2011	31	5	4	1	32	97%	16%	13%	3%
GBHE	2012	18	3	3	1	19	95%	16%	16%	5%
GBHE	2013	25	8	1	–	25	100%	32%	4%	–
GREG	2010	52	4	3	–	52	100%	8%	6%	–
GREG	2011	29	3	4	11	40	73%	8%	10%	28%
GREG	2012	35	3	1	–	35	100%	9%	3%	–
GREG	2013	72	12	6	–	72	100%	17%	8%	–
GWHE	2010	76	19	4	–	76	100%	25%	5%	–
GWHE	2011	85	14	14	1	86	99%	16%	16%	1%
GWHE	2012	52	14	1	1	53	98%	26%	2%	2%
GWHE	2013	70	22	8	4	74	95%	30%	11%	5%
ROSP	2010	11	2	–	–	11	100%	18%	–	–

Table A-4 (continued). Totals and percentages of nests occupied by birds, nests with eggs, nests with chicks, and empty nests. Occupied nests number includes nests with chicks and nests with eggs. Total active nest is comprised of occupied nests plus empty nest. Blanks are zero.

Species Code	Sample Year	Occupied Nests	Nests With Chicks	Nests With Eggs	Empty Nests	Total Active Nests	% Occupied Nests	%Nests With Chicks	% Nests With Eggs	% Empty Nests
ROSP	2011	21	6	–	–	21	100%	29%	–	–
ROSP	2012	4	–	–	–	4	100%	–	–	–
ROSP	2013	8	3	–	–	8	100%	38%	–	–
WHIB	2010	149	20	3	1	150	99%	13%	2%	1%
WHIB	2011	90	6	5	–	90	100%	7%	6%	–
WHIB	2012	46	–	1	–	46	100%	–	2%	–
WHIB	2013	131	11	11	–	131	100%	8%	8%	–

In 2013 the network completed its fifth year of monitoring colonial nesting birds in Biscayne National Park (BISC). Table Appendix A-1 provides a brief listing of the species detected either through field observations or photographs of nests. No new species were detected nesting in 2013. The data indicates more species are observed at the colonies than are photographed nesting. This table also provides the species codes used in subsequent tables and graphs.

The results of monitoring have yielded valuable nesting data for the observation of species-specific nesting patterns and trends. We have chosen to break down survey results by grouping bird species according to their feeding method: diver, stalk and strike, and tactile. The Double-crested Cormorant (*Phalacrocorax auritus*) dives for its prey. Nesting survey results show the Double-crested Cormorant is the most prominent bird surveyed, as its nests comprise up to 95% of all nests counted (Table Appendix A-1, Figure Appendix A-7, Figure Appendix A-8). Results show a seasonal pattern with spring and summer peaks for nesting. A reduction in nesting effort, of approximately 50% from peak effort, is seen from October through February (Figure Appendix A-2, Table Appendix A-2). Double-crested Cormorants nest year-round in Biscayne National Park.

Stalk and strike type feeders such as the Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), and Great White Heron (*Ardea herodias occidentalis*) all have similar nesting seasons (Figure Appendix A-3 and 4, Table Appendix A-2). The population of these charismatic birds makes up only a small fraction, when compared to cormorants, of the overall colonial nesting bird populations in Biscayne National Park. Tactile feeders include the Roseate Spoonbill (*Platalea ajaja*) and White Ibis (*Eudocimus albus*), which nest at different time periods. The White Ibis had the second highest quantity of nests counted in our survey.

The Mangrove Key colony Double-crested Cormorant nesting numbers have changed greatly over the four years surveyed. There has been a significant decline in cormorant nest counts from 2009 to 2013 with no nests detected in 2013, while the Ragged Key 5 colony has shown an increase over the same time. The Ragged Key 5 and Arsenicker Key colonies have consistently ranked high in peak nest counts (Figures Appendix A-9 and A-10).

West Arsenicker colony has the high species richness of observed and photographed nesting species of all the colonies (Figure Appendix A-6, Table Appendix A-3). Mangrove Key has the least.

Table Appendix A-1 shows higher species richness from observed data compared to photographed nesting data, thus indicating more species are found within the park foraging or roosting compared to species nesting. Table Appendix A-3 documents the nest counts from photographed data and bird count estimates from observed data from 2009 through 2013.

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