SOUTH FLORIDA WADING BIRD REPORT

Volume 27 Mark I. Cook and Michael Baranski, Editors March 2023

SYSTEMWIDE SUMMARY

NESTING IN SOUTH FLORIDA

An estimated 101,794 wading bird nests (excluding Cattle Egrets [CAEG], which do not rely on wetlands) were initiated in South Florida during the 2021 nesting season (December 2020 to July 2021). This is the second largest annual nesting effort observed since comprehensive systemwide surveys began in South Florida in 1996 and is comparable with reports of large nesting events from the 1940s. The 2021 nesting season is over double the 10-year average (48,328.8 nests) but falls short of the previous banner nesting season of 2018 (138,834 nests) by 37,040 nests.

While all species exhibited an increased nesting effort in 2021 relative to the 10-year annual average, one of the most notable improvements was for the tactile foraging White Ibis (WHIB). The large number of nests produced by WHIB (68,335 nests) was almost 2.5 times the 10-year average (28,200.6 nests) but only two-thirds the record 100,784 nests in 2018. WHIB are the most numerous wading bird in South Florida and accounted for 67.2% of all wading bird nests in the region in 2021. The federally threatened Wood Stork (WOST) produced 3,916 nests, which was 53% greater than the 10-year average (2,552.0 nests) and the fourth highest count since 2005, although it was only two-thirds of the count in 2018 (5,777 nests). Roseate Spoonbills (ROSP) produced 1,219 nests in South Florida, which was almost double the 10-year average (614.6 nests) and the second largest count since monitoring began in 1984 (1,262 nests in the 2020 nesting season). The sight-foraging Great Egret (GREG) produced 15,306 nests in 2021, which was 1.7 times the 10-year average (8,766.4 nests) and second only to the record nesting effort of this species in 2018 (17,960 nests).

The smaller *Egretta* heron species have exhibited consistent and steep declines in nest numbers over recent years, such that relatively few of these birds now nest in South Florida. In 2021, 2,301 Tricolored Heron (TRHE), 4,426 Snowy Egret (SNEG), and 996 Little Blue Heron (LBHE) nests were counted, representing a 104%, 55%, and 152% increase in nesting effort, respectively, relative to their decadal annual averages. While this is a welcome improvement, it remains considerably lower than the 10,000 or so pairs of each species that historically nested in South Florida. A relatively large number of Small Heron (SMHE) nests (3,254 nests) could not be identified to species this year (they were either LBHE, SNEG, or CAEG nests); therefore, the estimated counts for LBHE, SNEG, or both are considered conservative.

Wading bird nesting is not evenly distributed in South Florida (**Figure 1**). The most important region in terms of numbers of nests is the Everglades Protection Area (hereafter Everglades), which comprises the Water Conservation Areas (WCAs) and Everglades National Park (ENP) and supports 70% to 90% of all nests annually. Wading birds initiated an estimated 89,514 nests in the Everglades during 2021, 88% of all nests in South Florida. This nesting effort in the Everglades is one of the largest observed in more than 80 years and second only to the banner nesting effort of 2018 (122,571 nests). Nesting effort was approximately 2.3 times greater than the 10-year average (38,949.1 nests), and 2.4 times the number of nests produced in the 2020 season when 37,645 nests were recorded in the Everglades. The next most important nesting region is Lake Okeechobee, which typically supports approximately 10% of South Florida's nests. In the 2021 season, the lake produced an estimated 3,793 nests, a 9.8% decrease from the 10-year average (4,207.3 nests) but almost double the number of nests produced in the 2020 season (1,951 nests). The lake accounted for 3.7% of the nests in South Florida. Other regionally important nesting areas during 2021 were the Kissimmee Basin (2,350 nests) and Florida Bay (2,318 nests).

In terms of the spatial distribution of individual species in South Florida, the Everglades supported most of the nesting WHIB, GREG, WOST, SNEG, and LBHE (94%, 86%, 67%, 66%, and 79**%** of their total nests, respectively) but only 29% of TRHE nests. Florida Bay supported most of the nesting TRHE (48%). Lake Okeechobee was a relatively important nesting area for SNEG (23% of nests).

A nesting area that has experienced substantially reduced nesting activity in recent years is Audubon Florida's Corkscrew Swamp Sanctuary. This historically important nesting area, which supported up to 7,000 WOST nests per year in the 1960s and often more than 1,000 nests per year in the early 2000s, has failed to support nesting during 6 of the past 10 years and the last notable nesting event was 2009 (1,120 nests). While WOST did nest at Corkscrew Swamp Sanctuary in 2021, the number of nests was small (18 nests) given the historical nesting effort and the nesting effort recorded elsewhere in South Florida in 2021.

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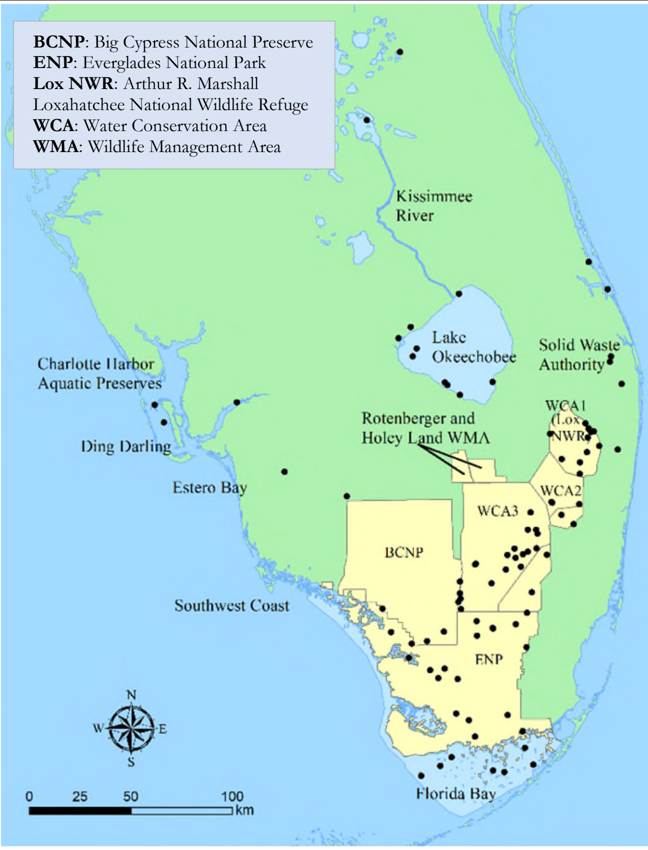

Figure 1. Locations of wading bird colonies with 50 or more nests in South Florida, 2021.

It is likely that loss of critical WOST foraging habitat in southwestern Florida and reduced hydroperiods in the sanctuary are responsible for the decline (Clem and Duever 2019).

NESTING IN THE EVERGLADES

A primary goal of the Comprehensive Everglades Restoration Plan (CERP) and other restoration programs in South Florida is the return of healthy populations of breeding wading birds to the Everglades. CERP predicts that restoration of historical hydropatterns will result in the return of large and sustainable breeding wading bird populations, reset the historical timing of nesting, and encourage birds to nest again in the coastal region of ENP (Frederick et al. 2009). There are two sets of performance measures aimed at assessing these responses based on historical ecological conditions and the hydrology-prey-foraging relationships that govern wading bird reproduction in South Florida. CERP's performance measures (https://www.evergladesrestoration.gov/comprehensive-everglades-restoration-plan) include the 3-year running average of the numbers of nesting pairs of key wading bird species, the timing of WOST nesting, and the proportion of the population that nest in the coastal ecotone (Ogden et al. 1997). In addition, the annual Stoplight Reports have added two other measures: (https://www.evergladesrestoration.gov/progress-report-1) 1) the ratio of visual to tactile foraging wading bird species breeding in the Everglades, and 2) the frequency of exceptionally large WHIB breeding events (Frederick et al. 2009).

Nest Numbers

Annual nesting effort is assessed using the average nest count from three successive nesting seasons to account for large, natural fluctuations in annual nesting effort. The primary indicator species are GREG, WHIB, WOST, and SNEG (Ogden et al. 1997) for mainland Everglades and ROSP for Florida Bay. TRHE originally was included among the mainland species but has proven difficult to monitor during aerial surveys due to its cryptic plumage and tendency to nest below the tree canopy. GREG, WHIB, WOST, and SNEG all exhibited greatly improved nesting effort in the Everglades during 2021 (**Figure 2**), but only GREG, WHIB, and WOST met their CERP numeric restoration targets based on the 3-year running average (**Table 1**). In terms of long-term trends, GREG and WHIB have exceeded target counts every year since 1996 and 2000, respectively, while WOST have exceeded their target 12 times since 2000, including 2021. SNEG and TRHE have been consistently below target since 1986 (**Table 1**).

The regional declines of *Egretta* herons over the last decade have been particularly acute in the Everglades (**Figure 2**). This year's nesting effort continues a moderate improvement compared to previous years but remains considerably lower than historic numbers (approximately 10,000 nests per year per species). The number of SNEG nests in 2021 (2,933 nests) was 2.2 times the 10-year average, and an order of magnitude more nests than in 2017 (228 nests), which was the lowest recorded since 1990. TRHE produced 617 nests, a moderate improvement on the decadal average (132.6 nests) and almost 18 times the number in 2017 (35 nests). The cause of the declines in *Egretta* nesting has yet to be determined, but the improved nesting in both 2018 and 2021 suggest hydrologically driven food limitation is at least partially responsible.

In Florida Bay, ROSP produced 246 nests, slightly below the 10-year average (294.3 nests) and only 20% of the target 1,258 nests per year. From a historical perspective, this is only 45% of the 34-year mean (445.8 nests) and far below the mid-20th century nesting effort when more than 1,000 nests per year occurred (J. Lorenz, personal communication). In the WCAs and mainland ENP, ROSP continued a recent trend of increasing nesting effort (809 nests in 2021). This nesting effort is second only to the record nesting season of 2020 when 986 nests were recorded, and it is more than twice the 10-year average (322.7 nests).

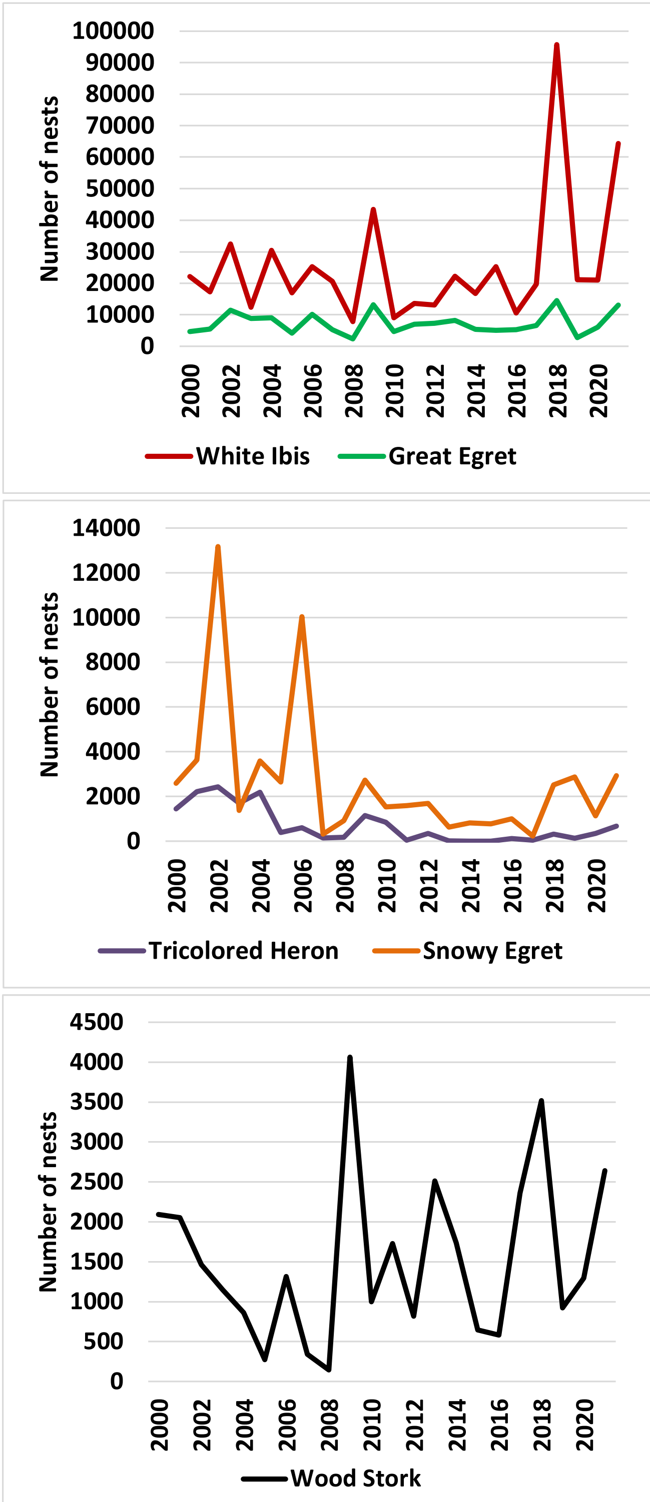

Figure 2. Wading bird nest numbers in the Everglades Protection Area (water conservation areas and Everglades National Park) for individual species from 2000 to 2021.

Table 1. Three-year running averages of numbers of nesting pairs of Great Egrets (GREG), Snowy Egrets (SNEG), White Ibises (WHIB), and Wood Storks (WOST) in the mainland Everglades (water conservation areas and Everglades National Park, not including Florida Bay). Bolded years are those in which the numbers of nesting pairs met the restoration criteria. (Data are provided by S.K. Morgan Ernest).

Period	GREG	SNEG	WHIB	WOST
1986-1988	1,946	1,089	2,974	175
1987-1989	1,980	810	2,676	255
1988-1990	1,640	679	3,433	276
1989-1991	1,163	521	3,066	276
1990-1992	2,112	1,124	8,020	294
1991-1993	2,924	1,391	6,162	250
1992-1994	3,667	1,233	6,511	277
1993-1995	3,843	658	2,107	130
1994-1996	**4,043**	570	2,172	343
1995-1997	**4,302**	544	2,850	283
1996-1998	**4,017**	435	2,270	228
1997-1999	**5,084**	616	5,100	279
1998-2000	**5,544**	1,354	**11,270**	863
1999-2001	**5,996**	2,483	**1,655**	**1,538**
2000-2002	**7,276**	6,455	**23,983**	**1,868**
2001-2003	**8,460**	6,131	**20,758**	**1,596**
2002-2004	**9,656**	6,118	**24,947**	1,191
2003-2005	**7,829**	2,618	**20,993**	742
2004-2006	**8,296**	5,423	**24,926**	800
2005-2007	**6,600**	4,344	**21,133**	633
2006-2008	**5,869**	3,767	**17,541**	552
2007-2009	**6,956**	1,330	**23,953**	**1,468**
2008-2010	**6,715**	1,723	**21,415**	**1,736**
2009-2011	**8,270**	1,947	**22,020**	**2,263**
2010-2012	**6,296**	1,599	**11,889**	1,182
2011-2013	**7,490**	1,299	**16,282**	**1,686**
2012-2014	**7,041**	1,017	**17,194**	**1,696**
2013-2015	**6,300**	710	**21,272**	**1,639**
2014-2016	**5,328**	837	**17,379**	995
2015-2017	**5,656**	639	**17,975**	1,196
2016-2018	**8,803**	1,224	**41,465**	**2,152**
2017-2019	**7,966**	1,840	**44,967**	**2,282**
2018-2020	**7,806**	2,191	**46,347**	**1,911**
2019-2021	**7,335**	2,328	**35,902**	**1,618**
Target Minima	4,000	10 - 20k	10 - 25k	1.5 - 2.5k

Spatial Distribution of Nests

The coastal region of ENP historically supported approximately 90% of all nesting wading birds in the Everglades, probably because it was the most productive region of the Everglades ecosystem. During the past 80 years, productivity has declined due to reduced freshwater flows to the coast and nearby marshes, and the location of nesting has shifted to inland colonies in the WCAs or elsewhere in the southeastern United States. An important goal of CERP is to restore the hydrologic conditions that will re-establish prey availability across the southern Everglades landscape, which, in turn, will support the return of large successful wading bird colonies to traditional estuarine rookeries. In 2021, ENP supported 39.4% of nests, while WCA-3A and WCA-1 supported 45.6% and 15.0%, respectively. The proportion of nests in the coastal region in 2021 (34%) was one of the highest recorded in recent decades and continues a trend of increased nesting in this area compared to the lows of the 1990s and early 2000s (2% to 10%). While this proportion remains short of the 50% restoration target, the magnitude of nesting (approximately 29,918 nests) was considerably higher than it has been in recent years (18-year average: 6,827 nests). This suggests that the coastal ecotone and adjacent marl prairies retain the capacity to support very large numbers of nesting birds when hydrologic conditions are suitable.

The locations of ROSP nesting colonies within Florida Bay have shifted in recent years. Most nesting historically occurred on small keys within the bay itself; however, during the past decade many birds have moved to mainland colonies adjacent to the Florida Bay coast (e.g., Madeira Hammock and Paurotis Pond colonies supported 150 nests during 2016, 41% of all nests in the region). However, this year, far fewer pairs nested at these two mainland colonies (2 nests) and the remainder nested on small keys within the bay (244 nests). Other individuals have deserted Florida Bay entirely. ROSP started nesting in the freshwater Everglades in the early 2000s in very small numbers (fewer than 50 pairs). From 2010 to 2019, an average of 220 ROSP pairs nested at colonies in northern WCA-3A and along the Gulf coast of ENP. This nesting effort increased considerably in the 2020 season, with 986 nests found in Everglades inland colonies, and the nesting effort was similar in the 2021 season (809 nests).

Timing of Nesting

WOST nesting success is highly dependent on the availability of aquatic prey (fish), which are easy to find and feed upon when concentrated at high densities in shallow water during the dry season (winter-spring) but are not available in the wet season (summer-fall) when they move into deeper waters and disperse across the landscape. To successfully fledge their young, WOST require a continuous supply of abundant and concentrated fish throughout the reproductive period. WOST have a relatively long reproductive period (approximately 4 months), so it is critical they start nesting early in the dry season to ensure nestlings have time to fledge and gain independence prior to the onset of the rainy season when fish availability declines. WOST nesting historically started in November or December; however, since the 1970s, the initiation of nesting gradually shifted to January to March (Ogden 1994). This delay is often associated with reduced nesting success (Frederick et al. 2009) and is thought to occur because of a reduction in the amount and quality of the high-elevation (short-hydroperiod) wetlands that provide foraging habitat early in the nesting season. In 2021, WOST nesting started moderately early, with a possible first lay date sometime between mid- to late-January (just outside the CERP November/December target time frame). While this is a little later than the late December/early January start dates of 2017 and 2018, it is considerably earlier than 2016 (late March) and 2015 (early February). The likely reason for this relatively early nesting is the extended flooding of the high-elevation inland and coastal marshes that occurred in late 2020 and supported large numbers of foraging WOST at this time. It should be noted that nesting was highly asynchronous in 2021; although some individuals nested relatively early, many other individuals did not start nesting until February and March.

ROSP in Florida Bay also have exhibited a recent shift towards later nesting. For more than 70 years (1936 to 2009), ROSP nest initiations in the northeast region of the bay consistently fell between October 1 and December 31. However, as of 2010, nesting began to start increasingly later in the season; from 2010 to 2014, nesting started between January 1 and 10; in 2015, it began on January 24; and in 2016, it began on February 5, the latest start date ever recorded. Moreover, the timing of laying appeared to be getting considerably more asynchronous both within and among colonies. While nest initiations within the bay historically would span a few weeks, lay dates during the past 2 years have extended from January through April. These changes in the phenology and synchrony of nesting might suggest that the timing of optimal foraging conditions for ROSP is changing both temporally and spatially within Florida Bay. However, 2017 and 2018 were notable for a complete reversal of this trend, with most nest initiations starting in November/December. In 2019 and 2020, nest initiations in the northeast region of the bay were relatively late again, with the first eggs laid in early January and laying continuing through March. In 2021, there was a slight improvement in the timing with the first eggs laid in early December and most laying occurring in December or early January. The reasons for these patterns are not entirely clear, but they are increasingly likely related to changes in where and when optimal foraging conditions become available, probably because of sea level rise (see *Roseate Spoonbill Nesting in Florida Bay* section).

Nesting Success

Nest success of CERP indicator species in the Everglades is often low and highly variable in time and space, with average probabilities of fledging at least one offspring ranging between 35% and 49% for the four indicator species (derived from 2010 to 2015 data). During 2021, the University of Florida monitored nest success (P; probability of fledging at least one nestling, Mayfield method) at 647 nests in 8 colonies. Nest success was relatively high and similar among the CERP indicator species: GREG (P=0.580; standard deviation [SD]=0.035), WHIB (P= 0.625; SD=0.030), WOST (P=0.706; SD=0.050), and ROSP (P=0.877; SD=0.067). These results are supported by observations from weekly South Florida Water Management District surveys of nesting colonies, which noted a large proportion of nests of all species produced fledglings. This high productivity was likely because hydrological conditions were generally optimum for foraging for much of the nesting season. Moreover, the duration of foraging was extended because of the relatively late start to the wet season (mid-June 2021). This was particularly important for providing late nesting WOST additional time to fledge their young before the onset of the rains. Of note was the high productivity of WHIB, with provisional estimates of at least 30,000 fledglings from just 2 colonies in the Everglades (see *Water Conservation Areas 2 and 3, and A.R.M. Loxahatchee National Wildlife Refuge* section).


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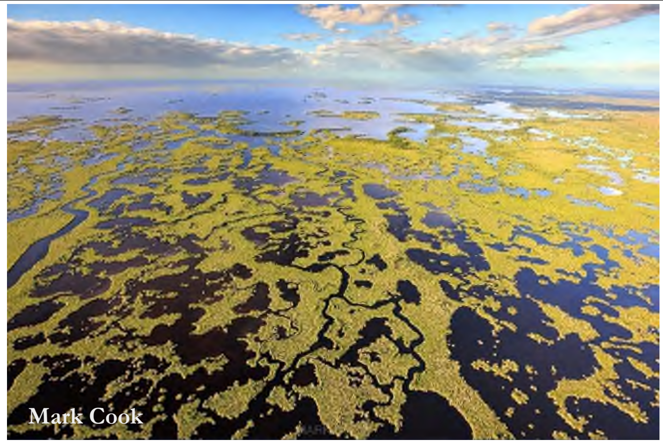
Role of Hydrology and Food Availability on Nesting Patterns

The most important process affecting wading bird nesting in the Everglades is the availability of prey (fishes and aquatic invertebrates). Prey availability is a function of prey production (the amount and size of prey animals) and vulnerability to capture by birds, with both components strongly affected by hydrologic conditions (Frederick and Ogden 2001, Herring et al. 2011). In a hydrologically fluctuating wetland such as the Everglades, prey production is influenced largely by the duration and frequency of wetland flooding and drying, with optimal conditions for population growth varying by species. Most fish populations peak after extended periods (multiple years) of relatively deep, flooded conditions over extensive areas of wetland (Trexler et al. 2005), while some invertebrate populations grow best during moderate hydroperiods punctuated by periodic dry conditions (Dorn and Cook 2015).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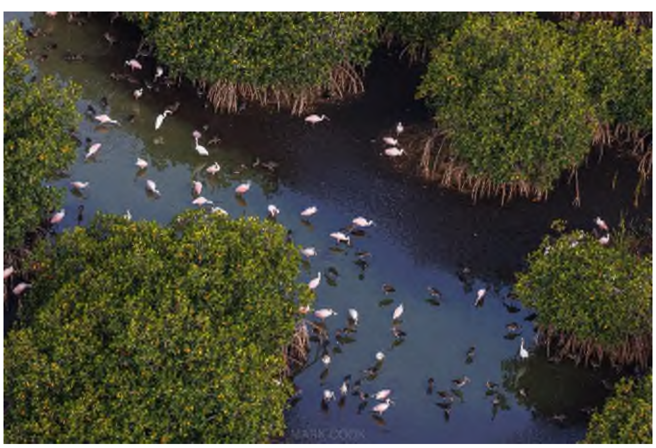
A particularly important prey group in the Everglades are the crayfish, which are critical for fueling WHIB nesting colonies (Boyle et al. 2014). Crayfish populations are strongly limited by predatory sunfishes such as warmouth that eat the small (young-of-the-year) juveniles. Once crayfish grow beyond a certain size threshold, they are less sensitive to this fish predation. During periodic dry conditions, predatory fish populations decline, but crayfish can survive in their burrows until the rains return and water levels rise again during the wet season. At this point, adult crayfish emerge and release their young into a marsh habitat that is largely free of fish predators, allowing for a temporary (1 to 2 years) boost in crayfish populations (Dorn and Cook 2015).

Prey vulnerability to capture is determined largely by water depth and whether the water level is rising or falling. Prey become easiest to capture during drying conditions when water levels decline to depths at which birds can forage effectively (5 to 40 cm) and the areal coverage of water shrinks such that prey become concentrated at relatively high densities (Gawlik 2002, Cook et al. 2014). Conversely, prey vulnerability declines when water levels rise and the concentrated prey can disperse across the marsh. Prey availability, therefore, is naturally variable among years depending on antecedent and current water conditions. Accordingly, wading bird nesting effort and success fluctuate considerably from year to year.

The considerable improvements in nesting responses during 2021 were the result of a series of highly favorable hydrologic conditions that were near optimal for prey availability both prior to and during the nesting season (see *Hydrologic Patterns for Water Year 2021* section). This year's nesting season was preceded first by relatively dry conditions (April to May 2020) over relatively large areas of the ecosystem. This can lead to a reduction in predatory sunfish populations and a boost in juvenile crayfish survival. The dry conditions were then followed by a wet season (June to November 2020) with record-breaking rainfall driven primarily by Tropical Storm Eta in November 2020. This led to long periods of relatively wet conditions with water levels that remained above ground across large areas of the Everglades for extended periods. This was expected to boost prey (fish and crayfish) production over large areas of the ecosystem and may have been particularly relevant in the short hydroperiod marshes of the Western Marl Prairies in ENP and southern Big Cypress Basin, foraging areas that historically may have been very important but today are overdrained and generally too dry for optimal small fish and crayfish production. This year's extended hydroperiods in this area were likely comparable to historic conditions: not long enough to boost predatory fish populations but optimal for production of the Everglades crayfish (*Procambaris alleni*), the primary prey species that triggers and supports irruptive WHIB nesting events in the coastal colonies (Cocoves et al. 2021). Following the wet 2020 summer and fall, the 2020–2021 winter–spring breeding season was drier than average. This led to a relatively continuous drop in water level across the Everglades landscape and produced water levels and recession rates that were ideal for promoting wading bird prey vulnerability and foraging across large areas of the Everglades. As the landscape dried, optimal foraging habitats moved slowly and continuously downstream such that their location and quality were predictable from November until very late in the dry season. The formation of this year's huge WHIB colonies in the marsh–mangrove ecotone and northern WCA-3A (approximately 22,000 and 20,000 WHIB nests, respectively), leading to one of the largest nesting events in the Everglades since the 1940s, was likely a result of the deep water conditions early in the breeding season and subsequent consistent drydown providing optimal foraging depths at the right time and place (near the colonies) throughout the nesting period (see *Hydrologic Patterns for Water Year 2021* section). This idea was strongly supported from weekly aerial surveys when exceptionally large numbers of foraging birds were observed across the Everglades landscape, especially in the prairie habitats of WCA-3A and western ENP (M. Cook, personal observation).

Water management played a particularly important role during the 2021 nesting season by maintaining appropriate hydrologic conditions around the large Alley North colony. This area of northern WCA-3A often dries out early in the nesting season, which can reduce the colony's attractiveness to nesting birds, allow mammalian predators (i.e., raccoons) to access the colony, and cause large-scale nest abandonment. The construction of an earthen plug in the adjacent L-38 canal helped to maintain higher marsh stages in northeastern WCA-3A throughout the nesting season and ensured hydrological conditions remained optimal for nesting.



The generally wetter hydrologic conditions and foraging observations of 2021 were comparable to those during the banner nesting season of 2018 when the Everglades supported 122,571 wading bird nests. The primary difference between the two years was that high water levels in southern WCA-3A persisted for longer in 2021 than in 2018 such that the timing of optimal foraging conditions in this region in 2021 was delayed by about two months and likely resulted in the reduced and late start to nesting. Despite the deeper conditions in 2021, a fortuitous late start to the wet season extended the duration of foraging conditions by over a month until late June 2021. This provided sufficient time for many of the late nesting birds to successfully fledge their young, thereby significantly boosting overall productivity, especially for WOST. Moreover, the annual survival of fledgling birds is strongly correlated with the quality of foraging conditions in the Everglades in the weeks immediately after fledging (Borkhataria et al. 2012); the exceptional foraging conditions available to fledgling birds in the spring of 2021 allowed for one of the most productive nesting seasons since the 1930s and probably provided a significant boost to wading bird breeding populations.

The nesting responses of 2021 and 2018 reveal that the Everglades ecosystem is resilient and retains the capacity to support exceptionally large populations of nesting wading birds given the appropriate hydrology. An expected outcome of CERP and other restoration programs is to extend the period of flooding in high-elevation marshes and repeat such nesting patterns on a more regular basis.

Long-Term Trends

To understand the status of wading bird populations and how they are responding to climatic conditions, water management, and restoration efforts, it is important to look beyond the annual fluctuations in nesting responses and instead consider longer-term (decadal and longer) trends in nesting responses. Long-term data reveal that several nesting responses have improved over the past 20 years, while others have shown no change or are getting worse. In short, numbers of WHIB, WOST, and GREG nests have increased over the past 20 years and appear to frequently meet restoration targets (**Table 1**). Moreover, the interval between exceptional WHIB nesting seasons has met the restoration target (<2.5 years) for 12 of the past 13 years. There have been some recent improvements in the number of birds nesting at historical coastal colonies, but the proportion remains below the 50% restoration target (25%). Several measures are not improving and are cause for concern. Despite slight improvements in recent years, the numbers of SNEG, TRHE, and LBHE have been sharply declining (**Figure 2**), and the causes of the declines are unknown. Also, despite improved WOST nesting effort, the late timing of their nesting (with the exception of a few recent years) has remained relatively static, and their nesting success often is below that necessary to sustain the regional population. The ratio of tactile (WOST, WHIB, and ROSP) to visual (herons and egrets) foragers has improved since the mid-2000s but remains an order of magnitude below the restoration target. For more information on Everglades restoration performance measures, see the *Status of Wading Bird Recovery* section at the end of this report.

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Abbreviations

Bird Species: American Flamingo (AMFL, *Phoenicopterus ruber*), Anhinga (ANHI, *Anhinga anhinga*), Bald Eagle (BAEA, *Haliaeetus leucocephalus*), Black-crowned Night Heron (BCNH, *Nycticorax nycticorax*), Brown Pelican (BRPE, *Pelecanus occidentalis*), Cattle Egret (CAEG, *Bubulcus ibis*), Double-crested Cormorant (DCCO, *Phalacrocorax auritus*), Glossy Ibis (GLIB, *Plegadis falcinellus*), Great Blue Heron (GBHE, *Ardea herodias*), Great Egret (GREG, *Ardea alba*), Great White Heron (GWHE, *Ardea herodias occidentalis*), Green Heron (GRHE, *Butorides virescens*), Least Bittern (LEBI, *Ixobrychus exilis*), Little Blue Heron (LBHE, *Egretta caerulea*), Neotropic Cormorant (NECO, *Phalacrocorax brasilianus*), Osprey (OSPR, *Pandion haliaetus*), Reddish Egret (REEG, *Egretta rufescens*), Roseate Spoonbill (ROSP, *Platalea ajaja*), Snowy Egret (SNEG, *Egretta thula*), Tricolored Heron (TRHE, *Egretta tricolor*), White Ibis (WHIB, *Eudocimus albus*), Wood Stork (WOST, *Mycteria americana*), Yellow-crowned Night Heron (YCNH, *Nyctanassa violacea*), Unidentified Small White Herons (SMWH, either Snowy Egret or juvenile Little Blue Heron), Unidentified Small Dark Herons (SMDH, either Little Blue Heron or Tricolored Heron), Small Heron (SMHE)

Regions, Agencies, and Miscellaneous: Arthur R. Marshall (A.R.M.), chicks per nest (c/n), Charlotte Harbor Aquatic Preserves (CHAP), Comprehensive Everglades Restoration Plan (CERP), Corkscrew Regional Ecosystem Watershed (CREW), Corkscrew Swamp Sanctuary (CSS), Estero Bay Aquatic Preserve (EBAP), Everglades National Park (ENP), Florida Department of Environmental Protection (FDEP), Florida Fish and Wildlife Conservation Commission (FWC), National Geodetic Vertical Datum of 1929 (NGVD29), National Wildlife Refuge (NWR), North American Datum of 1983 (NAD83), prey concentration threshold (PCT), Restoration Coordination and Verification (RECOVER), South Florida Water Management District (SFWMD), standard deviation (SD), unmanned aerial vehicle (UAV), Water Conservation Area (WCA), Water Year (WY)


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HYDROLOGIC PATTERNS FOR WATER YEAR 2021

WATER CONSERVATION AREAS AND NORTHEAST SHARK RIVER SLOUGH HYDROLOGY

Annual rainfall totals in the Everglades during Water Year 2021 (WY2021; June 2020 through May 2021) were above long-term average historical conditions. Rainfall for the year was approximately 11.6 inches (22%) above historical averages in Water Conservation Areas (WCAs) 1 and 2, 12.0 inches (21%) above average in WCA-3, and 7.4 inches (13.5%) above average in Everglades National Park (ENP). Accordingly, above average annual rainfall totals led to above average stages across the Everglades. Annual average stage was 1.0 foot above average in WCA-1, 0.2 feet above historical average in WCA-2, 0.8 feet above historical average in WCA-3, and 0.9 feet above average in ENP (**Table 2**).

Figures 3A to **3G** show stage data in the Everglades (WCAs and ENP) during the last 2.5 years relative to historical average stages and ground elevation (in feet National Geodetic Vertical Datum of 1929 [NGVD29]), and also the water level recession rates and depths that support foraging and nesting needs of wading birds. The suitability of wading bird foraging habitat is determined by a combination of water depths and recession rates and is divided into three categories (poor, moderate, and good) based on foraging requirements of wading birds in the Everglades (Beerens et al. 2011, 2015; Cook et al. 2014). A green arrow on the hydropattern figures indicates a period of good recession rates and depths for wading birds. A yellow arrow indicates water levels that are too shallow or too deep and/or recession rates that are slightly too rapid or too slow. A red arrow indicates poor conditions resulting from unsuitable depths (too high or low) and/or recession rates (rising or falling too rapidly). These figures correspond to foraging conditions at a specific gauge but do not represent conditions at the landscape scale. For a spatially explicit representation of the suitability of foraging habitat as water levels change throughout the nesting season, see **Figures 4A** to **4I**. These habitat suitability index maps represent the suitability of water depths across the Everglades landscape on the first day of each month from October through June. Water depths are categorized by color to represent conditions that are optimal (green), too dry (brown), or too wet (blue) for wading bird foraging based on the same criteria as above (i.e., Beerens et al. 2011, 2015; Cook et al. 2014), and are calculated at a 400-meter by 400-meter scale using the Everglades Depth Estimation network (https://sofia.usgs.gov/eden/wadingbirds/index.php). The maps reveal how foraging conditions change across the landscape through the nesting season as the ecosystem slowly dries during the WY2021 dry season and then rewets at the beginning of the WY2022 wet season.

Water depths in the Everglades at the beginning of the WY2021 were generally below average historic stages (with the exception of WCA-1) and in many areas were well below the soil surface when the wet season began on May 15, 2020. Thereafter, higher than average early summer rainfall led to rapid increases in water levels that climbed to or exceeded the long-term average stages through October, which is typically the peak of the wet season. On November 8, 2020, Tropical Storm Eta delivered torrential rain to South Florida dropping up to 20.7 inches on the Everglades area (Pasch et al. 2021). In November, the Everglades received between 350% and 550% of the monthly average rainfall by basin. This unusual precipitation pattern and the resulting high stages rehydrated many areas of the Everglades which are typically overdrained (e.g., the Western Marl Prairies and Big Cypress Basin) and extended hydroperiods closer to those of pre-drainage conditions. These extended hydroperiods resulted in improved fish and crayfish productivity across extensive areas of the Everglades. Rainfall remained above average from November 2020 until February 2021 but fell below average thereafter for the remainder of the dry season (until mid-June 2021). This resulted in higher-than-average stages through May but allowed water levels to recede in most basins at a rate close to the ecologically recommended rate of 0.05 to 0.12 feet per week at most gauge locations from mid-November to mid-June. This consistent drydown throughout the dry season coupled with initially deeper depths provided excellent foraging habitat at the right time and place for wading birds throughout the entirety of the nesting season (from pre-breeding to post-fledging) and ultimately led to one of the most successful nesting seasons on record. A similar hydropattern was evident in WY2018 and was also notable for its record-breaking wading bird nesting season.

Table 2. Average, minimum, and maximum stage (in feet NGVD29) and total annual rainfall in inches for WY2021 in comparison to historic stage and rainfall.[a] (Average depths calculated by subtracting elevation from stage.)

Area	Rainfall (inches)		Mean (Minimum; Maximum) Stage (feet NGVD29)		Elevation (feet NGVD29)
	WY2021	Historic / Period	WY2021	Historic / Period	
WCA-1	63.59	51.99 / WY1958–WY2020	16.81 (15.62; 17.82)	15.76 (10.00; 18.16) / 1960–2020	15.1
WCA-2	63.59	51.99 / WY1958–WY2020	12.69 (10.61; 15.25)	12.51 (9.33; 15.64) / 1961–2020	11.2
WCA-3	63.42	51.38 / WY1958–WY2020	10.45 (0.00; 12.80)	9.62 (4.78; 12.79) / 1962–2020	8.2
ENP Slough at P33	62.51	55.09 / WY1958–WY2020	6.91 (4.74; 7.96)	6.06 (2.01; 8.08) / 1954–2020	5.4

[a] Historical averages are based upon varying lengths of records at gauges.

Water Conservation Area 1

Water levels in WCA-1 (part of the Arthur R. Marshall Loxahatchee National Wildlife Refuge) at the start of WY2021 were comparable to the 26-year daily average (**Figure 3**). Wet season depths rose rapidly, responding to early and above average wet season precipitation, and from July rose quickly and continuously through the wet season. At the start of the dry season, from November 2020 to January 2021, WCA-1 received more than double the average amount of rainfall due to very active tropical weather. Stages peaked in late September 2020 and did not begin a sustained drawdown until mid-December. Stages remained well above average during most of the remainder of the water year but finished close to the long-term average (**Figure 3**). These above average depth conditions during the entire wet season were conducive to prey production. Good foraging conditions began in late February and early March in the northern portion of WCA-1 and continued as the drying front progressed south for the remainder of the wading bird nesting season (**Figures 4E to 4I**).

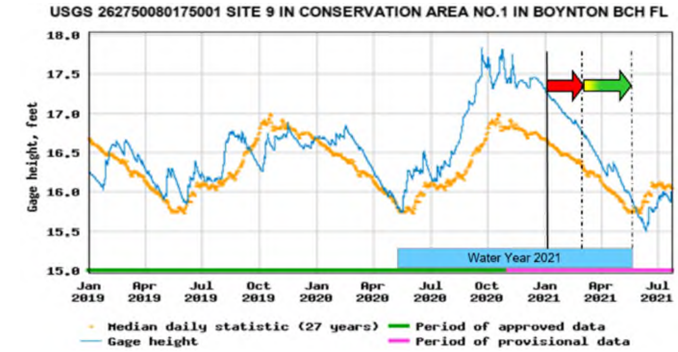
Water Conservation Area 2A

Stages in WCA-2A at the start of the WY2021 wet season (June 2020) began almost 1 foot below average (**Figure 3**) but ascended and quickly recovered such that stages generally followed the long-term average until November. Water depths then peaked in mid-November at nearly 2 feet above the average peak depth. Stages fell rapidly starting in December 2020, which subsequently created optimal depths early in the nesting season (February) for wading bird foraging (**Figures 3** and **4E**). Stages continued to drop providing optimal wading bird foraging conditions into May (**Figures 4F** to **4I**). Thereafter, conditions remained relatively dry and provided limited foraging conditions until the end of the wading bird nesting season.

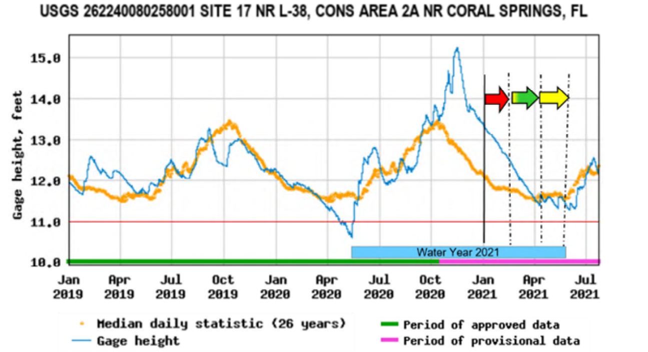
Water Conservation Area 2B

Unlike the rest of the Everglades, WCA-2B tends to be too deep for foraging most of the year (**Figure 3**). During WY2021, water depths at gauge 99 started well below average but rose quickly and then generally remained close to the historical average until late October. Stages then rose quickly and peaked in mid-November at more than 1 foot above the historical average. While some foraging opportunity was available for wading birds, few birds were observed in this sub-basin throughout the wading bird nesting season even when conditions became fair, perhaps due to better foraging in nearby regions.

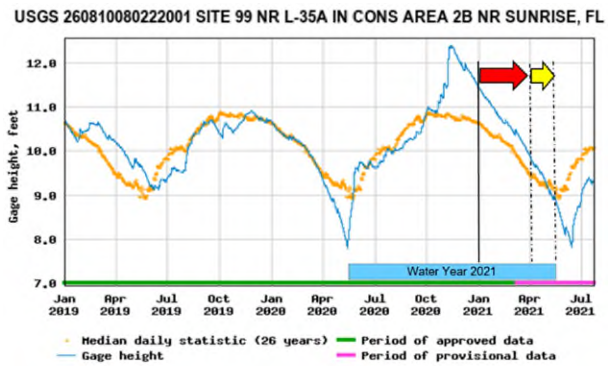
A. WCA-1 – Site 9



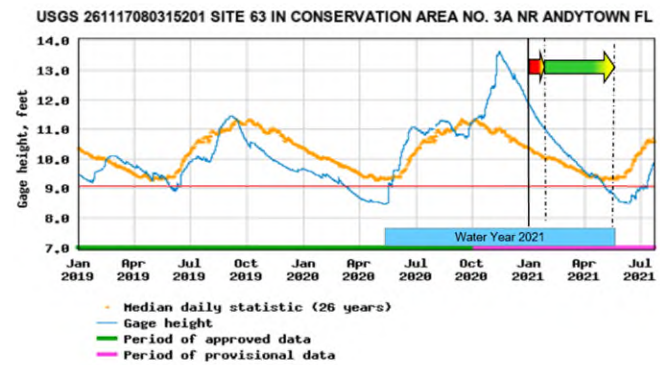
B. WCA-2A – Site 17



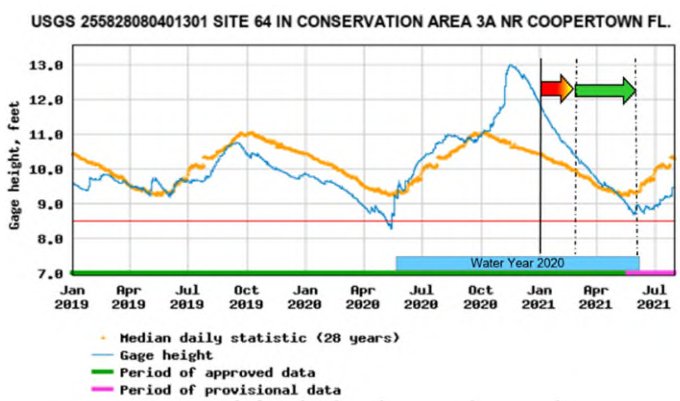
C. WCA-2B – Site 99



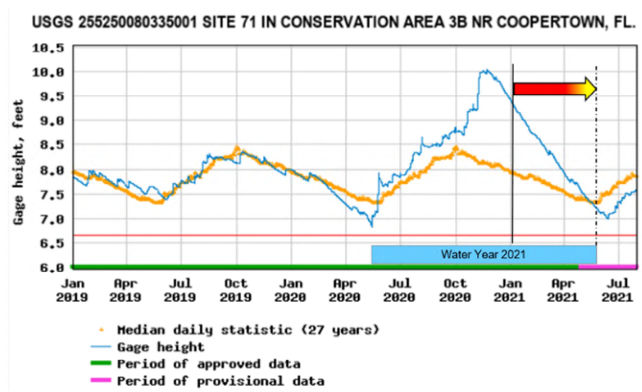
D. WCA-3A – Site 63



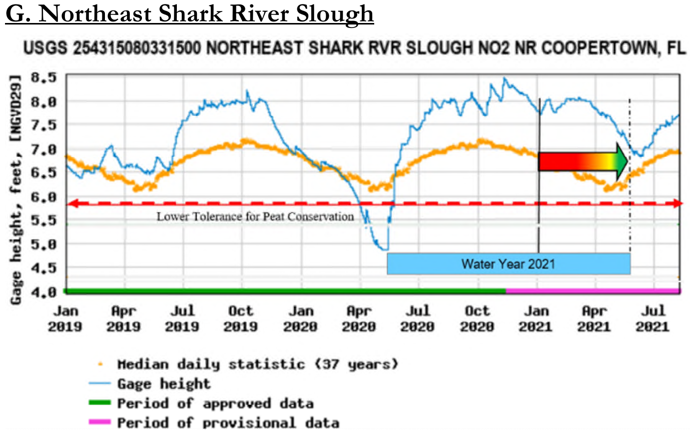
E. WCA-3A – Site 64



F. WCA-3B – Site 71



G. Northeast Shark River Slough



Median daily statistic by region:
A. WCA-1 Site 9 (27 years)
B. WCA-2A Site 17 (26 years)
C. WCA-2B Site 99 (26 years)
D. WCA-3A Site 63 (26 years)
E. WCA-3A Site 64 (28 years)
F. WCA-3B Site 71 (27 years)
G. Northeast Shark River Slough (37 years)

Good recession and depth

Fair recession or depth

Poor recession or depth

Figure 3. Hydrology in the WCAs and ENP in relation to average water depths (A: 27-year average, B: 26-year average, C: 26-year average, D: 26-year average, E: 28-year average, F: 27-year average, G: 37-year average) and indices for wading bird foraging.

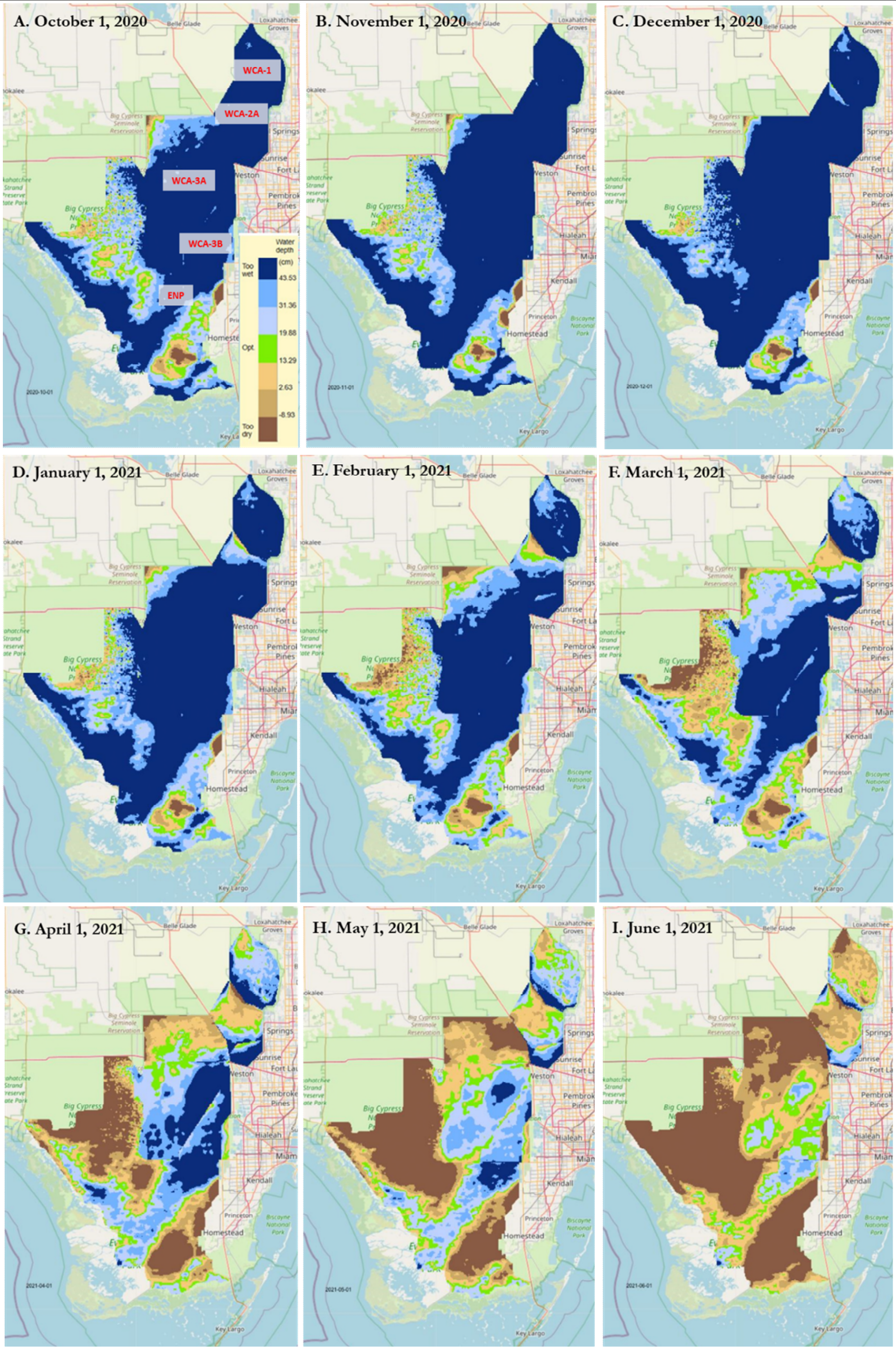


Figure 4. Habitat suitability index maps representing the suitability of water depths for wading bird foraging across the Greater Everglades landscape on the first day of each month from October 2020 through June 2021. Water depths are categorized to represent conditions that are optimal (green), too dry (shades of brown), or too wet (shades of blue) for foraging and are calculated at a 400-meter by 400-meter scale using the Everglades Depth Estimation network.

Water Conservation Area 3A

At the start of WY2021, northern WCA-3A (the region north of I-75) was relatively dry, with below average depths at gage 63 (**Figure 3**). Stages then rose quickly until July, plateued until the end of October, and then rose again and peaked in mid-November. Thereafter, stages fell continuously with no reversals through June (green arrow **Figure 3**). These conditions set the stage for excellent foraging and nesting conditions in this region. At the start of the dry season (October 2020), levels were too deep in northern WCA-3A for wading bird foraging (dark blue areas in **Figures 4A** to **4C**) but reached suboptimal and optimal foraging depths by early January and lasted through to early May (green and pale-blue areas in **Figures 4D** to **4H)**. This was confirmed from observations of extremely large foraging flocks of wading birds in northern WCA-3A from January to May. The relatively deep conditions in this region in WY2021 allowed for large-scale nesting (over 30,000 nests) at the Alley N colony in 2021.

The hydrologic pattern in central WCA-3A at gauge 64 (**Figure 3**) was similar to that at gauge 63; depths were below the long-term average at the start of WY2021 (October 2020), rose and peaked well above average by mid-November, and then fell steadily through the dry season until mid-June 2021. The relatively deep antecedent conditions set the stage for increased prey productivity, but stages remained too deep for optimal foraging until April (**Figures 4A** to **4G**). While this allowed for very large numbers of foraging wading birds during the later half of the nesting season, the delayed foraging was likely responsible for the relatively late, albeit successful, nesting in this area in 2021.

Water Conservation Area 3B

Water levels at site 71 in WCA-3B began WY2021 below the historic median (**Figure 3**). Stages climbed quickly above the median then followed just above it, peaking well above the median in mid-November. For most of the wading bird nesting season, depths were too deep for wading bird foraging (**Figures 4A** to **4H**), and relatively few birds utilized this area for foraging in WY2021.

Northeast Shark River Slough

At the beginning of WY2021, water levels in Northeast Shark River Slough were well below the historic average (**Figure 3**). Water levels rose quickly and reached median depths by late May. Levels continued to climb and peaked in mid-November well above the 37-year median at a stage above 8.0 feet NGVD29; this is the fifth year in a row and only the fifth time in the last 20 years that stage at this location has exceeded this depth. Depths remained above the historic average for the remainder of the water year. The multicolored arrow in **Figure 3** denotes conditions that were initially too deep and transitioned to fair and then good near the end of the water year as levels fell within the upper range of depths that are suitable for foraging. Relatively deep conditions in the northern reaches of Shark River Slough kept foraging to the fringes of the slough; however, excellent foraging conditions prevailed throughout the season and attracted large numbers of foraging birds downstream at the coastal margins, in the western marl prairies, and in the adjacent Lostmans Slough (**Figures 4E** to **4I**). Moreover, unprecedented freshwater flows to the coastal marshes of both Florida Bay and the Gulf of Mexico attracted tens of thousands of foraging birds from November through February. Near record numbers of nesting wading birds at coastal colonies within ENP were comparable to the record-breaking WY2018.

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REGIONAL NESTING REPORTS

WATER CONSERVATION AREAS 2 AND 3, AND A.R.M. LOXAHATCHEE NATIONAL WILDLIFE REFUGE

The University of Florida Wading Bird Project continued its long-term monitoring of wading bird reproduction throughout Water Conservation Areas (WCAs) 2 and 3 and Arthur R. Marshall Loxahatchee National Wildlife Refuge (A.R.M, also WCA-1) in the 2021 nesting season. Monitoring focused primarily on counts for Great Egret (GREG), White Ibis (WHIB), Snowy Egret (SNEG), and Wood Stork (WOST), the species that serve as bioindicators for the Comprehensive Everglades Restoration Plan (CERP) and are most readily located and identified through aerial searches. Estimates for these and other species were gleaned from aerial and systematic ground surveys, as well as visits to nesting colonies and more intensive studies of nest success (**Tables 3** and **4**).

METHODS

Aerial and ground surveys were performed in 2021 to locate and characterize nesting colonies. Due to the COVID-19 pandemic, systematic fixed-wing aerial flights were halted in March 2020 and did not resume during the 2021 nesting season. Without standardized and comprehensive aerial surveys via fixed-wing aircraft, it is important to highlight that the reported overall numbers of nest starts for 2021 should be interpreted as minimums rather than maximums. The location of active colonies and individual colony nest starts were derived from a combination of information sources, including peak estimates of nests in any colony via supplemental information from weekly South Florida Water Management District helicopter surveys, ground visits via airboat, unmanned aerial vehicle (UAV) flights, and inference from observations across the season.

In 2021, a UAV was used to supplement the aerial survey sampling method in WCAs 2 and 3 during the pandemic. Surveys were conducted over as many previously known active colony locations as possible to obtain maximum nest starts. However, because of declining water levels throughout the season, not all potentially active colonies could be reached at peak nesting for all species. Additionally, UAV flights were conducted over 8 colonies (6th Bridge, Alley North, Cypress City, Jetport South, Joule, Jerrod, Vacation, Start Mel) in WCA 3A to determine nest turnover and success. A UAV quadcopter, fitted with a Zenmuse X7 35-mm equivalent camera lens was used to conduct aerial surveys. Images captured via UAV were from an altitude of 350 feet above ground level, were shot at an angle of 15^0 from nadir, and included more than 75% overlap in all four directions. The images were stitched together using AgiSoft Metashape on a 10-core computer and were annotated manually by a single observer using Photoshop or Zooniverse software. Imagery collected by the UAV most likely increased overall detection of wading bird species compared to imagery collected via Cessna due to several factors which include higher resolution photos, lower flight heights (250 feet above ground level versus 500 feet above ground level), and angle of imagery. In particular, visibility of subcanopy and understory nesting species such as WHIB, *Egretta* herons, and Roseate Spoonbills (ROSP) was much higher in UAV imagery.

Since 2005, systematic ground surveys have been performed in parts of WCA 3, that give an index of abundance for small colonies and dark-colored species that are not easily located during aerial surveys. During ground surveys, all tree islands within sixteen 500-meter-wide belt transects comprising a total of 336 km^2 are approached closely enough to flush nesting birds, and nests were counted directly if visible, or estimated from flushed birds. The totals were added to the numbers derived from aerial estimates. Because ground surveys were conducted on a subset of the total area, the resulting nest estimates should be used mainly for year-to-year comparisons and reflect minimum estimates for the total number of nesting pairs of Little Blue Herons (LBHE), Tricolored Herons (TRHE), and Great Blue Herons (GBHE).

Table 3. Minimum number of nesting pairs found in A.R.M. Loxahatchee National Wildlife Refuge (WCA-1) during aerial and ground surveys, January through June of 2021.

Colony	Latitude	Longitude	GREG	WHIB	ROSP	SNEG	GBHE	LBHE	TRHE	CAEG	SMDH	SMWH	Colony Total
Canal N	26.55993	-80.24871						40	21	42			**103**
Lox Ramp/011	26.49511	-80.22533	220		3	453		180	292	60	30	100	**1,338**
Cook NC4	26.53280	-80.27617	321	8,710									**9,031**
New	26.46806	-80.27889	86										**86**
Lox 99	26.43822	-80.39053	475	800	21	200		23	14				**1,533**
Lox West	26.55014	-80.44268	157	74	4	27		30	20	40			**352**
Yamir	26.57228	-80.27217	56										**56**
Zulu	26.59650	-80.28623				240	12	80	120				**452**
Yew	26.55737	-80.25987						47	24	14			**85**
Uweta	26.30000	80.31220	210										**210**
New	26.42300	-80.31000	140									60	**200**
Utu	26.37197	-80.31035	85										**85**
Colonies > 50 nests			1,750	9,584	28	920	12	400	491	156	30	160	**13,531**
Colonies < 50 nests*			96	0	0	0	0	0	0	0	0	0	**96**
Total by Species			**1,846**	**9,584**	**28**	**920**	**12**	**400**	**491**	**156**	**30**	**160**	**13,627**

Note: WOST, GLIB, BCNH, YCNH, and ANHI were not observed (count = 0).
* Includes count of wading bird nesting pairs from ground surveys.

Table 4. Minimum number of nesting pairs found in WCA-2 and WCA-3 during aerial and ground surveys, January through June 2021.

Colony	WCA	Latitude	Longitude	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	BCNH	SMDH	SMWH	ANHI	Colony Total
New	2A	26.24780	-80.43600										100	200		**300**
Rhea	2A	26.23782	-80.31280	496	29		1	180	21	18	14					**759**
New	2B	26.19038	-80.39236	60									40	65		**165**
6th Bridge	3	26.12428	-80.54148	870	800		248		20							**1,938**
Alley North	3	26.20132	-80.52873	1,796	19,455		323	1,541	22	+	+	+		2,500	+	**25,637**
Diana	3	25.84727	-80.52347	184												**184**
Forsetti	3	25.88681	-80.70217	116					5						+	**121**
Vulture	3	26.02765	-80.54106	205					32							**237**
Kidlow	3	26.04123	-80.59968	99					19							**118**
Kinich	3	26.04250	-80.50308	54					19							**73**
Jupiter	3	26.01557	-80.56272	180					13							**193**
Jerrod	3	26.00012	-80.59513	144					14							**158**
Joule	3	26.01230	-80.63233	114					2							**116**
Start Mel	3	25.94812	-80.63816	89					1							**90**
Henry	3	25.81913	-80.83983	134			6									**140**
Shamash	2A	26.24412	-80.43317	178			2		9							**189**
Cypress City	3	26.12410	-80.50440	120			19		24				50			**213**
Hidden	3	25.77353	-80.83722	256	5,636		4	90		52	78					**6,116**
Lucky13	3	25.89500	-80.84167	137		152		15	2		8					**314**
New Jetport	3	25.84278	-80.84222	50		98										**148**
Jetport South	3	25.80510	-80.84902	270		631	6							20	+	**927**
Nanse	3	26.10715	-80.49802	340				29	20							**389**
Horus	3	25.96052	-80.57207	434					67		1	4		11	+	**517**
Juno	3	26.01360	-80.45632	340												**340**
995 (Ground Survey)	3	25.974112	-80.77236					30		60	12					**102**
993 (Ground Survey)	3	25.970403	-80.77477					4		55						**59**
Colonies > 50 nests				6,666	25,920	881	609	1,889	290	185	113	4	190	2,796	0	**39,543**
Colonies < 50 nests*				308	13	12	0	43	182	153	9	518	0	0	337	**1,238**
Total by Species				**6,974**	**25,933**	**893**	**609**	**1,932**	**472**	**338**	**122**	**522**	**190**	**2,796**	**337**	**40,781**

Note: GLIB, CAEG, and YCNH were not observed (count = 0).
+ Present but not counted.
* Includes count of wading bird nesting pairs from ground surveys.

RESULTS

Monitoring during the 2021 breeding season continued to be impacted by COVID-19. Because of distancing rules, the University of Florida field team was unable to accomplish systematic manned flights during the season. Despite lack of traditional fixed-wing aerial surveys, the field team was able to monitor nesting via drone and ground surveys. Together with frequent aerial surveys accomplished by Mark Cook of the South Florida Water Management District (SFWMD), monitoring of total nest starts and detection of colonies is presumed to be very close to the standards of previous years.

Nesting Effort

An estimated minimum of 54,408 wading bird nests were initiated at colonies within WCA-1, WCA-2, and WCA-3 in 2021 (**Tables 3** and **4**). This is considered a relatively comprehensive overview of nesting effort in the WCAs despite the lack of systematic aerial surveys due to COVID-19. However, 100% coverage was not achieved; therefore, reported nesting numbers must be considered minimums.

The total estimated number of nests was 2.1 times the 10-year average nesting effort and 1.6 times the average of the last 5 years and the fourth largest nesting event recorded in the WCAs (1975-2021). Nesting effort by WHIB accounted for much of this difference in the WCAs (35,517 nests) with 1.6 and 2.0 times the 5- and 10-year averages. It is significant to note that these averages do include the supercolony season of 2018 (record 58,893 WHIB nests within the WCAs). Nesting effort for ROSP (637 nests) were at least 2.0 and 3.0 times the 5- and 10-year averages and 5.6 times the nesting effort of the last 20 years. This follows the trend of increasing nesting effort by ROSP in the WCAs. Most nesting ROSP were in two large mixed colonies 6th Bridge (248 nests) and Alley North (323 nests) in WCA-3. However, much higher detection rates of ROSP via varying survey methods used in 2021, as compared to traditional aerial surveys may have influenced total counts.

Numbers of WOST nests were 1.5 and 2.0 times the 5- and 10-year averages. While the majority of nesting occurred in the historical colony of Jetport South (631 nests), WOST initiated nesting in two new colonies north of Jetport South (New-12 nests, and Jetport New-98 nests). WOST continued to nest for a third year in Lucky13 (152 nests). All active WOST colonies in 2021 were located on the southwestern edge of WCA-3 bordering Big Cypress National Wildlife Refuge. GREG nesting effort was also a large portion of overall nesting effort (8,820 nests) with 1.9 times both the 5- and 10-year averages.

In comparison to average nesting between 1996 and 2007, the average number of small dark *Egretta* seen between 2007 and 2021 has steadily declined for LBHE and TRHE during systematic ground surveys. However, there has been a recent and sustained increase in LBHE nesting effort. In 2021, the second highest nesting effort (268 nesting pairs) in the last 22 years was observed in small tree islands. This was 2.6 times the 10-year average. In contrast, TRHE nest numbers remained low with only 21 nesting pairs. TRHE nesting effort was 1.1 times the 10-year average. While few TRHE were observed during systematic ground surveys, nesting TRHE were observed in large mixed colonies including Alley North. These patterns could be the result of a general reduction in nesting by these species throughout the Everglades, or it could indicate that these species are nesting elsewhere in the system such as in larger colonies as mentioned or in coastal areas. For logistical reasons, *Egretta* herons are difficult to count in these large colonies. Competing predictions about the declining trends may suggest a decline or shifts in composition of the prey base, displacement by Black-crowned Night Herons (BCNH), or movement to coastal colonies. BCNH are likely to be a predator on nestlings of *Egretta* herons, and BCNH have been increasing rapidly as nesters, roosters, and foragers during the past 10 years. However, dramatically fewer BCNH were observed in 2021 with only 57% and 66% of the 5- and 10-year averages during systematic ground surveys.

Reproductive Success

Nest success was monitored at eight colonies, including one in WCA-3A North (Alley North) and seven in WCA-3A South (6th Bridge, Cypress City, Henry, Hidden, Joule, Jerrod, and Jetport South). Individual nests of GREG (n=255 at six colonies), WHIB (n=272 at Alley North and Hidden) WOST (n=91 at Jetport South), ROSP (n=26 at 6th bridge, Cypress City, Henry, Jetport South, and Alley North), and BCNH (n=3 at Henry) were monitored during ground-based nest checks every 5 to 7 days throughout the season. While *Egretta* heron nests are usually monitored, no nests occurred within the transects while hydrological conditions enabled access to the colonies

Nest success (P; probability of fledging at least one young, Mayfield method) systemwide showed slight variation by species and across colonies, but overall, over 50% of all wading bird nests monitored were successful: GREG (P=0.580; standard deviation [SD]=0.035), WHIB (P=0.625; SD=0.030), WOST (P=0.706; SD=0.050), BCNH (P=0.666; SD=0.270), and ROSP (P=0.877; SD=0.067). Nestling success (83% to 100%) was higher than incubation success (61% to 95%) across species and colonies. Record high water levels in November resulted in asynchronous nesting across species and delayed nest initiations of GREG and WOST. ROSP nesting effort was more asynchronous compared to other species, and some fledglings were observed during initial visits to colonies in early March. Notably, WOST began nesting in mid-February and continued nest initiation into the first week of April, at least two months later than recent historical records. Despite such late nest initiations, overall nesting success was high (85% and 83%, respectively). With little to no rainfall occurring throughout the nesting season, rapid water recession rates provided favorable foraging conditions through June. The delayed onset of the rainy season occurring in late June allowed most WOST nests to successfully fledge chicks in favorable conditions, likely resulting in higher post-fledging survival rates.

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EVERGLADES NATIONAL PARK

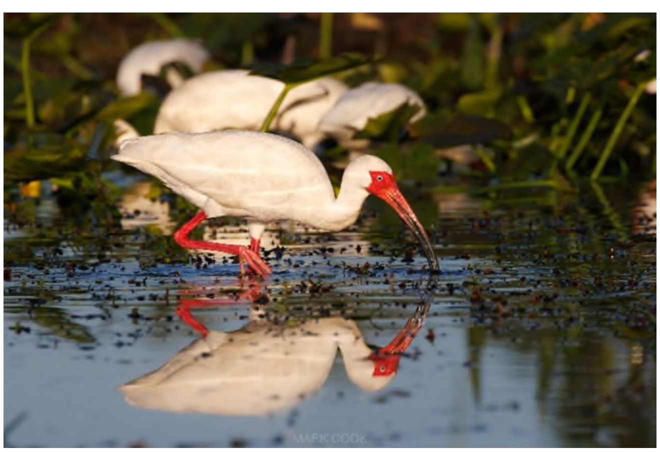
MAINLAND

This summary report addresses wading bird colony monitoring within the slough and estuarine areas of Everglades National Park (ENP) using data collected during the 2021 wading bird breeding season. Wading bird nesting colonies in ENP are surveyed as part of a regional monitoring program to track wading bird nesting effort and success throughout the greater Everglades ecosystem. Data collected during surveys and monitoring flights help guide ongoing ecosystem restoration projects. The long-term monitoring objectives for wading bird nesting colonies in ENP are as follows:

- Collect data on locations of wading bird colonies, numbers of nests, timing of nesting, and nesting success.
- Compile and share data with other agencies that monitor wading birds in South Florida, with the ultimate goal of restoring and sustaining wading bird populations in the Everglades.

METHODS

Airplane and helicopter surveys of known colony locations were conducted by park staff from February to August 2021. Flight dates were February 1 and 23, March 18, April 12, May 6 and 25, June 23, and August 4. The South Florida Water Management District (SFWMD) also conducted helicopter surveys of known colonies in ENP from January to June 2021. SFWMD flight dates were January 6, 8, 22, and 29; February 3 and 5; March 3, 5, and 26; April 30; May 23; and June 18 and 25. Flight altitude was maintained at 600 to 800 feet above ground level during all surveys. During each flight, visual estimates of nest numbers by species were made and photos were taken using a digital SLR camera with a 100-400mm lens. Photos were compared to visual estimates to assist with determining nest numbers, nesting stage, and species composition. Due to unavailability of the park's fixed-wing aircraft, ENP staff were unable to conduct a systematic reconnaissance flight to search for new colonies. Species monitored included Great Egret (GREG), Wood Stork (WOST), White Ibis (WHIB), Snowy Egret (SNEG), Roseate Spoonbill (ROSP), Tricolored Heron (TCHE), and Little Blue Heron (LBHE).



RESULTS

An estimated 35,292 wading bird nests were initiated in ENP in 2021 (**Table 5**). This was the second largest nesting effort in ENP since the exceptional 2018 nesting season (44,688 nests) and continues the pattern of increasing nesting effort in ENP relative to recent decades. Additionally, the 2021 season was the seventh season in the last 20 years when total counts for ENP exceeded 10,000 nests. As observed during the 2018 season, the most abundant nesting species in the 2021 season was WHIB with a total of 28,875 nests (36,385 in 2018). For the second time since the 1940s, an ENP WHIB colony reached "supercolony" size. The Cabbage Bay colony contained 23,280 nesting pairs of which 21,700 were WHIB. A total of 24 wading bird colonies were active and surveyed (**Figure 5**) compared to 16 in 2020, 16 in 2019, and 37 in 2018. Eight new colony sites were discovered during surveys of known colony sites. One of the new colonies was a large, mostly WHIB colony (4,317 nests), that formed adjacent to the northwestern section of Shark Valley Loop Road.

WOST appeared to have a successful nesting season in ENP, despite the fact that the majority of birds started nesting later in the season than in recent years. About 50 birds were incubating on January 29 at Broad River and 10 at Cabbage Bay, but most birds initiated nesting later in different asynchronous groups. On February 23, approximately 223 WOST were incubating at three colony sites: Broad River, Cabbage Bay, and Cuthbert Lake. On March 18, the count grew to 849 nests. Paurotis Pond WOST were active with 40 new nests; however, just a few birds were incubating. On April 12 the combined WOST nest count peaked at 1,747. While most nests contained small- and medium-sized downy young, some adults were still incubating eggs. On May 6, these last nests contained small young, while the earliest nests had large chicks and were fledging young. Some WOST fledglings were also seen grouped together in adjacent marshes near the colonies on May 6 and May 25. On June 23, the rest of the chicks were near fledging or had fledged, but still remained in the colonies. Many of these fledged birds probably continued to leave the colonies into July. These late nests would have been abandoned by the adults and failed if not for a delayed start of the wet season.

Other colonial wading birds in ENP also had a successful nesting season with the exception of GREG at the Rodgers River Bay site. Colonies were active with GREG and ROSP when first surveyed on January 6 and 8. Some GREG and ROSP were incubating at Broad River, but most birds were in early stages of nest building in the other colonies. SFWMD surveyed the larger traditional colony sites through the end of January and on February 1, the first ENP survey was flown and included the rest of the known colony sites. Alligator Bay, Cuthbert Lake, Rodgers River Bay, Rookery Branch, and Shark Valley Observation Tower contained mostly GREG which were all in early stages of nesting. Otter Creek had more than 300 GREG with many birds incubating. On February 23, Grossman Ridge Willowhead and Tamiami West colony sites were active with GREG in the colonies but most were roosting. On March 18, most of the existing traditional sites were active with increases seen in GREG nests. Approximately 6,000 to 8,000 WHIB pairs, many with nests, were setting up at Cabbage Bay and a couple hundred WHIB were roosting at Otter Creek. On March 29, SFWMD discovered a new WHIB colony at the northwest side of Shark Valley Loop Road, and on April 12, this colony contained 4,200 WHIB nests. On April 12, Cabbage Bay had 21,500 WHIB nests, GREG nests had fledged young in most colonies, fledged ROSP were seen at Otter Creek, and fledged WHIB young were also seen in the Cabbage Bay, Otter Creek, and Shark Valley Loop Road Northwest colonies. On June 23, a group of late nesting WHIB (200 nests, many adults incubating) were seen at Cabbage Bay. It was not possible to recheck the WHIB and WOST sites in July, and on August 4 there was no evidence of nesting.

For reasons unknown, about 160 GREG abandoned their nests at the Rodgers River Bay colony. On February 1, about 210 GREG were roosting in the colony with a few new nests and incubating birds seen. On February 23, 193 finished nests were counted, but 128 of these were empty with some dead young and abandoned eggs. At least 2 nests had living or fresh dead chicks without attending adults. The remaining 65 nests were active with adults incubating eggs or brooding small chicks. When checked again on March 18, there were only 33 active nests with adults tending to medium- and large-sized young. The site was not checked again after March, so the outcome for the final 33 nests is unknown.

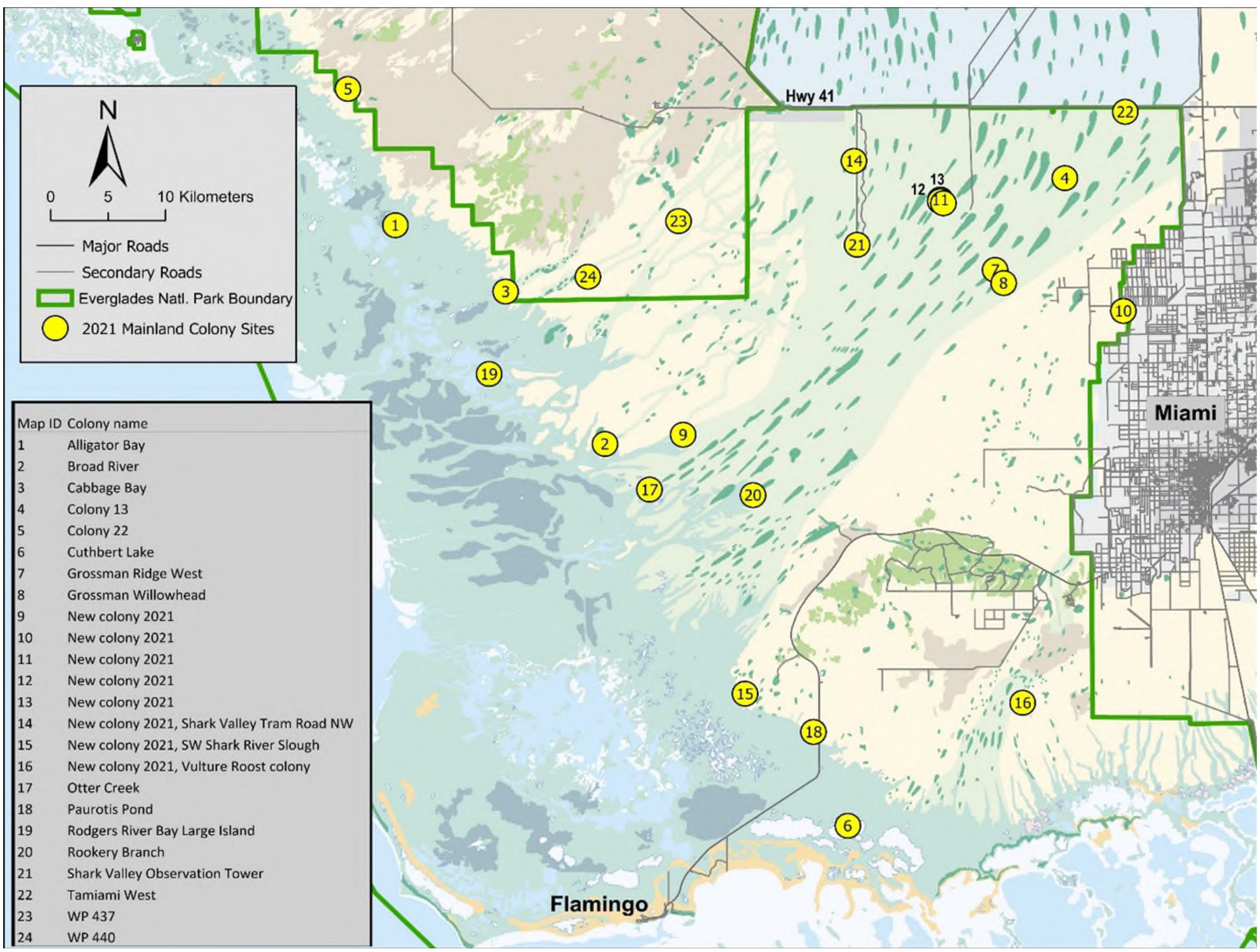


Figure 5. Wading bird nesting colonies in ENP, 2021. **Table 5** contains colony details.

Table 5. Peak nest counts for ENP, January 2021 through August 2021.

Map ID	Colony name	Latitude	Longitude	GREG	WHIB	WOST	ROSP	SNEG	LBHE	TRHE	BCNH	CAEG	Total
1	Alligator Bay	25.67099	-81.14714	225				+	+	+			**225**
2	Broad River	25.50292	-80.97440	555		809	65	80	29	16			**1,554**
3	Cabbage Bay	25.62000	-81.05612	715	21,700	742	60	+	21	42			**23,280**
4	Colony 13	25.70660	-80.59504	150									**150**
5	Colony 22	25.77563	-81.18633	58									**58**
6	Cuthbert Lake	25.20933	-80.77500	134		31							**165**
7	Grossman Ridge West	25.63627	-80.65275	40									**40**
8	Grossman Ridge Willowhead	25.62613	-80.64582	42				+					**42**
9	New colony 2021	25.51000	-80.91000	150									**150**
10	New colony 2021	25.60446	-80.54722	65								30	**95**
11	New colony 2021	25.69041	-80.69770	12									**12**
12	New colony 2021	25.68918	-80.69790	53							+		**53**
13	New colony 2021	25.68764	-80.69528	121									**121**
14	New colony 2021, Shark Valley Loop Road NW	25.72023	-80.76894	112	4,200		5	+			+		**4,317**
15	New colony 2021, SW Shark River Slough	25.31090	-80.85932	86			5						**91**
16	New colony 2021, Vulture Roost	25.30360	-80.63102	89									**89**
17	Otter Creek	25.46780	-80.93772	698	2,975	8	20	+	+	+			**3,701**
18	Paurotis Pond	25.28150	-80.80300	102		157	14	1					**274**
19	Rodgers River Bay Large Island	25.55667	-81.06984	65									**65**
20	Rookery Branch	25.46356	-80.85256	198				+					**198**
21	Shark Valley Observation Tower	25.65581	-80.76640	249									**249**
22	Tamiami West	25.75745	-80.54502	60									**60**
23	WP 437	25.67417	-80.91361	85			3						**88**
24	WP 440	25.63134	-80.98832	215									**215**
	Total			**4,279**	**28,875**	**1,747**	**172**	**81**	**50**	**58**	**+**	**30**	**35,292**

Note: GBHE was not observed (count = 0).
+ Present and nesting but numbers unknown.

Florida Bay

ENP staff did not conduct baywide aerial surveys in Florida Bay during the 2021 season due to unavailability of fixed-wing aircraft. Audubon Florida conducted ground surveys of islands in Florida Bay (see *Nesting Activity of Water Birds on Spoonbill Colony Keys in Florida Bay and Baywide Aerial Survey Results, 2021 Season Including Notes on Tricolored Herons* section for Florida Bay survey data).

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ROSEATE SPOONBILL NESTING IN FLORIDA BAY

METHODS

Roseate Spoonbill (ROSP) nesting patterns are used as an indicator of the ecological health of the Florida Bay ecosystem (Lorenz et al. 2009). Historically, ROSP nested on 61 keys in Florida Bay and three adjacent mainland sites (**Figure 6**). These colonies are divided into five distinct nesting regions based on primary foraging locations used by the birds (**Figure 6**; **Table 6**; Lorenz et al. 2002). ROSP time breeding efforts in tune with seasonally declining water levels on their primary foraging grounds north of the bay (Lorenz 2014, Lorenz et al. 2002) which historically started at the end of the wet season in November and continued until approximately April (Powell et al. 1989). Steady declines in water levels through this period are vital for the success of the Florida Bay population.

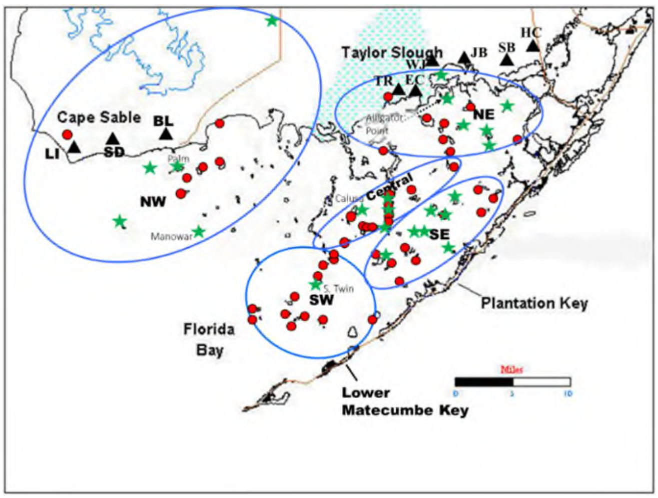

Figure 6. Roseate Spoonbill active nesting colonies in the 2021 nesting season (green stars) and inactive historical colonies (red circles) in Florida Bay, split into five distinct nesting regions (blue rings; NW, NE, Central, SW, and SE). Everglades Science Center hydrostations are marked with black triangles (Cape Sable; LI, SD, BL., Northeastern Florida Bay; TR, EC, WJ, JB, SB, HC).

During the 2021 nesting season (November 2020 through June 2021), complete nest counts were performed on 56 mangrove islands within Florida Bay and three adjacent colony sites on the mainland. Each colony was entered on foot or by kayak, and all nests were counted.

Nest production was estimated using mark-and-revisit surveys. These surveys involved marking as many nests as possible shortly after full clutches had been laid, and then revisiting the colonies on a 10- to 21-day cycle. Nests were monitored until failure or until all surviving chicks reached at least 21 days of age, which is when chicks begin branching and can no longer be assigned to a nest. A colony was considered successful if it averaged at least one chick to 21 days per nesting attempt. If revisits placed chicks (ROSP or other species) in danger or could not be performed because of logistical reasons (e.g., water levels were too low to access the colony), flighted young of the year (they conspicuously roost in the colony tree tops) prior to fledging from the island were counted, and the maximum observed number was used. Estimates of lay and hatch dates were calculated using the standard 21-day incubation period for ROSP and age approximations gathered from each revisit survey.

RESULTS

Northeast Region

Six colonies were found in the northeast region (**Table 6**) including a new colony on a small island inside Alligator Point just south of Alligator Bay (**Figure 6**). The discovery can be attributed to a bird with a tracking device nesting at the location. The northeast had the highest regional nesting effort with 78 nests. The 67 nests with known fates yielded an average of 0.9 chicks per nest, with 51% successful of rearing at least one chick to 21 days old. The estimated mean lay date was January 10, and the mean hatch date was January 31.

Northwest Region

A total of 75 nests from six colonies were observed throughout the northwest region, including the first record of nesting at Man of War Key. Of the 33 nests having known fates, 57% were successful, yielding an average 0.98 chicks per nest (**Table 6**). Nesting activity in this region centered on the average lay date of December 27 and a mean hatch date of January 17. Two asynchronous colonies occurred at Palm Key and were treated separately as interior and exterior colonies. The interior colony was discovered when a majority of chicks were at or near 21 days of age. An estimated 39 chicks were counted from 25 nests resulting in a production of 1.56 chicks per nest, much higher than the other colonies in the northwest.

Central Region

The central region produced a total of 53 nests at five colonies. The 37 nests with known fates yielded an average of 0.7 chicks per nest (**Table 6**). The mean lay date was December 12, and the mean hatch date was January 9. The Calusa colony proved difficult to monitor because of the risk of excessive nest disturbance, and only three of the 18 nests could be monitored safely. The three nests provided an estimated mean lay date of

December 7 and a mean hatch date of December 28, but these estimates lack precision given the limited sample size. A subsequent survey on Calusa discovered 19 fledglings in proximity to empty nests, and these were attributed to each nest evenly to provide an estimated production of 1.1 chicks per nest. However, because the fate of each individual nest was not known, the percentage of nests that successfully raised chicks could not be estimated for the colony or region.

Southeast Region

The southeast region contributed 34 nests from 7 colonies. Of the 27 nests with known fates, 33% produced at least one chick that survived to 21 days old, and the mean estimated production for the region was 0.67 chicks per nest. The mean lay date was December 26, and the mean hatch date was February 1.

Southwest Region

The southwest region continues to attract low numbers of nesting ROSP (**Table 6**). This season, six nests were discovered on a single colony, South Twin Key. Three of the four nests with known fates (75%) produced at least one nestling that survived to age 21 days, and total production was 1.75 chicks per nest. The average lay date was December 23, and the mean hatch date was January 14.

Table 6. Roseate Spoonbill colony locations, production values, and nest timing in Florida Bay.

Region	Colony	Latitude	Longitude	# Nests Observed	# Nests with Known Fate[1]	# Chicks Reaching 21 days	Estimated Production of Chicks to 21 Days per Nest	Nests Producing at Least One Chick	% Success	Mean Lay Date	Mean Hatch Date
Northeast	Diamond	25.2320	-80.5645	13	12	6	0.50	2	17%	3/16/21	4/6/21
	Alligator Point	25.1977	-80.5673	24	22	26	1.18	12	55%	12/30/20	1/20/21
	Tern	25.1590	-80.5534	13	8	11	1.38	7	88%	1/7/21	1/27/21
	North Nest	25.1501	-80.5092	26	24	18	0.75	12	50%	12/30/20	1/21/21
	South Nest	25.1310	-80.5074	1	0	UNK	UNK	UNK	UNK	12/30/20	1/20/21
	Duck	25.1801	-80.4893	1	1	1	1.00	1	100%	1/16/21	2/6/21
		Regional Subtotal		**78**	**67**	**62**	**0.93**	**34**	**51%**	**1/10/21**	**1/31/21**
Northwest	Sandy	25.0347	-81.0140	3	3	0	0.00	0	0%	UNK	UNK
	Palm (interior)	25.1134	-80.8782	25	0	39	1.56	25*	100%	UNK	UNK
	Palm (exterior)	25.1140	-80.8812	3	3	1	0.33	1	33%	12/7/20	12/28/20
	Oyster	25.1039	-80.9515	3	0	0	0.00	0	0%	UNK	UNK
	Man of War	25.0326	-80.9107	39	27	17	0.63	7	26%	1/3/21	1/24/21
	Paurotis Pond	25.2826	-80.8025	2	UNK	UNK	UNK	UNK	UNK	UNK	UNK
		Regional Subtotal		**75**	**33**	**57**	**0.98**	**33**	**57%**	**12/27/20**	**1/17/21**
Central	Central Jimmie	25.0520	-80.6449	27	26	13	0.50	7	27%	12/29/20	1/19/21
	Calusa	25.0589	-80.6947	18	3	19	1.06	UNK	UNK	12/7/20	12/28/20
	First Mate	25.0268	-80.6469	6	6	1	0.17	1	17%	12/21/20	1/11/21
	North Jimmie	25.0663	-80.6429	2	2	2	1.00	1	50%	12/24/20	1/14/21
		Regional Subtotal		**53**	**37**	**35**	**0.70**	**9**	**UNK**	**12/19/20**	**1/9/21**
Southeast	Pigeon	25.0559	-80.5112	12	12	3	0.25	3	25%	1/4/21	1/25/21
	Middle Butternut	25.0842	-80.5165	9	7	11	1.57	4	57%	12/16/20	2/21/21
	Bottle	25.0637	-80.5558	2	1	2	2.00	1	100%	12/24/20	1/14/21
	Stake	25.0567	-80.5872	3	3	0	0.00	0	0%	UNK	UNK
	East	24.9994	-80.6092	3	2	2	1.00	1	50%	12/21/20	1/11/21
	West	24.9874	-80.6492	1	1	0	0.00	0	0%	UNK	UNK
	Crane	25.0055	-80.6147	4	1	UNK	UNK	UNK	UNK	1/3/21	1/24/21
		Regional Subtotal		**34**	**27**	**18**	**0.67**	**9**	**33%**	**12/26/20**	**2/1/21**
Southwest	South Twin	24.9636	-80.7445	6	4	7	1.75	3	75%	12/23/20	1/14/21
		Regional Subtotal		**6**	**4**	**7**	**1.75**	**3**	**75%**	**12/23/20**	**1/14/21**
		BAYWIDE TOTAL		**246**	**168**	**179**	**1.07**	**88**	**52%**	**12/30/20**	**1/23/21**

UNK = unknown.

[1] Nests with known fates are a subsample of nests chosen within a colony to be marked and revisited to determine if any chicks survived to 21 days post-hatch, when they leave the nest and become branchlings.

DISCUSSION

Audubon Everglades Science Center collects water level data in the ephemeral dwarf mangrove wetlands north of Florida Bay, that were historically the primary foraging grounds of ROSP nesting in the northeastern and northwestern regions of Florida Bay (**Figure 6**; Bjork and Powell 1994). Using these data, Lorenz (2014) described the concept of a prey concentration threshold (PCT); during the dry season, there are short-lived pulses in prey concentrations as fish flee from drying wetlands. The first threshold occurs at approximately 13 centimeters in depth (the PCT). Successive reconcentration events happen as waters continue to recede below 13 centimeters, while simultaneously, overall prey numbers decrease from increased predation or increasingly poor environmental conditions. During any of these concentration events, foraging ROSP capitalized on the concentrated prey to quickly capture enough prey to meet the energetic demands of their rapidly growing chicks.

Figure 7 presents water level data from three hydrostations on Cape Sable (LI, SD, and BL) indicating the daily minimum, mean, and maximum water depths. **Figure 7** also indicates the average time periods for ROSP nesting activity in the northwestern region, showing initial dates of detection (discovery), estimated lay and hatch dates, and the approximate date at which chicks reached 21 days old. These data indicate that chicks hatched during a period when water levels were well below the PCT at all three sites suggesting that the adults read environmental ques correctly to have optimal foraging conditions as chicks emerged. These optimal conditions continued until many of the chicks reached the branchling phase; however, this was followed by a reversal in the drying pattern with water levels above the PCT for more than a week at all three stations (most of the wetland was above the PCT for several weeks). This reversal occurred before the period where the late hatching nests would have reached the branchling phase, likely explaining the moderate nest production and the low nest success rate in the northwestern region (**Table 6**).

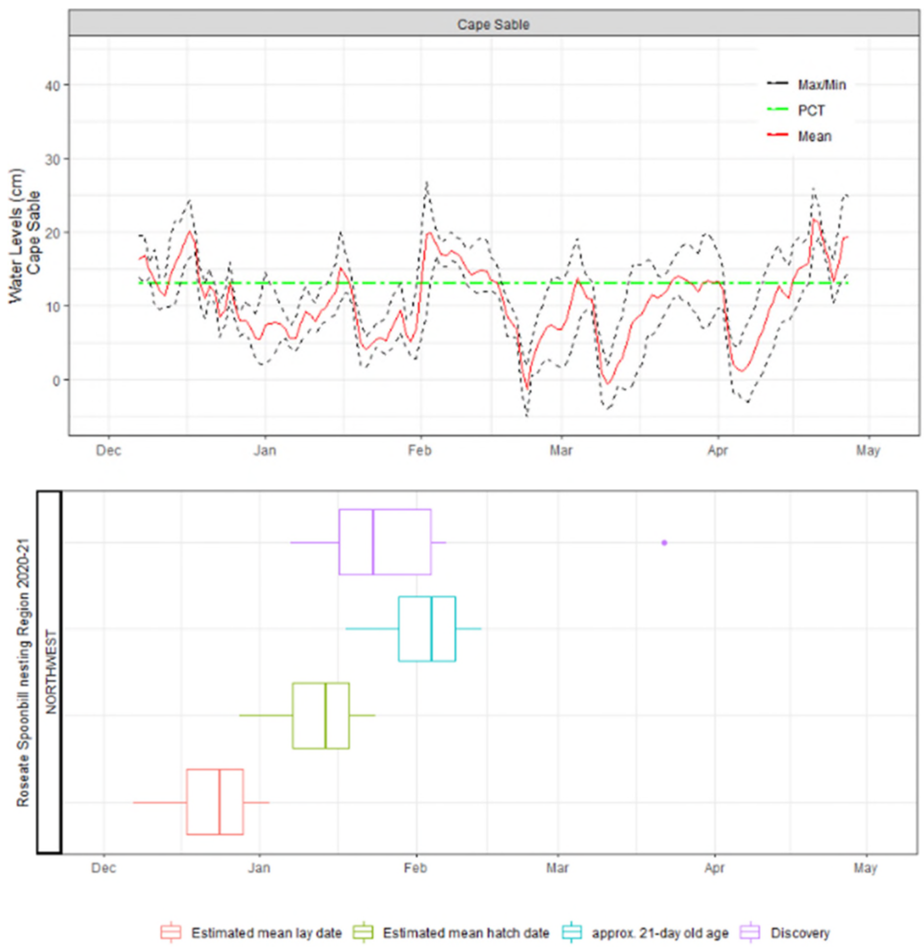

Figure 7. TOP: water levels at Cape Sable (Audubon hydrostations; LI, SD, and BL), showing mean (red solid) and minimum and maximum (black dashed) water levels, and the prey concentration threshold (13 cm, green dashed). BOTTOM: boxplots showing time periods in northwest region for ROSP nesting activity. Initial dates of detection (discovery, purple), estimated lay (orange), hatch dates (green), and the approximate date in which chicks reached 21 days old (blue). Triangles indicate the mean of dates. Box plots are median (centerline), 25th and 75th percentiles (boxes), 5th and 95th percentiles (whiskers), and outliers (dots). Dates are in connection with the water level data.

Figure 8 is similar to **Figure 7** with water level data from six hydrostations in northeastern Florida Bay (TR, EC, WJ, JB, SB, and HC) as well as the timing of nesting activities for ROSP in the northeastern and central regions. In both these regions, chicks hatched at a time when at least a portion of the wetland was below or near the PCT; however, shortly after hatching, reversals in the drying pattern occurred. Under these conditions, high chick mortality would have been expected if the adults were wholly reliant on these as foraging grounds. Surprisingly, the northeastern region had similar results to those of the northwestern region. The central region had a slightly lower performance but still had moderate production values (**Table 6**). Recent results from the ROSP tracking project reveal that ROSP nesting in these regions have begun using novel foraging habitats further north and west of the historic foraging area as well as heavily foraging in the interior ponds of the Florida Bay keys (Rafferty et al. 2021), perhaps ameliorating the relatively poor conditions on their traditional foraging grounds. The authors also demonstrated that the greatly reduced number of days below the PCT was a result of differential sea level rise (SLR) in southern Florida. Furthermore, they found that ROSP have responded by expanding their foraging range further north and west (presumably to areas of higher elevation such that PCT is reached with greatly predictability) and also onto the wetlands inside bay keys. They speculated that, perhaps, SLR has actually made the bay keys more suitable for ROSP foraging.

The frequency, duration, and quality of prey concentration events on traditional foraging grounds have become more capricious due to the effects of SLR placing Florida Bay's ROSP nesting population in a precarious state. There is still a significant effort by the birds to nest in the estuary but in much lower numbers; however, nest numbers have remained relatively stable for the past 10 years (**Table 7**), owing to this species' resiliency in responding to changing conditions caused by SLR.

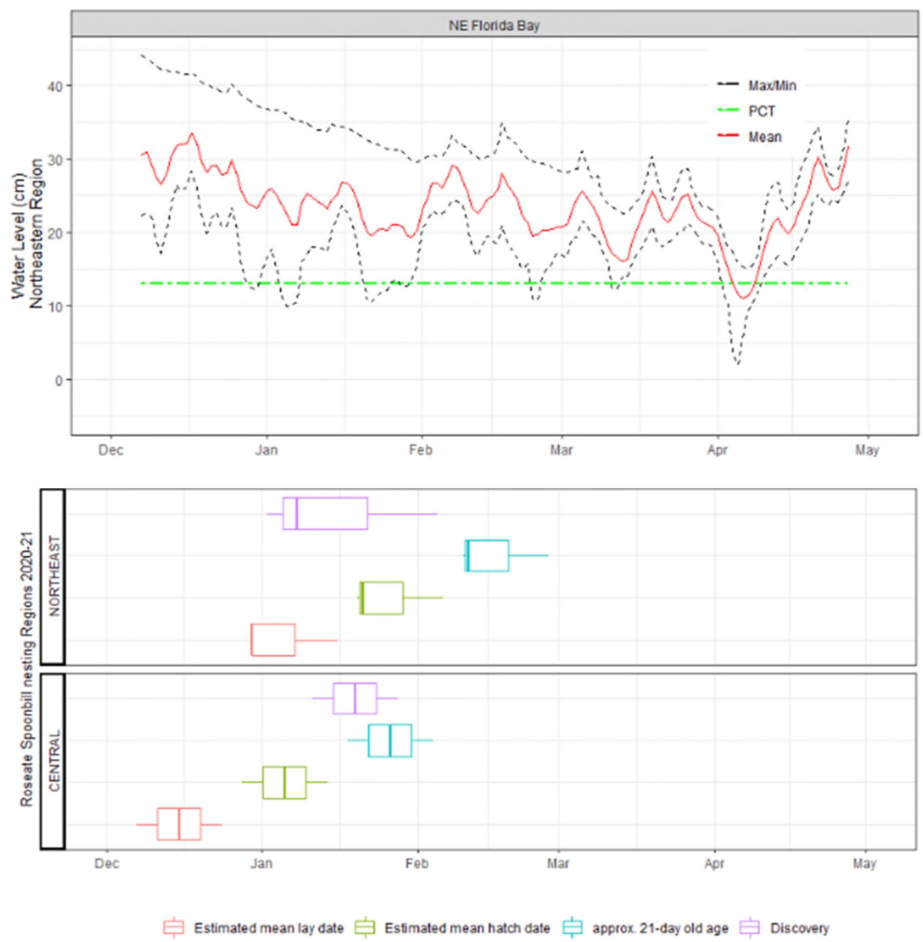

Figure 8. TOP: water levels in northeastern Florida Bay (Audubon hydrostations; TR, EC, WJ, JB, SB, HC), showing mean (red solid) and minimum and maximum (black dashed) water levels, and the prey concentration threshold (13 cm, green dashed). BOTTOM: boxplots showing time periods in northeast and central regions for ROSP nesting activity. Initial dates of detection (discovery, purple), estimated lay (orange), hatch dates (green), and the approximate date in which chicks reached 21 days old (blue). Triangles indicate the mean of dates. Box plots are median (centerline), 25th and 75th percentiles (boxes), 5th and 95th percentiles (whiskers), and outliers (dots). Dates are in connection with the water level data.

Table 7. Numbers for regional and Florida Bay nesting Roseate Spoonbills, for the time periods 2011-2012 to 2020-2021, showing the 10-year averages.

Season	Northeast	Northwest	Central	Southeast	Southwest	Baywide Total
2011-2012	183	178	44	29	2	**436**
2012-2013	188	127	30	22	0	**367**
2013-2014	76	85	19	10	1	**191**
2014-2015	158	173	24	4	6	**365**
2015-2016	189	141	29	6	2	**367**
2016-2017	56	103	13	34	3	**209**
2017-2018	58	140	55	23	2	**278**
2018-2019	24	202	27	28	0	**281**
2019-2020	57	66	40	39	1	**203**
2020-2021	78	75	53	34	6	**246**
Average	**106.7**	**129**	**33.4**	**22.9**	**2.3**	**294.3**

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NESTING ACTIVITY OF WATER BIRDS ON SPOONBILL COLONY KEYS IN FLORIDA BAY AND BAYWIDE AERIAL SURVEY RESULTS, 2021 SEASON INCLUDING NOTES ON TRICOLORED HERONS

Surveys of nesting water birds in Florida Bay and adjacent habitats were conducted by Audubon Florida, Everglades National Park (ENP) and Lignumvitae Key Aquatic Preserve. The results of those surveys were combined by selecting the largest nest count for each species for each nesting site regardless of who performed the survey, the survey method, or the time of the survey. Results are presented in **Table 8**.

METHODS

Audubon Florida

While surveying known Roseate Spoonbill (ROSP) colonies throughout Florida Bay, 12 other species of water birds were observed nesting on the islands (**Figure 9**). Attempts were made to count the nests, but these findings should not be treated as a thorough or exhaustive survey of water birds in the bay. Many keys were not surveyed because ROSP did not nest on them. Also, areas beyond ROSP nesting sites on a given key were not searched.

That stated, every effort was made to find all ROSP and Reddish Egret (REEG) nests. Total counts were used when possible, rather than the maximum count on a given survey because REEG timing of nesting is highly asynchronous in Florida Bay (Cox et al. 2017). REEG recently became a species of interest at the state and local level and are now surveyed the same as ROSP (i.e., attempts are made to find all nests and document productivity). The REEG estimates are likely an accurate representation of effort for this species in Florida Bay.

Everglades National Park

Aerial surveys were not conducted over Florida Bay in the 2021 season (due to limited flight time available) except at the two most northern colonies: Madeira Hammock and Diamond Key. These two colonies were surveyed using a National Park Service contracted Bell 206 Jet Ranger Helicopter.

Lignumvitae Key Aquatic Preserve

Nest counts were conducted by kayak at Ashbey-Horseshoe Key using the double-observer method. Surveys were performed once a month within a 2-week window from January until there were no active nests. Surveys were made by circling the island (including the interior bight) at a distance of approximately 50 feet from the island such that species and nesting outcomes could be identified.

RESULTS

Table 1 presents the peak nest estimates per species from the combined Audubon Florida's nest counts, ENP's aerial surveys of Madeira Hammock and Diamond Key, and Lignumvitae Key Aquatic Preserve's kayak surveys of Ashbey-Horseshoe Key. In recent decades, nesting surveys throughout southern Florida have indicated a marked decline in Tricolored Herons (TRHE) (Cook and Baranski 2020). However, Audubon Florida surveys indicate that TRHE are using nesting sites in Florida Bay at relatively high levels in relation to the rest of southern Florida. Furthermore, the number of TRHE foraging in the interior lakes of Florida Bay keys appears to have increased in recent years, compared to what was observed in the early 2000s (J. Lorenz, personal observation).

For the second time in 4 years, two Neotropic Cormorant (NECO) nests were found on Duck Key. This may become more common as global climate change continues to alter the ranges of bird species by allowing them to nest in novel areas as temperatures become warmer. Another surprising result from this year was the discovery of a Least Bittern (LEBI) nest on North Nest Key. We believe this to be the first report of this species nesting in Florida Bay.

Correction to Previous Reports

Audubon Florida began collecting Florida Bay nesting data and reporting them in the January 2016 issue of the *South Florida Wading Bird Report* (2015 nesting season). However, those data were not combined with, and were reported separately from, data from ENP until the 2018 nesting season. There were also inconsistencies in the reporting for three colonies: Paurotis Pond, Madeira Hammock, and Diamond Key. In some years, these three colonies were reported as part of Florida Bay and other years as ENP mainland colonies. To correct these discrepancies in previous reporting, the total number of nests for each species for each year have been standardized to include both Audubon and ENP data sets. They are further standardized by including Madeira Hammock and Diamond Key as part of Florida Bay, while Paurotis Pond is now reported as a mainland colony with the exception of ROSP which include nest counts from Paurotis Pond to be consistent with the report on ROSP nesting patterns in Florida Bay (see *Roseate Spoonbill Nesting in Florida Bay* section). These corrected counts are reported in **Table 9** with notes on changes from previous reports.

Table 8. Peak nest numbers found in Florida Bay wading and water bird colonies through July 2021. Underlined numbers are estimates collected from Everglades National Park aerial surveys. Italicized numbers are estimates collected from Lignumvitae Key Aquatic Preserve kayak surveys. Plain text numbers are estimates collected from Audubon Florida ground surveys. Figure 9 shows the location of active nesting colony sites in Florida Bay for the 2021 season.

Colony	Latitude	Longitude	Nesting Waders										Additional Non-wading Nesters					Others		Total
			GBHE/ GWHE	GREG	TRHE	REEG	SNEG	LBHE	BCNH	GRHE	WHIB	ROSP	BRPE	DCCO	ANHI	OSPR	BAEA	LEBI	NECO	
										Northeast										
Tern	25.158979	-80.553397			213	4					34	13				1				**265**
Deer	25.184453	-80.536647								1										**1**
North Park	25.127304	-80.567412	2													1				**3**
Duck	25.180121	-80.48929			17	6				1		1	12	33					2	**72**
North Nest	25.150075	-80.509195	4			1						26			1	2		1		**35**
South Nest	25.131011	-80.507439	1			1						1								**3**
Porjoe	25.137778	-80.472976																		**0**
Pass	25.157438	-80.576232																		**0**
Lake	25.142466	-80.561633																		**0**
Little Betsy	25.130566	-80.653877												6						**6**
Madeira	25.219639	-80.659281		<u>37</u>																**37**
Diamond	25.23200	-80.564499		<u>250</u>	82		33					13			1					**379**
Eagle	25.167972	-80.596312	3													1				**4**
Alligator Point	25.197713	-80.567259	6			2				5		24								**37**
										Central										
East Bob Allen	25.034329	-80.66561				1										1				**2**
Central Bob Allen	25.031902	-80.678421				1										2				**3**
West Bob Allen	25.028416	-80.682805	1			6										2				**9**
North Jimmie	25.066264	-80.642915	2			7						2				1				**12**
Central Jimmie	25.051991	-80.644882	7		177	2						27				4				**217**
Little Jimmie	25.034229	-80.646737				1										2				**3**
South Park	25.109233	-80.564909				1														**1**
Calusa	25.058868	-80.694716	4		89	2				2		18	7			1	1			**124**
Pollock	25.018036	-80.702457	3			1								27		1				**32**
Manatee	25.06990	-80.61242																		**0**
First Mate	25.026772	-80.646308	2			2						6		9						**19**
Captain	25.026638	-80.632053	4			1										1				**6**
Bruce	25.043694	-80.712222	1			4										1				**6**
Russell	25.079888	-80.641988																		**0**
Ogden	25.070921	-80.634448																		**0**
										Northwest										
Sandy	25.034702	-81.013958	16		102	6			3		27	3		37		6	1			**201**
Clive	25.078471	-80.929556	8	12	250	3	100	2	5		5		4	200		4				**593**
Oyster	25.10391	-80.951505	5			1						3	18							**27**
Palm	25.117533	-80.879954	14		116	4	191					28				4				**357**
Frank	25.10202	-80.909359	2																	**2**
Catfish	25.098648	-80.922155	4																	**4**
Hanvan	25.17079	-80.877505																		**0**
Cape Sable	25.185547	-81.121248																		**0**
Murray	25.107105	-80.939779	7													2	1			**10**
Dildo	25.05947	-80.88559	23											16		2				**41**
Man of War	25.032641	-80.910696	9									39	13	36		3				**100**
										Southeast										
Middle Butternut	25.08424	-80.516493			44	2					14	9								**69**
Big Butternut	25.078851	-80.497833	1																	**1**
Bottle	25.063663	-80.555821				1						2								**3**
Stake	25.056686	-80.587225	3		18	3						3				1				**28**
Low	25.050895	-80.579635	2													2				**4**
Cowpens	25.004791	-80.560546	1											5						**6**
Crane	25.005501	-80.614711	7			1						4				3				**15**
East	24.999395	-80.609232	3									3		11						**17**
Crab	24.989648	-80.658936																		**0**
West	24.987427	-80.649206										1				2				**3**
Cotton	24.960618	-80.624226												10		1				**11**
Pigeon	25.055947	-80.511193	4		7	1				2		12		56						**82**

Table 8. Continued

Colony	Latitude	Longitude	Nesting Waders										Additional Non-wading Nesters					Others		Total
			GBHE/ GWHE	GREG	TRHE	REEG	SNEG	LBHE	BCNH	GRHE	WHIB	ROSP	BRPE	DCCO	ANHI	OSPR	BAEA	LEBI	NECO	
Southwest																				
East Buchanon	24.919846	-80.773283											5							**5**
West Buchanon	24.917837	-80.777828																		**0**
Barnes	24.939236	-80.783158				1										1				**2**
North Twin	24.968682	-80.744373	1													1				**2**
South Twin	24.96355	-80.744472				3						6		102		1				**112**
Petersons	24.912851	-80.743702	2																	**2**
Gophers	24.983777	-80.73521																		**0**
Hobo	25.007805	-80.721518																		**0**
Panhandle	24.99865	-80.727764														2				**2**
Shell	24.925977	-80.667769																		**0**
Horseshoe	24.931452	-80656923	*7*				*3*							*12*						**22**
Green Mangrove	24.925664	-80.785055												15		1				**16**
Upper Arsnicker	24.931614	-80.827753	2																	**2**
Lower Arsnicker	24.920571	-80.826739												120						**120**
Total			**161**	**299**	**1,115**	**69**	**327**	**2**	**8**	**11**	**80**	**244**	**59**	**695**	**2**	**57**	**3**	**1**	**2**	**3,135**

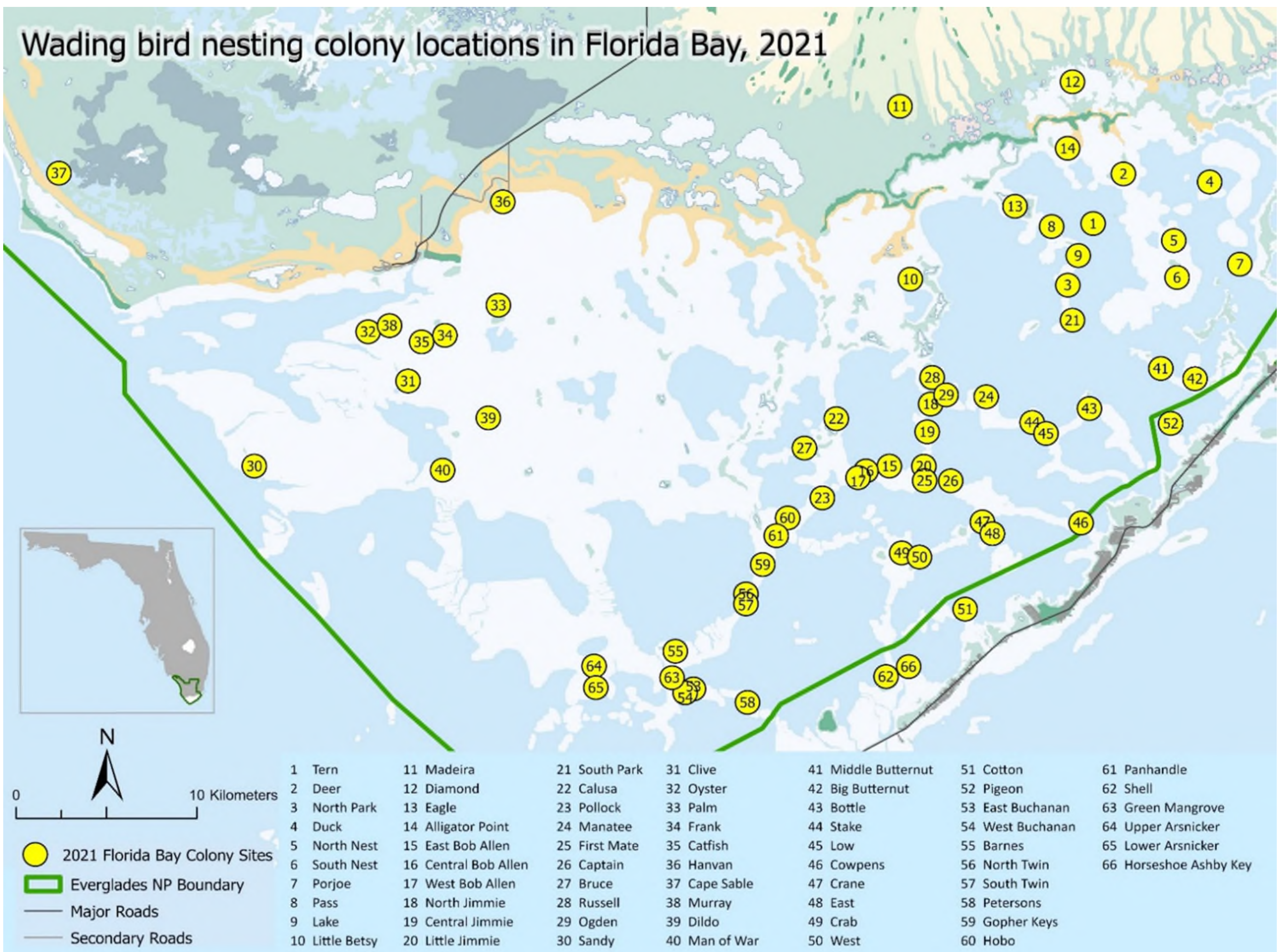

Figure 9. Active nesting colony sites in Florida Bay, 2021.

Table 9. Annual peak nest numbers found in Florida Bay by species for each year since surveys were started in 2014-2015 with corrections from previous reports noted.

Year	Nesting Waders																Other Water Birds							Total Nests
	GBHE	GWHE	GREG	REEG	LBHE	SNEG	TRHE	BCNH	YCNH	GRHE	WOST	ROSP[a]	WHIB	GLIB	LEBI	Total	BRPE	DCCO	NECO	ANHI	OSPR	BAEA	Total	
2014-2015[b]	13	95	133	66	1*	34*	518*		2	6*	0*	365	65*	3		**1,301**	68	247		55*	34	1	405	**1,706**
2015-2016[c]	70	227	177	74		45	642			3	0*	367	160			**1,765**	797	12		1		26	836	**2,601**
2016-2017[c]	101	204	208	51	3	49	246			38	0*	209	281			**1,390**	376	569		22	23		990	**2,380**
2017-2018[d]	36	175	253*	62	1	34*	684*	29				278	40*			**1,743**	114	282	2	16*			414	**2,157**
2018-2019[d]	35	131	200*	30	2		835*					282*	180			**1,695**	169	171					340	**2,035**
2019-2020[d]	44	167	137	65	6	193	1,317					203*	353			**2,485**	127	365		2			494	**2,979**
2020-2021[e]	161[f]		299	69	2	327	1,115	8				246	95		1	**2,323**	59	685	2	2	57	3	808	**3,131**

Note: Blank spaces may not represent zero but indicate nests were simply not identified in some of the rarer and more cryptic nesting species.

* Indicates different from previously reported.

[a] ROSP is the only species where nest counts include those at the Paurotis Pond colony to be consistent with the report on ROSP nesting in Florida Bay (see *Roseate Spoonbill Nesting in Florida Bay* section).

[b] Paurotis Pond counts were removed. Aerial surveys were not performed by ENP in 2014-2015 and included only Audubon Florida data.

[c] Paurotis Pond counts were removed and aerial counts by ENP incorporated.

[d] Nest counts from Paurotis Pond were removed and counts from Madeira Hammock and Diamond Key were added. These data already had been incorporated in both the ENP and Everglades Science Center data sets.

[e] Aerial surveys of Florida Bay were not performed by ENP in 2020-2021 with the exception of aerial surveys of Madeira Hammock and Diamond Key which are incorporated here.

[f] Nests of GBHE and GWHE were not distinguished from one another in 2020-2021.

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COLONIAL NESTING BIRDS IN BISCAYNE NATIONAL PARK

Nesting colonies of wading birds and seabirds are important indicators of ecosystem health as they respond to changes in food abundance, food quality, contaminants, invasive species, and disturbances. The acts of selecting mates, building nests, laying eggs, and rearing chicks are energy intensive. If the habitat is insufficient to support these activities, nesting success will suffer and may indicate a problem in the ecosystem. The South Florida/Caribbean Inventory and Monitoring Network (SFCN) of the National Park Service is monitoring colonial nesting birds in Biscayne National Park, and this report summarizes the results for the July 2020 through June 2021 nesting season.

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

- The number and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants (DCCO), Great Egrets (GREG), Great White Herons (GWHE), Great Blue Herons (GBHE), White Ibises (WHIB), and Roseate Spoonbills (ROSP) (referred to as focal species).
- The annual peak active nest counts of colonial nesting birds in Biscayne National Park for the focal species.
- Changes in an annual nesting index (sum of monthly nest counts) for the focal species.
- Changes in the timing of peak nest counts for the focal species.

METHODS

The 2021 monitoring process consisted of an annual park-wide survey via helicopter to locate new nesting colonies of wading birds and seabirds coupled with monthly surveys of colonies detected during the annual survey. Two SFCN staff, a photographer, and an observer, participated in each survey. As the helicopter circled each island colony, the colonies were photographed, and the observer recorded the number of visible nesting and non-nesting birds. Approximately 450 photographs were taken during each survey. The photographs were downloaded for processing and analyzed to identify active nests by species. Nests were circled and counted from the processed photographs.

Peak nest counts were identified for each colony and summed across colonies to calculate the peak nesting year total across the park for each species. In addition, an annual nesting index was calculated, which is the sum of monthly nest counts for the entire nesting year. The nesting estimates for months with no sampling were calculated as the average of the months before and after the missing month. Staff used the annual nesting index as well as peak nest counts because some species (e.g., DCCO) nest in all months, and peak nest counts alone were considered insufficient to describe the nesting effort. Trying to estimate the true number of nest starts is not currently feasible. This year's peak nest counts and nesting index were compared to the 10 previous nesting years' mean, maximum, and minimum (**Table 10**). Complete methods are described by Muxo et al. (2015).

Colony surveys were conducted from October 2020 through April 2021. The July through September 2020 surveys did not take place because of COVID-19 precautions, and the May and June surveys did not take place because of inability to maintain helicopter training because of COVID-19. The nine colonies surveyed during the routine monthly flights were as follows: Kings Road Island (25.49250, -80.33861), Mangrove Key (25.39444, -80.31583), West Arsenicker (25.40528, -80.31722), Arsenicker Key (25.39667, -80.28611), Jones Lagoon (25.37194, -80.24111), Ragged Key 4 (25.53040, -80.17234), Ragged Key 5 (25.52722, -80.18972), Soldier Key, (25.59027, -80.16139), and Kings Bay (25.62860, -80.30667) (**Figure 10**). Although the Kings Bay colony is located north of the park boundary, it is being monitored because of its proximity to the park. The birds nesting at Kings Bay most likely use the park for resources and provide a more complete picture of colonial birds using Biscayne Bay.

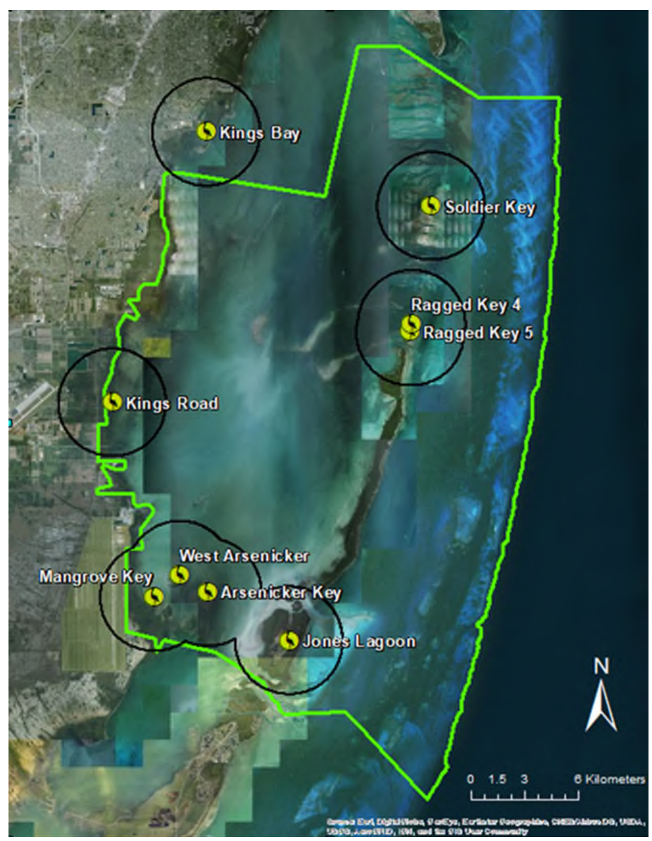

Figure 10. Nine island colonies monitored within Biscayne National Park and the estimated foraging areas.

RESULTS AND DISCUSSION

With the 2020-2021 nesting year, the SFCN completed its eleventh year of monitoring colonial nesting birds in Biscayne National Park. When interpreting the data for this nesting season, it is important to consider that many surveys did not take place.

Jones Lagoon, Ragged Key 4, and Ragged Key 5 all showed an increase in the number of species nesting compared to last year (**Figure 11**). Two colonies showed a decrease, and four showed the same number of species nesting.

The 2019-2020 nesting data showed a significant reduction in DCCO nesting (**Figure 12**). Even though surveys at the start of the 2020-2021 nesting year did not occur, once the surveys did start, the data showed a substantial recovery in DCCO nesting.

Figure 13 shows an increase in peak active nests for most of the focal species, while the annual nesting index (**Figure 14**) shows a decrease for the focal species. Unfortunately, some of the timing of the missed surveys affect which species are captured nesting (e.g., WHIB).

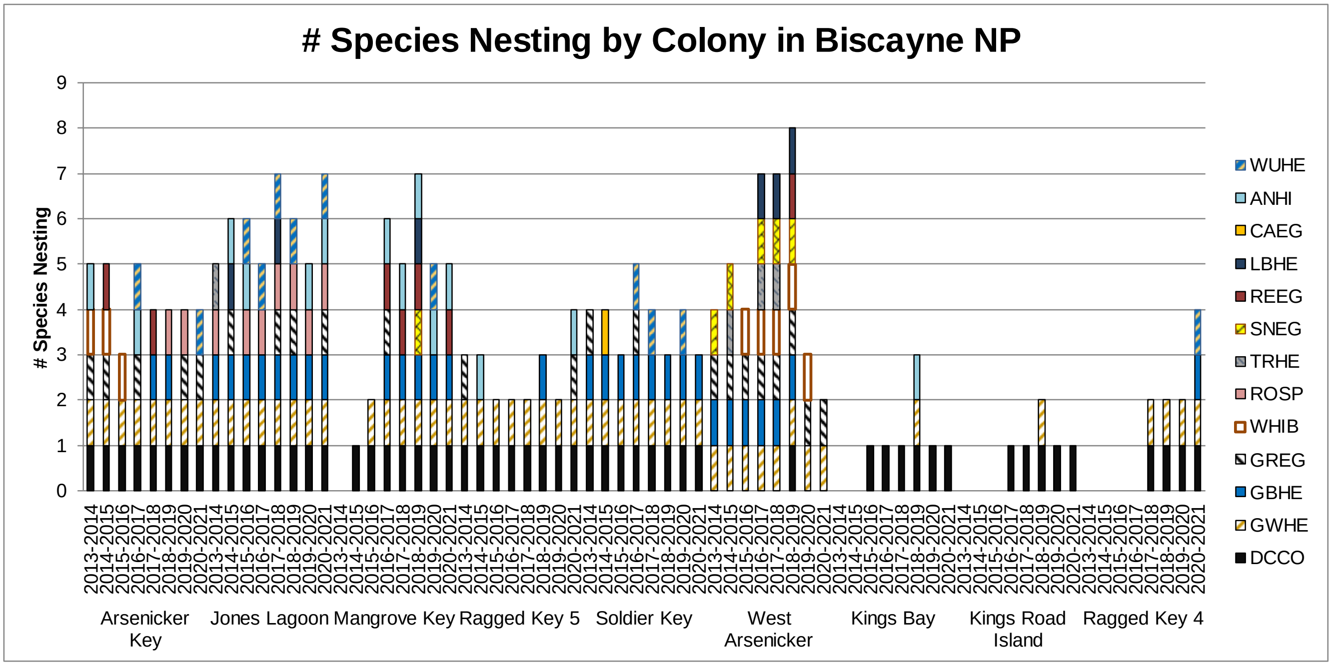

Figure 11. Number of species detected nesting, by colony and year. (Includes all egrets, ibises, spoonbills, and herons.)

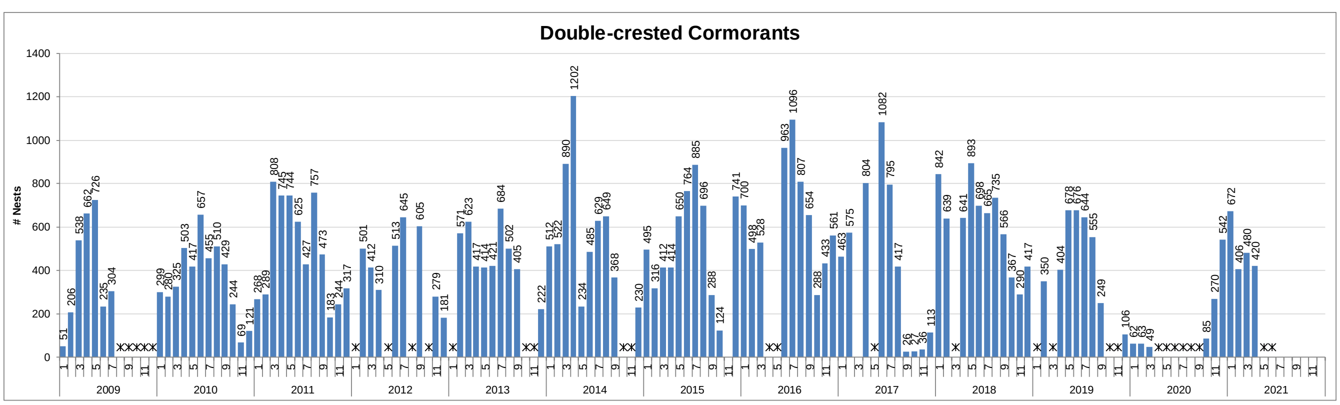

Figure 12. Number of DCCO nests per month. (*Months not sampled.)

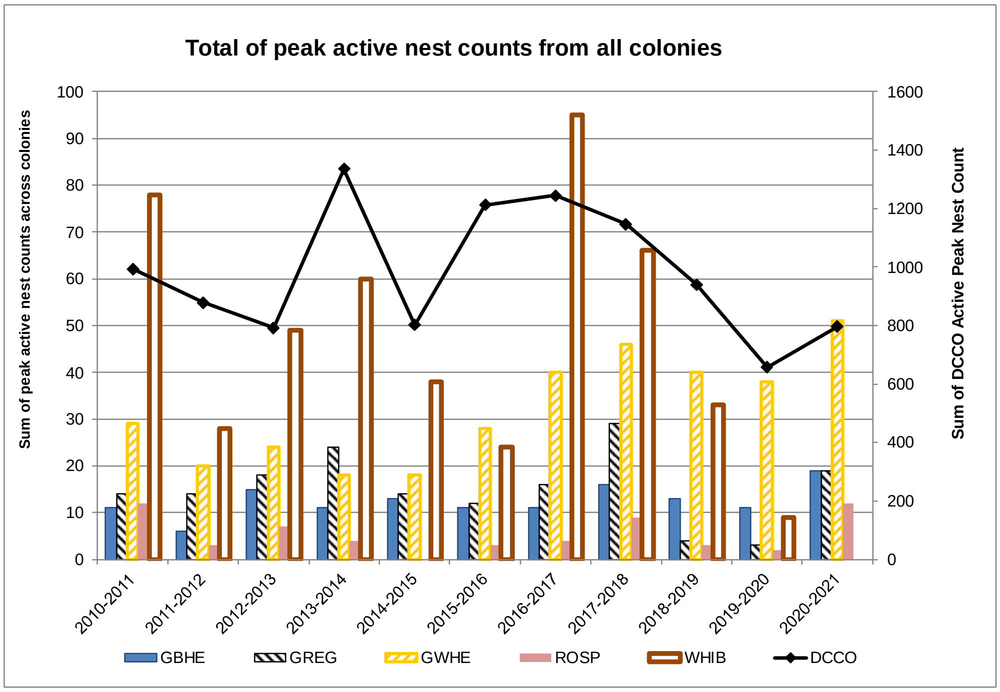

Figure 13. Total of peak active nest counts from all colonies.

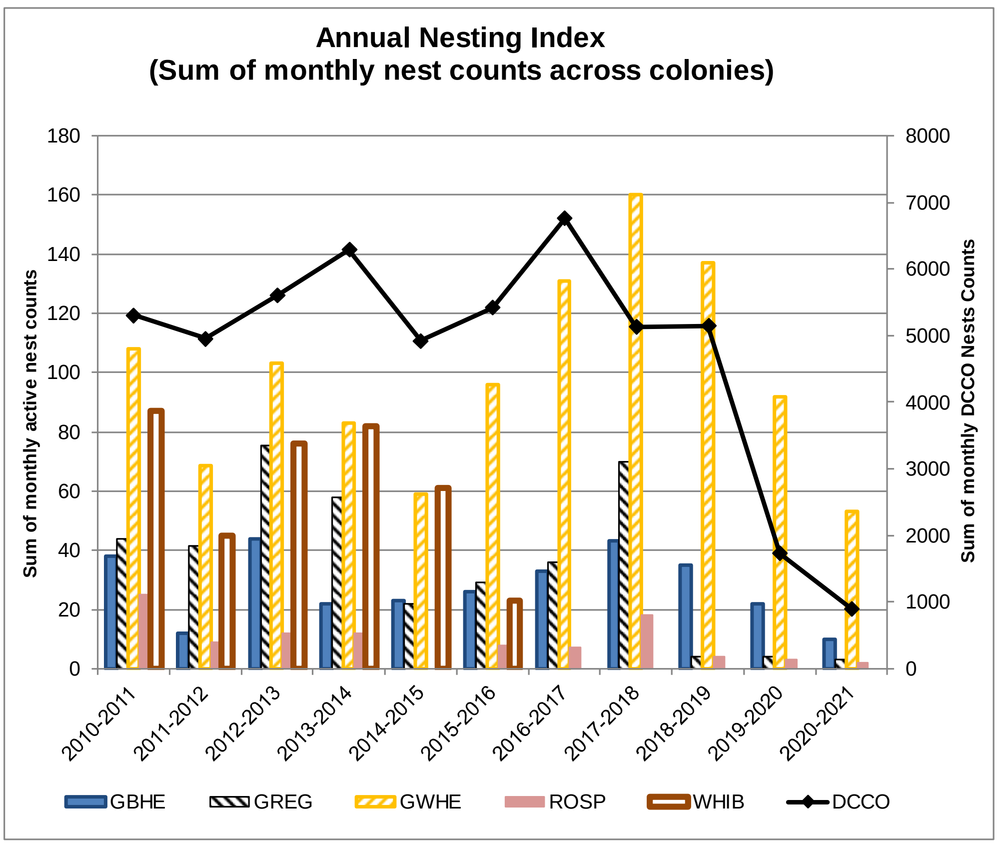

Figure 14. Annual nesting index summed from all colonies.

Table 10. Comparison of peak nest numbers and nesting index for the 2020-2021 nesting season to all previously monitored years. Peak nest 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. The peak nest values are on the left side of the table, and the nesting index values are on the right side of the table. An asterisk (*) indicates colonies with fewer survey periods.

Species	Peak Nest				Peak Index			
	2020-2021	Mean	Max.	Min.	2020-2021	Mean	Max.	Min.
Biscayne National Park								
DCCO	796	981.9	1,336	657	897	4,742	6,763	897
GBHE	19	12.5	19	6	10	28	44	10
GREG	19	15.2	29	3	3	35.2	75.5	3
GWHE	51	32	51	18	53	99.1	160	53
ROSP	12	5.4	12	0	2	9.1	25	0
WHIB	0	43.6	95	0	0	34	87	0
Arsenicker Key								
DCCO	67	130.5	257	49	6	523.7	983.5	6
GBHE	0	0.4	2	0	0	0.6	5	0
GREG	1	0.7	2	0	1	1.2	5	0
GWHE	8	5.6	13	2	10	18.8	46	10
ROSP	0	0.5	1	0	0	0.5	1	0
WHIB	0	25.2	60	0	0	34	87	0
Jones Lagoon								
DCCO	43	93	135	43	64	443.7	905	64
GBHE	9	6.5	10	2	9	17.7	30	6.5
GREG	1	0.9	2	0	1	0.9	2	0
GWHE	19	10.5	19	6	19	33.1	48	18
ROSP	12	5.2	12	0	2	8.9	25	0
WHIB	0	0	0	0	0	0	0	0
Mangrove Key								
DCCO	36	31.5	115	0	5	85.7	309	0
GBHE	5	1.7	5	0	0	3	9	0
GREG	0	0.5	1	0	0	0.3	2	0
GWHE	5	2.7	8	0	7	6	29	0
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0
Ragged Key 5								
DCCO	313	382.5	706	198	472	2,144.1	3,568	472
GBHE	0	0.4	1	0	0	0.4	2	0
GREG	1	0.3	1	0	1	0.3	1	0
GWHE	6	4.7	8	2	4	15.1	29	4
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0
Soldier Key								
DCCO	243	205.7	342	140	275	1,026.4	1,531	275
GBHE	4	1.5	4	1	0	2.5	9	0
GREG	0	0.4	1	0	0	0.4	1	0
GWHE	7	5	10	2	11	15.1	33	5
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0
West Arsenicker								
DCCO	0	1.2	10	0	0	1.5	13	0
GBHE	0	2.5	5	0	0	4.3	15	0
GREG	16	13.2	27	2	0	32.4	73	0
GWHE	1	2.8	6	1	0	9.8	29.5	0
ROSP	0	0	0	0	0	0	0	0
WHIB	0	20.7	95	0	0	0	0	0

Table 10. Continued.

Kings Bay*								
DCCO	56	199.8	357	56	35	797.7	1,578	35
GBHE	0	0	0	0	0	0	0	0
GREG	0	0	0	0	0	0	0	0
GWHE	0	0.3	1	0	0	0.2	1	0
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0
Kings Road Island*								
DCCO	26	45.4	66	26	28	104	209	0
GBHE	0	0	0	0	0	0	0	0
GREG	0	0	0	0	0	0	0	0
GWHE	0	0.5	1	0	0	0.3	1	0
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0
Ragged Key 4*								
DCCO	12	21.3	38	12	12	69	164	12
GBHE	1	0.3	1	0	1	0.3	1	0
GREG	0	0	0	0	0	0	0	0
GWHE	5	2.3	5	1	2	2.5	3	2
ROSP	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0

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SOUTHWEST FLORIDA

The 2021 nesting season represented the 64th consecutive year monitoring the historic Corkscrew Wood Stork (WOST) colony. In 2021, Audubon Florida monitored four wading bird colonies in Lee and Collier counties. In addition to the colony at Audubon's Corkscrew Swamp Sanctuary (CSS), each site has had a WOST colony at some point in the past decade.

The decline in WOST nesting in this region has been concurrent with development and loss of foraging habitat, particularly short hydroperiod wetlands used early in the nesting season. Since 2007, a pattern has emerged in the Corkscrew colony where WOST fail to nest more frequently than they successfully nest. Clem and Duever (2019) suggested this change may be associated with a significant hydrologic change (marked reduction of hydroperiod) that they described at CSS during the same time period. A recently completed hydrologic modeling study concluded that reducing downstream drainage from flood control operations can reduce CSS's dry season water loss. The study recommended developing a mitigation plan to reverse hydrologic change and restore ecologic function for WOST at this historic colony (Clem and Cornell 2021). This restoration would complement ongoing wetland restoration projects like those in Picayune Strand and the Southern Corkscrew Regional Ecosystem Watershed, with the goal of improving foraging and nesting habitat for wading birds.

METHODS

Monthly aerial surveys were conducted from a fixed-wing aircraft December 2020 to June 2021. At each colony location, a series of overlapping photographs were taken of the colony from an altitude of 500 to 1,000 feet. While WOST were the primary target for these surveys, all light-colored wading birds were counted.

HYDROLOGY

Long-term rainfall data from CSS indicate Water Year (WY) 2021 rainfall was typical (57.03 inches), although the distribution throughout the year was not. CSS received above average rainfall in July, October, and December, while cumulative rainfall January to May was low. This resulted in higher-than-typical water levels in the early dry season (through January; likely leading to the observed delay in nest initiation) and high water level recession rates throughout the nesting season. Dry season overdrainage continued to be a problem at CSS in WY21, with water levels falling below ground level for 46 days at CSS's long-term staff gauge. In the 1960s and 1970s, water levels at this gauge only reached ground level an average of 5 days per year.

RESULTS

Flights were conducted December 8, January 5, February 4, March 3, March 16, April 6, May 4, and June 1. Peak nest counts are reported for each colony from the month with the largest number of nests with chicks still associated with individual nests.

Corkscrew Swamp Sanctuary (26.381013, -81.619753)

Nesting at the Corkscrew colony initiated in late February. By mid-March, the colony contained nearly 70 adult WOST. Peak counts included 18 WOST nests, 67 Great Egret (GREG) nests, 2 Roseate Spoonbill (ROSP) nests, and 33 unidentified white wader (WW) nests. WOST chicks began fledging by late May, with 26 fledglings observed on June 1. Monitored since 1958, this colony averaged 2,469 nests per year in the 1960s and 1970s, with effort declining steadily in the 1980s and 1990s, and markedly since the early 2000s. The 2021 WOST nesting effort at this colony was 82% lower than the 5-year average for this colony.

Barron Collier 29 (26.273025, -81.344057)

WOST nesting initiated in late February, and peak nesting was seen in May, with 204 WOST nests, 57 GREG nests, 1 ROSP nest, and 16 WW nests. A total of 291 WOST nestlings were recorded, the majority of which had fledged by early June. Monitored since 2009, 2021 WOST nesting was 24% higher than the 5-year average for this colony.

Collier-Hendry Line (26.370383, -81.272717)

No wading bird activity was observed in 2021. The last nesting effort at this colony was 2012.

Lenore Island (26.688867, -81.830150)

WOST were first observed in January, although nesting activity was not confirmed until early March. Peak nesting was seen in May, with 340 WOST, 3 GREG, 2 WW, 13 Great Blue Heron (GBHE), and 1 ROSP nest. Monitored since 2006, 2021 WOST nesting was 6% higher than the 5-year average for this colony.

Caloosahatchee East (26.696583, -81.794950)

No WOST nesting was observed in 2021. Successful nesting was also confirmed for GBHE and GREG, although nest counts were not available for these species. Monitored since 2006, WOST nesting has only been observed three times at this site (most recent was 2011).

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HOLEY LAND AND ROTENBERGER WILDLIFE MANAGEMENT AREAS

For the fourth consecutive year, Holey Land Wildlife Management Area supported two small nesting colonies on the eastern boundary of the area (26.392066, -80.687990; 26.364234, -80.685069). The nest numbers increased from last year: approximately 9 Tricolored Heron (TRHE) and 25 Little Blue Heron (LBHE) nests in the northern colony and approximately 4 TRHE and 8 LBHE nests in the southern colony.

Rotenberger Wildlife Management Area supported 1 wading bird nesting colony on the western boundary of the area (26.438883, -80.882432). It contained approximately 6 Anhinga (ANHI) nests, 102 Cattle Egret (CAEG) nests, 13 Great Egret (GREG) nests, and 6 LBHE nests.

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ROOKERY BAY NATIONAL ESTUARINE RESEARCH RESERVE

Staff at Rookery Bay collaborated with the Florida Fish and Wildlife Conservation Commission (FWC) to monitor the ABC Islands Critical Wildlife Area (CWA) and Rookery Islands CWA. The FWC will submit the results.

The ABC Islands are northeast of Marco Island and are closed year-round for nesting wading birds (25.956980, -81.703354). In the 2021 nesting season, this colony was surveyed by two people on kayak with the occasional boat survey.

Rookery Islands CWA is located between Marco Island and Naples in Rookery Bay (Island 2: 26.028584, -81.742763; Island 1: 26.031425, -81.745141; Island 0: 26.034497, -81.754245). The islands were surveyed by kayak or boat. This year, all bird activity was centered around Island 1. This location was used primarily as a night roost location for large numbers of wading birds and is closed with an in-water buffer for wading bird use. A small number of Great Egrets (GREG) also nested on this island (**Table 11**).

Curcie Lake had an active colony, but surveying was suspended this year.

Table 11. Nest number at peak count.

Year	Colony	Latitude	Longitude	ANHI	BCNH	CAEG	DCCO	GBHE	GLIB	GRHE	GREG	LBHE	REEG	SNEG	TRHE	WHIB
2021	Rookery Islands CWA	26.03143	-81.7451								5					
2021	ABC Islands CWA	25.95698	-81.7034	1			4	6			23	1	2	2	1	
			Total	**1**	**0**	**0**	**4**	**6**	**0**	**0**	**28**	**1**	**2**	**2**	**1**	**0**

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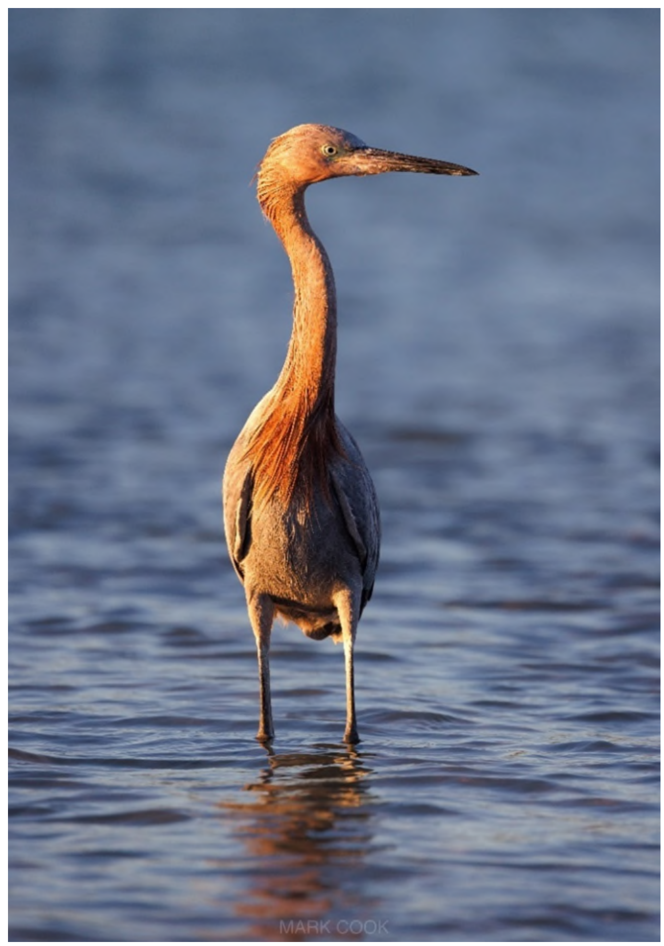

CHARLOTTE HARBOR AQUATIC PRESERVES AND J.N. "DING" DARLING NATIONAL WILDLIFE REFUGE COLONIAL WADING AND DIVING BIRD NEST MONITORING

INTRODUCTION

For 14 consecutive years, the Florida Department of Environmental Protection (FDEP) and United States Fish and Wildlife Service have collaborated to collect wading and diving bird nesting data. Staff at Charlotte Harbor Aquatic Preserves (CHAP), a field site of FDEP's Office of Resilience and Coastal Protection, and J.N. "Ding" Darling National Wildlife Refuge (NWR) have conducted colonial nesting bird surveys within the "Ding" Darling NWR Complex, and the Matlacha Pass, Pine Island Sound, Gasparilla Sound-Charlotte Harbor, Cape Haze, and Lemon Bay Aquatic Preserves (**Figure 15**). Colonial wading and diving bird nest monitoring began in 2008 with nine islands and expanded to 34 islands in 2011. In this 2021 nesting season, 40 islands were monitored and 29 were identified as active wading and diving bird nesting sites. Goals of this continuous study include establishing a long-term data set to assess nesting effort and seasonality as well as to monitor activity status of known rookeries and establishment of new rookeries in the greater Charlotte Harbor area. In 2017, two islands in Pine Island Sound (Hemp Key and Broken Islands) were designated by the Florida Fish and Wildlife Commission as Critical Wildlife Areas (CWA). The islands were posted as CWAs in 2018.

METHODS

The study area was divided between two agencies based on location. J.N. "Ding" Darling NWR staff monitored islands in South Matlacha Pass, San Carlos Bay, and South Pine Island Sound. FDEP/CHAP staff monitored islands in North Matlacha Pass, North Pine Island Sound, Gasparilla Sound, Lemon Bay, and Cape Haze. Both agencies employed the same direct count method with a boat captain, data recorder, and two observers. Islands were circled by boat, and nests were recorded by nesting stage as either incubating, chicks, or unknown for each species. The incubating stage was used when an adult was sitting on and shading the nest. The chicks stage was used when juvenile birds were visible in or near the nest. This category was counted as a nesting stage (chicks in the nest) and not used as a measure of productivity. The unknown stage was used when the nesting stage could not be determined. Data were collected from February through July 2021. Peak numbers reflect the highest number of nests per species throughout the survey period. The total number of peak nests were also calculated for each island.

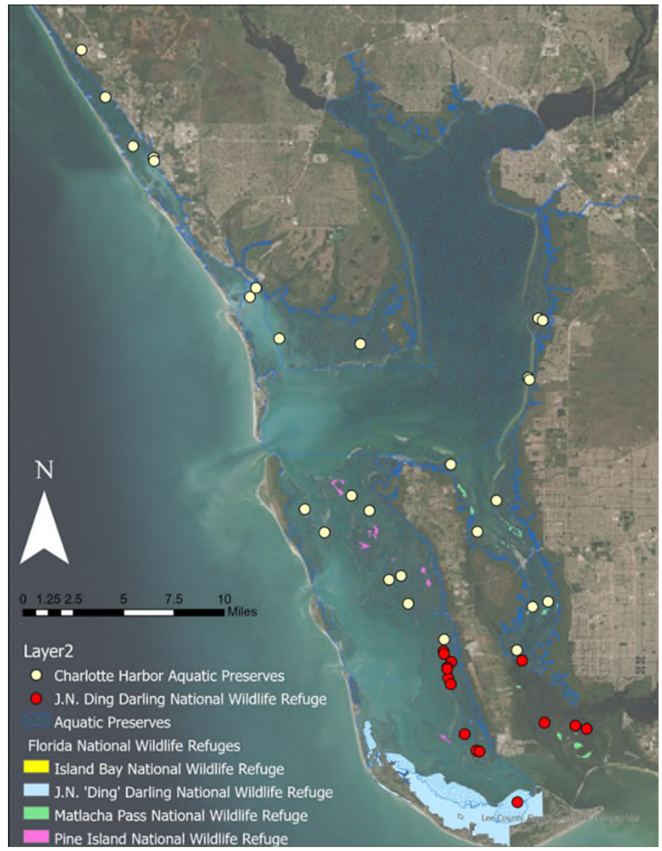

Figure 15. Locations of monitored bird colonies in the Charlotte Harbor Aquatic Preserves and J.N. "Ding" Darling NWR Complex.

RESULTS

The peak estimate for all colonial nesting birds in the study area was 1,769 nests (**Table 12**). This was a 5.5% increase, 92 nests, from the the 2020 season total peak nesting effort of 1,677. Diving birds constituted approximately 65% of the documented nests, while the remaining 35% were wading bird nests. Diving bird nests decreased by 2%, while wading bird nests increased 13% in 2021 compared to 2020. The largest nesting efforts in 2021 occurred on Hemp Key (337 nests), Broken Islands (333 nests), and Useppa Oyster Bar (127 nests). In 2021, Tarpon Bay Keys supported the greatest species diversity with 12 species nesting.

Table 12. Colonial nesting bird peak counts for Charlotte Harbor Aquatic Preserves and J.N. "Ding" Darling NWR complex between February through July 2021.

Colony (Island)	Latitude	Longitude	GBHE	TRHE	LBHE	SNEG	GREG	REEG	CAEG	YCNH	BCNH	GRHE	WHIB	BRPE	DCCO	ANHI	ROSP	Total
Bodifer Key	26.4977	-82.1125	1															**1**
Broken Islands	26.6777	-82.1940	3	26	2	3		1	9				48	144	88	7	2	**333**
Burnt Store Marina N	26.7625	-82.0669	5	3	6	10	5				1			25	3			**58**
Burnt Store Marina S	26.7611	-82.0660	2							5		2						**9**
Clam Key	26.5063	-82.1128	1					1		1				3	20	2		**28**
Crescent Island	26.5979	-82.0639										1						**1**
E of Chadwick Cove	26.9289	-82.3511	11			18	14								2		1	**46**
Fish Hut Island	26.5467	-82.1245	3	3	1	2	2	1	2		1			4	5	3		**27**
Forked Creek Keys	26.9980	-82.3879		4	4	11	24		5		6	1		3	6	3		**67**
Gasparilla Marina S	26.8269	-82.2625	4	2		3	10				2			25	32	3		**81**
Givney Key	26.5145	-82.0553	1															**1**
Hemp Key	26.5999	-82.1532	21				29	3		1	1			115	167			**337**
Lumpkin Island	26.6015	-82.0526	4													2		**6**
N of York Island	26.4945	-82.1043	1	1		2	4							31	16	5		**60**
N of Big Smokehouse	26.0000	-82.1225	5												15			**20**
NE of York Island	26.4940	-82.1021	1											14		2		**17**
NW of Mason Island	26.5543	-82.125													1	3		**4**
NW of Pumpkin Key	26.5660	-82.1279	2								1				13			**16**
Oyster Creek W	26.8181	-82.3359	6			1	9							31	21		9	**77**
Pirate Harbor N	26.8052	-82.0597	6			5	23	1		1				31	31	5		**103**
Pirate Harbor SE	26.8037	-82.0565	2	18	4	10			28		1			25	17	2	1	**108**
Royal Palm Marina W	26.9640	-82.3708	8															**8**
Skimmer Island	26.5104	-82.0250	3	7		2	2	1			1			25	22	1		**64**
SW of Mason Island	26.5534	-82.1250	1												9	2		**12**
SW of Pumpkin Key	26.5640	-82.1275	2				1	1							8			**12**
Tarpon Bay Keys	26.4577	-82.0744	3	2	1	3	27	1	2	1		1	0	10	13	1		**65**
Turtle Bird Island	26.7876	-82.1876		9		9	6	1	1		1			1	14			**42**
Useppa Oyster Bar	26.6513	-82.2134	3	1			1							60	62			**127**
White Pelican Island	26.7905	-82.2463	8			16	9	3		1	1				1			**39**
Total			**107**	**76**	**18**	**95**	**166**	**14**	**47**	**10**	**16**	**5**	**48**	**547**	**566**	**41**	**13**	**1,769**

Note: Nesting birds were not observed at the following colonies (islands): Bird Keys, Bird Rookery Keys, Cork Island, Darling Keys, Little Oyster Creek, Lower Bird Island, Masters Landing, N of Mason Island, N Regla, and Upper Bird Island.

Species Summaries – Diving Birds

Double-crested Cormorant (DCCO)

DCCO nesting peaked at 566 nests, which is approximately 32% of the total nests in the 2021 season. This was a 10% decrease from 628 peak nests documented in 2020. Nesting was documented on 22 islands, with the highest nest count of 167 occurring on Hemp Key in April.

Brown Pelican (BRPE)

BRPE nesting peaked at 547 nests on 16 islands accounting for approximately 31% of the nesting effort documented this season. This was a 14% increase from the 478 peak nest count in 2020. The highest peak nest count occurred in June at Broken Islands with 144 nests.

Anhinga (ANHI)

ANHI nesting peaked at 41 nests, which was up 64% from the 2020 peak count of 25. The highest nest count observed occurred on Broken Islands with a peak nest count of 7.

Species Summaries – Wading Birds

Great Blue Heron (GBHE)

GBHE nesting efforts were documented on 25 of the 29 active islands. The peak nest count for GBHE was 107. This was a 19% increase from last year's peak nesting effort of 90. Hemp Key (21 nests) had the largest number of peak nests.

Tricolored Heron (TRHE)

TRHE nests were documented on 11 islands with a peak nest count of 76. This was a 3% increase from last year's peak nest count of 74. The highest peak nesting effort occurred on Broken Islands with a peak nest count of 26.

Little Blue Heron (LBHE)

LBHE nesting peaked at 18 in 2021. This was a 40% decrease from the peak nest count of 30 in 2020. Nests were documented on 6 islands with the highest nest count of 6 on Burnt Store Marina N.

Snowy Egret (SNEG)

SNEG nesting occurred on 14 islands with a peak nest count of 95. The highest nest count of 18 was recorded at E. of Chadwick Cove.

Great Egret (GREG)

GREG nesting peaked at 166. This was a 91% increase from the peak nest count of 87 in 2020. The greatest GREG nesting effort was documented on Hemp Key with a nest count of 29 nests.

Reddish Egret (REEG)

REEG were documented nesting on 10 islands with a peak nest count of 14. This was an increase of 1 nest from the 2019 peak nesting effort. The highest nest count observed occurred on White Pelican Island and Hemp Key, each having a peak nest count of 3.

Yellow-crowned Night Heron (YCNH)

YCNH had a peak nest count of 10 in the 2021 nesting season. Burnt Store Marina S. had the highest peak nest count (5 nests) in May.

Black-crowned Night Heron (BCNH)

BCNH nesting was documented on 10 islands and peaked at 16 nests. This was an increase of 100% from the peak nest count of 8 in 2020.

Green Heron (GRHE)

GRHE nesting peaked at 5, and nesting activity occurred on 4 islands. This was a decrease of 1 nest from the 2020 peak nesting effort.

White Ibis (WHIB)

WHIB nesting occurred on 2 islands with a peak count of 73. This was a 55% increase from last year's peak nest count of 47. Broken Islands accounted for the most documented nests (71 nests).

Cattle Egret (CAEG)

CAEG nesting peaked at 47 in 2021. This was a 34% decrease from the peak nest count of 47 in 2020. The highest peak nest count of 28 was recorded at Pirate Harbor SE in May.

Roseate Spoonbill (ROSP)

ROSP were first documented in the study area in 2018. Since then, ROSP continue to be documented in 2019, 2020, and 2021 seasons. The peak nesting effort (13 nests) occurred on 3 islands with the highest nest count of 9 on Oyster Creek W. This was a 225% increase from the peak nest count of 4 in 2020 and the highest peak nesting effort to date.

CONCLUSIONS

The total peak nesting effort in 2021 was 1,769 nests. This is a 5.5% increase from the 2020 nesting season. The 2021 monitoring season marks the highest annual peak nest count to date. From 2020 to 2021, the peak nest count increased for five wading bird species and two diving bird species. Overall, the annual peak nesting data from 2014 to 2021 indicate the peak nesting effort has been stable over time (**Figure 16**).

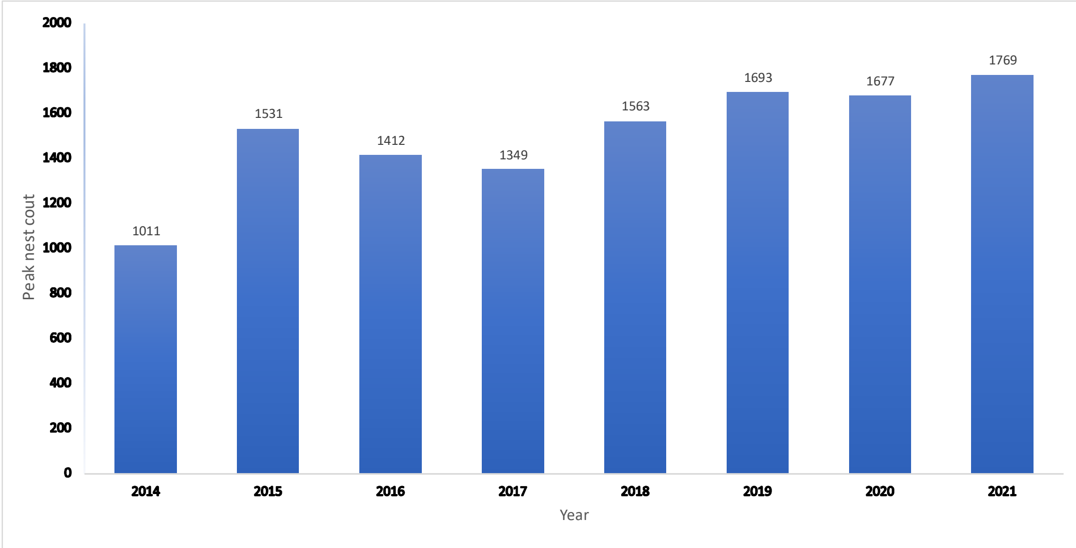

Figure 16. Annual peak nest counts in study area from 2014 to 2021

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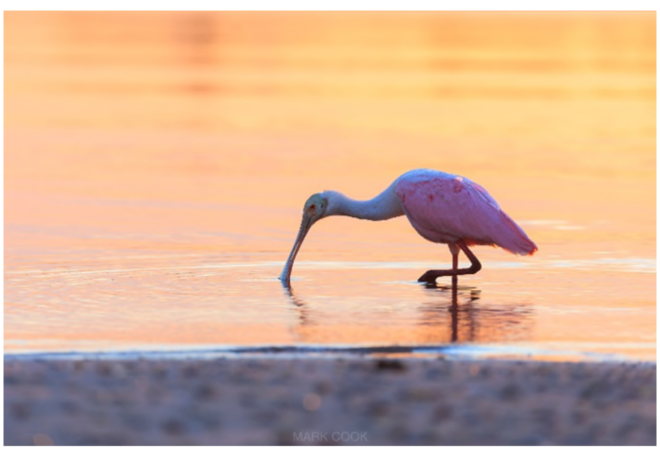
ESTERO BAY AQUATIC PRESERVE COLONIAL NESTING WADING AND DIVING BIRD MONITORING AND PROTECTION PROGRAM

Estero Bay Aquatic Preserve (EBAP) was designated in 1966, becoming Florida's first aquatic preserve. EBAP is a field site of the Florida Department of Environmental Protection managed by the Office of Resilience and Coastal Protection. The colonial nesting wading and diving bird monitoring and protection program began in 2008 with 15 islands and has since expanded to 34 islands, 15 of which were active in this 2021 nesting season.

Historically, the highest concentration of wading and diving bird nesting activity has been observed on three islands: Matanzas, Coconut Point East, and Big Carlos Pass West of M-52. These islands are designated as Critical Wildlife Areas and were marked in February of 2018.

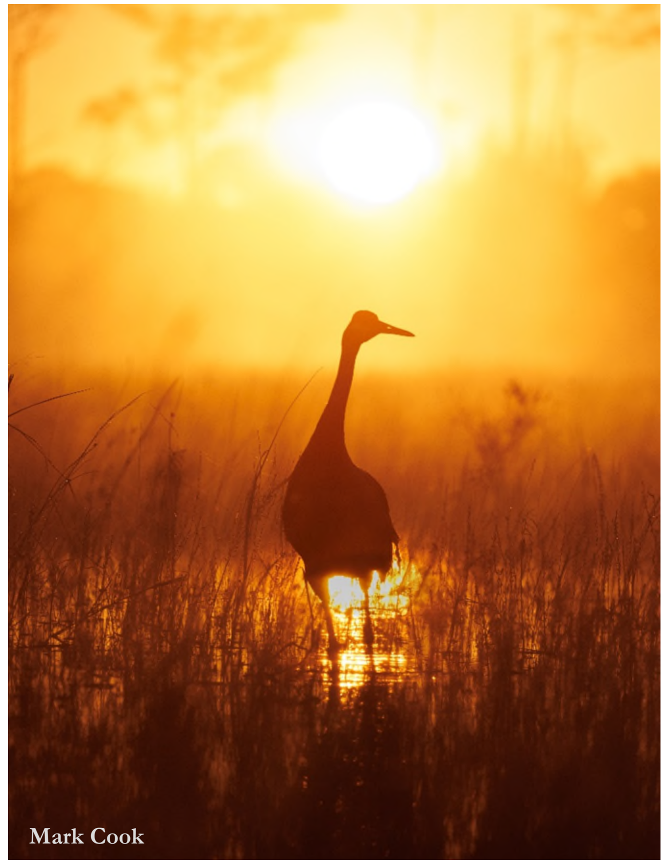
The objectives of this program are to

- Provide peak estimates of nesting effort for each species of colonial nesting bird;
- Monitor population trends;
- Record movement of colonies, human disturbance, and bird fatalities due to fishing line entanglement;
- Reduce the number of entanglements and fatalities due to fishing line and trash within the bay; and
- Provide recommendations for the management of nesting wading and diving bird colonies in the aquatic preserve.



METHODS

Surveys between 2008 and 2021, were conducted monthly throughout the nesting season. Since 2012, surveys have been conducted year-round due to the extended period of nesting. Employing a direct count method, two observers surveyed each island by boat from 30 meters away with a third person recording the data for each nest's species and stage (Paul and Paul 2004). Staff from EBAP, Charlotte Harbor Aquatic Preserves (CHAP), and the Florida Fish and Wildlife Conservation Commission (FWC) fulfilled all roles while volunteering was suspended (mid-March 2020 through June 2021), after which staff or volunteers filled the secondary observer and data recorder roles. The average of the two observers' counts were reported. Peak nest counts from 2021 were compared with mean peak nest counts from 2008 through 2020, which represent a 13-year average. Peak nest counts of species that started nesting in recent years (ANHI, WHIB, and ROSP) were compared to the average since their nesting was documented in EBAP.



RESULTS

The observed peak nesting effort for wading and diving birds was 311 nests (**Table 13**). Nesting peaked in March in EBAP with an estimated 177 active nests. The Matanzas Pass colony, with an annual peak of 91 nests, had the greatest nesting concentration in the bay. Overall, nesting effort decreased 33% from the 13-year average (**Table 14**). All species-specific increases or decreases in nesting effort are in comparison with the 13-year average unless noted otherwise.

Double-crested Cormorant (DCCO) nests were documented on 5 islands. Nesting activity peaked in June (45 nests). The annual peak (66 nests) decreased 4%.

Brown Pelican (BRPE) nests were documented on 3 islands. Nesting peaked in June (55 nests). The annual peak (65 nests) decreased 48%.

Great Blue Heron (GBHE) nests were documented on 12 islands. Nesting effort peaked in February and March (37 nests). The annual peak (48 nests) decreased 28%. One white morph was documented in 2021.

Great Egret (GREG) nests were documented on 5 islands. Nesting peaked in March (46 nests). The annual peak (52 nests) decreased 6%.

Snowy Egret (SNEG) nests were documented on 5 islands, with peak nest counts in June (19 nests). The annual peak nest count (24 nests) decreased 19%.

Little Blue Heron (LBHE) nests were documented on 2 islands, with peak nest counts in April and August (1 nest). The annual peak nest count (2 nests) decreased 85%.

Tricolored Heron (TRHE) nests were documented on 4 islands. Peak nesting effort occurred in July with (16 nests). The annual peak (19 nests) decreased 51%.

Reddish Egret (REEG) nests were documented on 5 islands, with peak nesting effort in April (9 nests). The annual peak nest count (10 nests) increased 24%.

Black-crowned Night Heron (BCNH) nests were documented on 4 islands, with peak nesting effort in July (8 nests). The annual peak (9 nests) decreased 43%.

Yellow-crowned Night Heron (YCNH) nests were not documented on any of the islands, representing a 100% decrease in nesting effort.

Green Heron (GRHE) nests were documented on 3 islands, with peak nesting effort in May (5 nests). The annual peak nest count (6 nests) decreased 15%.

Cattle Egret (CAEG) nesting was not documented in Estero Bay in 2021, representing a 100% decrease in nesting effort.

Roseate Spoonbill (ROSP) nests were documented on 1 island with peak nesting in April (7 nests). The annual peak nest count (7 nests) increased 367% compared to the 4-year average since ROSP nesting activity was first documented in 2017.

Anhinga (ANHI) nesting was not documented on any islands, representing a 100% decrease in nesting effort compared to the 3-year average. There was minimal nesting in the previous 3 years.

White Ibis (WHIB) nesting was documented on 1 island with peak nesting in September (3 nests). The annual peak nest count (3 nests) equaled to the previous 3-year average since nesting was first documented in 2018.

This year's work was completed with the invaluable assistance from CHAP and FWC. Staff and volunteers removed 462 feet of fishing line and 12 hooks from nesting islands and nearby locations between January and September. Large-scale cleanups of the islands are conducted after nesting season to minimize disturbance to colonies. Twenty-one bird fatalities (2 DCCO, 8 BRPE, 1 SNEG, 1 TRHE, 2 ANHI, 4 BCNH, and 3 unknown) due to fishing line entanglement were documented.

Table 13. Peak nest counts documented in Estero Bay Aquatic Preserve colonies, January through August 2021.

Colony	Latitude	Longitude	DCCO	ANHI	BRPE	GBHE	GREG	SNEG	LBHE	TRHE	REEG	CAEG	BCNH	YCNH	GRHE	ROSP	WHIB	Total
Big Bird Island	26.38285	-81.84995	10			3												**13**
Big Carlos Pass between M-50 and M-52	26.42244	-81.89527				2												**2**
Big Carlos Pass between M-46 and M-48	26.42773	-81.90218													1			**1**
Big Carlos Pass W of M-52	26.42469	-81.89359			4	2	17	1			1							**25**
Big Hickory E of M-85	26.35315	-81.84164	13			7					2							**22**
Coconut Point East	26.38411	-81.84905	10		32	3	17	3		2	1		2			7		**77**
Coconut Point West	26.38111	-81.84976				1												**1**
Chain of Islands	26.43802	-81.86937													4			**4**
Denegre Key	26.43771	-81.86728	15			7	1	1		2			1					**27**
Estero River M-30	26.43029	-81.86112													1			**1**
Matanzas Pass	26.46092	-81.95717	18		29	14	7	6	1	6	5		2				3	**91**
New Pass M-9	26.40465	-81.86816				3												**3**
North Coconut E of M-3	26.41131	-81.85486				2	10	13	1	9	1		4					**40**
North Coconut M-4 Monkey Joe Key	26.40737	-81.85998				3												**3**
Taryn's Key	26.41069	-81.85411				1												**1**
Total			**66**	**0**	**65**	**48**	**52**	**24**	**2**	**19**	**10**	**0**	**9**	**0**	**6**	**7**	**3**	**311**

Note: Nests were not observed in the following colonies: 619038C, Big Carlos Pass M-43, Big Carlos Pass W of M-46, Big Carlos Pass M-48, Big Carlos Pass S of M-48, Big Hickory M-83 Seagrass Island, Big Hickory Pass M-49 2 NW, Big Hickory Pass M-49 3 NW, Estero River North, Estero River South, Houge Channel M-78, Hurricane Pass/Rebecca's Island, Kelsey's Island, Little Davis Key, New Pass M-21, North Coconut M-2, Ruth's Island, Emily's Keys, and Taylor Island.

Table 14. Mean peak nest counts (2008 to 2020), standard error, current (2021) peak nest count, and percent mean difference by species.

Species	Mean (2008-2020)	Standard Error	Standard Deviation	Peak (2021)	Percent Change	Percent Change 2020-2021
DCC0	69	5	17.5587	66	-4	-12
ANHI*	2	0	0.5774	0	-100	-100
BRPE	124	13	48.5698	65	-48	-38
GBHE	66	5	16.4395	48	-28	-17
GREG	56	7	24.8952	52	-6	-12
SNEG	29	3	10.2194	24	-19	-29
LBHE	13	2	6.4420	2	-85	0
TRHE	38	5	18.9676	19	-51	-73
REEG	8	1	2.8420	10	24	-9
CAEG	1	0	1.7022	0	-100	-100
BCNH	16	3	9.6622	9	-43	-18
YCNH	18	2	7.5073	0	-100	-100
GRHE	7	1	4.6630	6	-15	-57
ROSP**	2	0	0.5774	7	367	250
WHIB*	3	2	3.6056	3	0	-57
Total	**448**	**25**	**91.4831**	**311**	**-31**	**-33**

Note: *WHIB and ANHI 2021 peaks were compared to 2018-2020 data, not the 13-year average.
**ROSP 2021 peak was compared to 2017-2020 data, not the 13-year average.

DISCUSSION

Estero Bay nesting activity continues to exhibit annual variation. The annual peak nest count this season (311 nests) was the lowest recorded in the last 13-year period during (448 nests) (**Figure 17**).

One species (REEG) increased nesting activity in 2021 compared to the 13-year average. ROSP nesting (7 nests) also increased from its previous years' average (2 nests) since EBAP first documented ROSP nesting in 2017. While 11 species (DCCO, GBHE, GREG, LBHE, CAEG, YCNH, BCNH, BRPE, SNEG, TRHE, and GRHE) decreased nesting activity in 2021 compared to the 13-year average. ANHI also decreased in nesting effort, while WHIB equaled nesting effort compared to data from 2018 to 2020. One island, Big Carlos Pass W of M-52, experienced a colony collapse between March and April and did not recover. This is historically one of Estero Bay's most active islands, and the causes, such as natural predators or human disturbance, are currently under investigation.

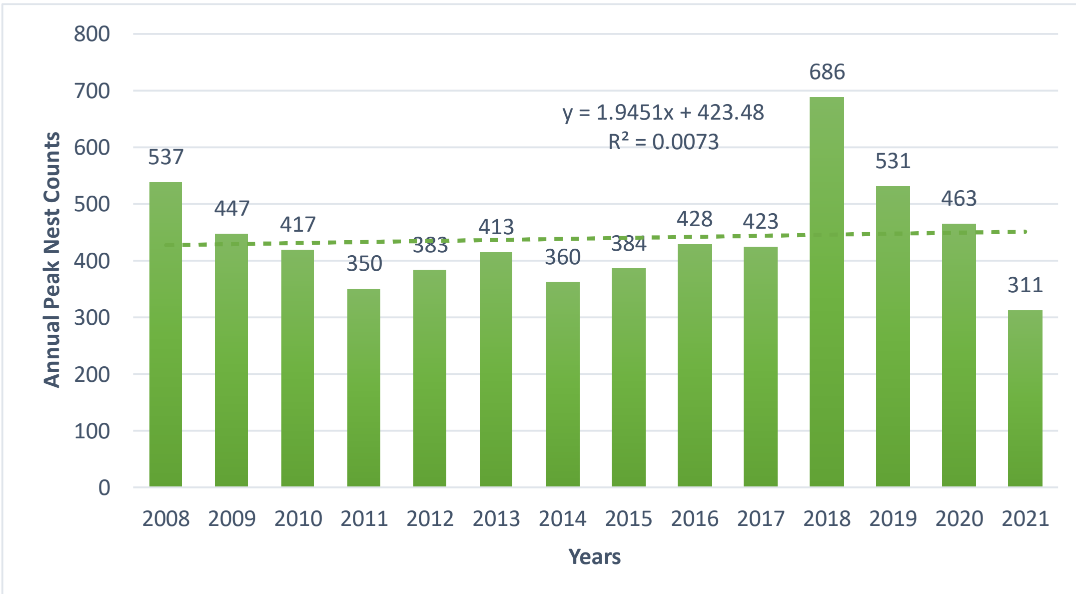


Figure 17. Annual peak nest counts in Estero Bay Aquatic Preserve from 2008 to 2021.

ACKNOWLEDGMENTS

Sincerest thanks to the staff from CHAP and FWC for their assistance this season; without their help, it would not have been possible.

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CORKSCREW REGIONAL ECOSYSTEM WATERSHED MANAGEMENT AREA

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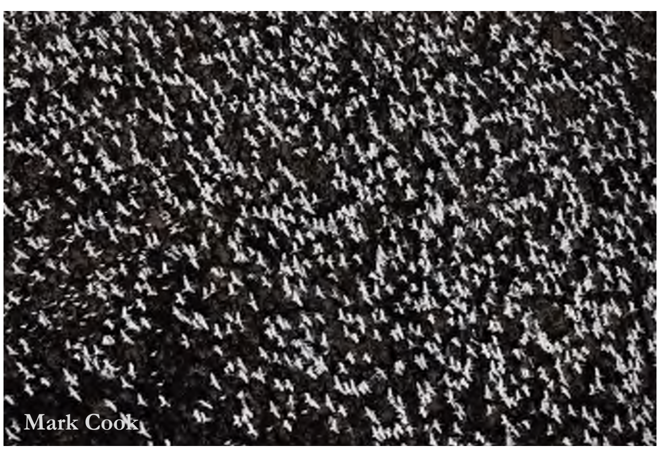
The Florida Fish and Wildlife Conservation Commission (FWC) did not conduct any wading bird surveys in the 2021 season in the Corkscrew Regional Ecosystem Watershed (CREW) Management Area. Moving forward, until drones are permissible to use, the FWC will not conduct wading bird surveys. Drones may become an option in the near future; however, the FWC has eliminated aerial surveys via aircraft.

WADING BIRD NESTING AT LAKE OKEECHOBEE

Florida Atlantic University (FAU) has been annually monitoring the timing, size, and location of wading bird colonies at Lake Okeechobee as part of the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan since 2005. In 2021, three focal species, Great Egret (GREG), Snowy Egret (SNEG), and White Ibis (WHIB), initiated an estimated 3,024 nests which is 9% lower than the average since 2008, when the current lake schedule went into effect. Nest abundances were 12% and 11% below average for GREG and SNEG, respectively, whereas WHIB were 4% higher. Nest abundances in this 2021 season were moderate, with 7 years showing lower nest abundances, and 7 years showing higher nest abundances, since 2008. Nesting was observed on marsh, spoil island, and off-lake colonies due to wet conditions in the littoral zone. The Moonshine Bay (1,114 nests) and Pahokee Airport (425 nests) colonies, a marsh and a spoil island and off-lake colony, respectively, supported the largest number of nests of these species.

METHODS

FAU personnel have monitored annually the location, timing, and number of nest initiations of wading birds in colonies on the lake from February to June. Systematic aerial surveys were conducted monthly along transects covering the lake's littoral zone, with two dedicated observers surveying for nests of the five focal species: SNEG, GREG, WHIB, Wood Stork (WOST), and Roseate Spoonbill (ROSP). Counts and species composition of large colonies were subsequently verified by airboat. Estimates of nest initiation date were based on nest monitoring by boat at three spoil island colonies. More detailed methods are described in the 2015 edition of the *South Florida Wading Bird Report.*



Rainfall and lake stage data were obtained from the South Florida Water Management District (SFWMD) DBHYDRO database. The lake stage is calculated as the mean of four gauges in the pelagic zone of Lake Okeechobee (L001, L005, L006, and LZ40). All elevation data are presented in National Geodetic Vertical Datum 1929 (NGVD29), and locations are in North American Datum 1983 (NAD83). Stage data from 2008 represent the lake levels under the current Lake Okeechobee Regulation Schedule.

RESULTS

Hydrology

The 2021 nesting season was characterized by high lake stage, a moderate recession rate, and four reversals preceding the seasonal rise in water levels in June (**Figure 18**). From January 1 to February 6, the mean recession rate was 0.8 inches per week before unseasonal rainfall caused the lake stage to increase to a season high of 15.92 feet on February 18. The lake receded at a mean rate of 1.45 inches per week from February 18 to April 11 when heavy rainfall caused the lake stage to increase from 14.14 feet on April 11 to 14.23 feet on April 13. The lake receded at a rate of 1.85 inches per week from April 14 to June 14, except for one minor reversal in late May. During that reversal, lake stage increased .04 inches before receding to the lowest level of the season, 12.41 feet on June 14. The two moderate reversals (February 18 and April 13) during this season likely lowered prey availability and thus nest numbers. The first reversal in particular may have impacted nest numbers as it occurred just prior to peak nest initiation for GREG at the lake. The second reversal occurred after peak nesting in Small Herons (SMHE), but observed SMHE nest initiation decreased during, and increased immediately after, the reversal.

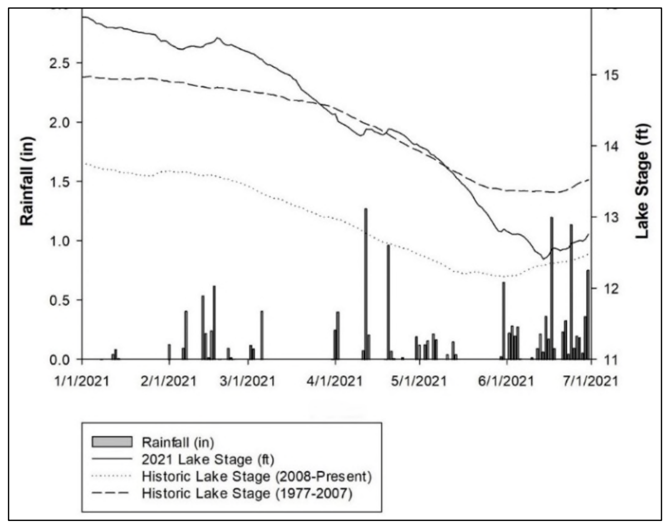


Figure 18. Hydrologic patterns on Lake Okeechobee from January to July 2021 and mean lake stage from 1977 to 2007 and from 2008 to present since the 2008 Lake Okeechobee Regulation Schedule was implemented.

Colony Location and Size

Ten colonies (**Figure 19**) supporting 3,024 GREG, SNEG, and WHIB nests were detected, which is 9% lower than the average from 2008 to 2021 (3,309 ± 1,563; all averages use standard deviation [SD]). Colonies were located at four natural willow colonies in the marsh (Eagle Bay Island, Clewiston Marsh, Moorehaven, Moonshine Bay), three created spoil islands (Little Bear Beach, Clewiston Spit, and Pahokee Airport), and three off-lake created islands (Lakeport Marina, Gator Farm, Gun Range). Moonshine Bay was the largest colony, supporting 1,114 GREG, SNEG, and WHIB nests (**Table 15**). Peak nest abundance was 693, 758, and 1,573 for GREG, SNEG, and

WHIB, respectively, which is close to the median for nest abundance since 2008 (**Table 16**). GREG and SNEG nest abundance was 2% and 27% lower than average from 2008 to 2019, whereas WHIB nest abundance was 33% greater, respectively (707 ± 476 GREG nests, 1,423 ± 1,055 SNEG nests, 1,179 ± 875 WHIB nests). GREG and WHIB showed a similar decline in the Water Conservation Areas (72% and 38% below the 10-year average, respectively). However, SNEG nesting was a notable exception, with Everglades' nest numbers being 4.1 times higher than the 10-year average. Average abundance of GREG, SNEG, and WHIB nests continues the trend of being higher under the current lake regulation schedule (3,048 ± 1,607) compared to the 1977 to 2007 lake regulation schedule (2,601 ± 2,364).

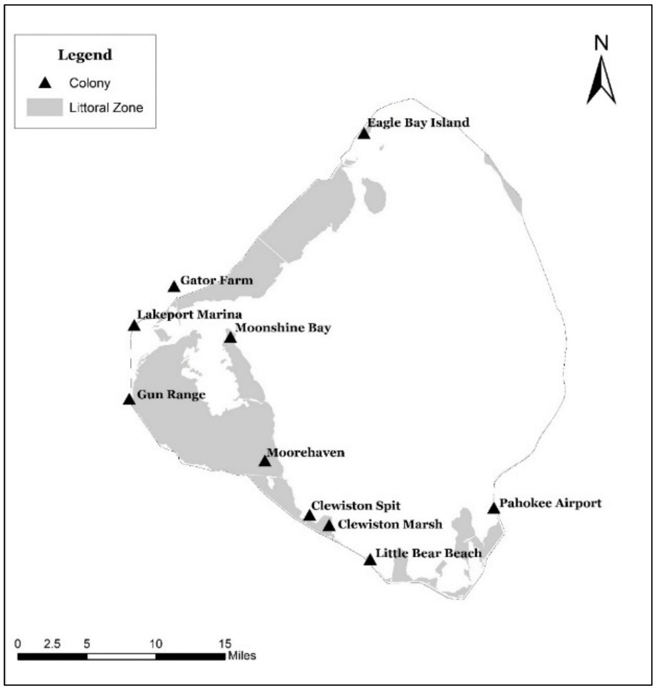


Figure 19. Map of wading bird colonies detected on Lake Okeechobee from February to June 2021.

Timing and Success

The median clutch initiation date for GREG (March 7 ± 13.6 days) was 7 days earlier than the average since 2009 (March 14). Median clutch initiation date for SNEG (April 3 ± 11.20 days) was one day earlier than the average since 2009 (April 4). Median clutch initiation date for WHIB (May 8 ± 20.27 days) was 9 days earlier than the average since 2009 (May 17). Apparent nest survival (proportion of monitored nests that fledged at least one chick) was 0.86 for GREG, 0.76 for SMHE, and 0.76 for WHIB, which is 16%, 1%, and 14% higher than the average apparent survival from 2011 to 2021, respectively (0.60 ± 0.20 GREG, 0.75 ± 0.09 SMHE, 0.62 ± 0.08 WHIB), the period for which nest survival data are available. Overall, survival in 2016, a hydrologically similar year, was identical for SMHE (0.62) and nearly identical for GREG (0.75).

Wood Storks and Roseate Spoonbills

Forty-one WOST nests and 24 ROSP nests were detected at the Gator Farm, an off-lake colony located north of the Moonshine Bay area. Three ROSP nests were also detected at Clewiston Spit, and one ROSP nest was detected at Moonshine Bay. Although this is the first time since 2015 that ROSP have been observed nesting in on-lake colonies, all nests outside of the Gator Farm failed. Forty-one WOST fledglings were counted in photos taken during the aerial survey on May 17, and 24 ROSP fledglings in photos taken during the aerial survey on June 17. WOST have nested at the Gator Farm in 10 of the last 15 years (2007 to 2010 and 2016 to 2021) and have successfully fledged chicks every year nesting has occurred. ROSP have nested at natural colonies in the littoral marsh (3 nests in 2009; 2 nests in 2013; 1 nest in 2021), at a created spoil island colony (1 nest in 2015; 3 nests in 2021), and at the Gator Farm (4 to 24 nests from 2016 to 2021) where they successfully fledged chicks from 2018 to 2021.

Table 15. Geographic coordinates (NAD83) and species-specific peak nest abundances in detected colonies during the 2021 breeding season at Lake Okeechobee.

Colony	Peak Month [1,2]	Latitude	Longitude	GREG	SNEG	TRHE	ROSP	WHIB	LBHE	GLIB	GBHE	CAEG	WOST	Total[1]
Clewiston Spit	March	26.77658	-80.90914	148	202	67	2							**419**
Clewiston Marsh	June	26.76599	-80.89796		45			205				120		**250**
Eagle Bay Island	April	27.17064	-80.84643	3	206	50		137		137		343		**533**
Gator Farm	March	27.02278	-81.06084	175	4	3	16	25					25	**248**
Gun Range	March	26.893216	81.124687	40										**40**
Lakeport Marina	April	26.9726	-81.1144	187	19	9						277		**215**
Little Bear Beach	April	26.721389	-80.842222	115	120	56			3		5			**299**
Moonshine Bay	June	26.92755	-81.03479	15	101	14		998		71				**1,199**
Moorehaven East 4	April	26.892645	-81.050998	56	5						4			**65**
Pahokee	June	26.77908	-80.697596		298	100		127				26		**525**
	Total			**739**	**1,000**	**299**	**18**	**1,492**	**3**	**208**	**9**	**766**	**25**	**3,793**

[1] Does not include CAEG or ANHI.
[2] Peak month refers to the month during which combined nest effort peaked and does not refer to species-specific peak nest numbers.

Table 16. Timing and nest numbers for species breeding in wading bird colonies at Lake Okeechobee in 2021.

Month	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	ANHI
February	432	--[a]	--[a]	19	--[a]	**5**	--[a]	--[a]	--[a]	--[a]	--[a]
March	**693**	25	361	16	18	5	3	133	--[a]	50	--[a]
April	548	562	**758**	28	**21**	5	--[a]	**239**	**457**	647	--[a]
May	284	739	462	**40**	9	--[a]	**8**	171	381	1,030	--[a]
June	109	**1,573**	635	11	6	--[a]	--[a]	156	91	**1,456**	--[a]

[a] Large number of roosting birds present, but not on nests.
Note: Bold values denote peak nest effort for species.

ACKNOWLEDGMENTS

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SAVANNAS PRESERVE STATE PARK

The Savannas Preserve State Park is a 5,000-acre property in northern Martin County and southern St. Lucie County, situated just west of the Indian River Lagoon. The property is bisected by an oligotrophic, linear basin marsh system that stretches from Jensen Beach to southern Fort Pierce. It is the longest contiguous freshwater marsh system of its kind remaining in southeast Florida, spanning approximately 10 miles north and south. The western preserve is dominated by a pine flatwood community with numerous depression marshes and wet prairies. The eastern preserve is along the Atlantic Coastal Ridge and typically dominated by sand pine scrub and scrubby flatwood communities. The marsh and associated wetlands provide a stopover for migrating birds and support nesting activities in small tree islands and dense sawgrass patches.

Beginning in February 2021, Florida State Park staff surveyed a historic wading bird rookery at Savannas Preserve State Park. This rookery and two others to the south were originally surveyed between 1995 and 2003 by the South Florida Water Management District.

The Savannas Preserve State Park basin marsh hydrological conditions are driven primarily by annual rainfall patterns but also are influenced by local runoff. Rainfall accumulation for 2021 peaked in mid-June with the monthly accumulation of 11.82 inches. Drought followed a typical pattern and peaked from early March through late April. In 2021, basin marsh levels remained low to moderate throughout the breeding season, with a deficit of approximately 8 inches when compared to average rainfall figures from 2016 to 2021 (**Figure 20**).

METHODS

The North Marsh Rookery is a shrub island within the basin marsh located approximately 1 mile north of Walton Road and 0.5 mile west of Indian River Drive. This island primarily consists of pond apple and wax myrtle with sawgrass edges. Surveys were completed by canoe along the island's western and southern edge.

Figure 20. Savannas Preserve State Park basin marsh view from the water.

RESULTS

Overall nest numbers in the 2021 season are similar to numbers observed in the 2020 season and approximately 3 times greater than numbers collected from 2018 and 2019. This site was surveyed February through June with peak nesting figures in May and June. The 2021 nest counts for the North Marsh Rookery are provided in **Table 17**.

FUTURE PLANS

Savannas Preserve State Park strives to continue surveys to develop long-term data that can be matched with statewide numbers. This, coupled with rainfall and water level data, will help to determine long-term water management strategies within the basin marsh system. Plans are to continue surveys at the North Marsh Rookery and observe any notable nest numbers at the South Marsh Rookery (27.2769, -80.2474) between February and June 2021. Habitat improvement efforts, including invasive plant management and prescribed burning will take place on the basin marsh prior to the 2022 breeding season.

Table 17. Peak nest counts at Savannas Preserve State Park from 2018 to 2021.

Year	Colony	Latitude	Longitude	CAEG	SNEG	GBHE	LBHE	BCNH	TRHE	WHIB	GLIB	ANHI	Total
2018	North Marsh Rookery	27.3117	-80.2713	0	3	10	5	1	0	1	5	17	**49**
2019	North Marsh Rookery	27.3117	-80.2713	8	0	12	3	0	0	0	0	14	**43**
2020	North Marsh Rookery	27.3117	-80.2713	13	10	9	6	2	0	26	37	29	**156**
2021	North Marsh Rookery	27.3117	-80.2713	11	9	12	7	0	7	3	22	53	**141**
	Total			**32**	**22**	**43**	**21**	**3**	**7**	**30**	**64**	**113**	**389**

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KISSIMMEE BASIN

WADING BIRD NESTING

Birds are integral to the Kissimmee River floodplain ecosystem and highly valued by the public. The South Florida Water Management District (SFWMD) surveys wading bird nesting colonies and foraging wading bird abundance along the Kissimmee River as part of the Kissimmee River Restoration Evaluation Program (KRREP) (Williams et al. 2005a, 2005b). While quantitative pre-channelization data are sparse, available data and anecdotal accounts indicate that the system once supported an abundant and diverse bird assemblage with several recurring breeding colonies of greater than 1,000 nests (National Audubon Society 1936-1959, Florida Game and Fresh Water Fish Commission 1957). The Kissimmee River Restoration Project (KRRP) is expected to reproduce the necessary conditions to once again support such an assemblage.

Construction for the KRRP was completed in July 2021, an historic milestone that sets the stage for gradual implementation of the new Headwaters Revitalization Schedule (HRS), which controls operations at the S-65 water control structure at the outlet of the Headwaters Lakes (**Figure 21**). With completion of the construction phase of the restoration project, over 24,000 acres of wetland habitat have now been partially restored, and the interim response of foraging wading birds has exceeded the restoration expectation when averaged over the interim period from 2001 to 2021 (Cheek et al. 2014, Koebel et al. 2021). While there is no formal expectation for wading bird nesting effort, the number and size of colonies that have formed along the river since restoration began in 2001 has been below historic levels (Williams et al. 2005a, Cheek 2016).

While foraging conditions on the floodplain can become optimal for wading birds during parts of the year (see *Wading Bird Foraging Abundance* paragraph), the current timing and magnitude of floodplain inundation and recession is not optimal for rookery formation due to constraints and other demands on water control operations that may limit prey availability. Now that restoration construction has been completed, the HRS will be incrementally implemented in several phases starting in 2022. These increments will allow successively higher stages in the Headwaters Lakes until 2026, when the HRS is projected to be fully implemented. The objective of the HRS is to provide sufficient water storage in the Upper Kissimmee Basin that will allow water managers to more closely mimic the historical flow patterns of the pre-channelized Kissimmee River. The expected changes in hydrologic conditions will presumably occur at the appropriate spatial and temporal scales to positively impact wading bird nesting colonies within the vicinity of the KRRP area. Wading bird responses to the river restoration project will be monitored for 5 years after full implementation of the HRS.

Detailed information regarding the breadth of the avian evaluation program and the initial response of avian communities to Phase I restoration can be found in Williams et al. 2005b and Cheek et al. 2014.

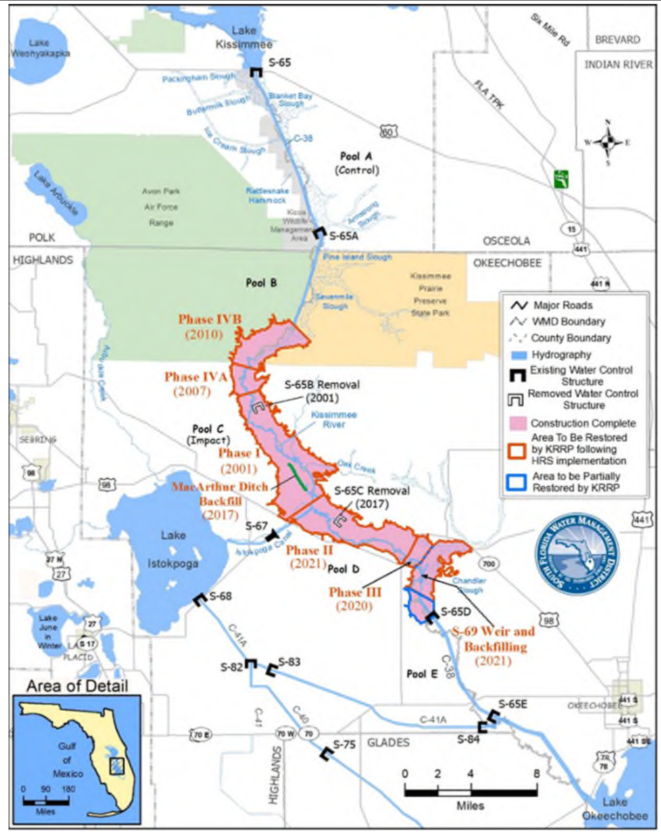

Figure 21. Kissimmee River Restoration Project Area showing the major features of the Lower Kissimmee Basin with completion dates of construction phases.

Methods

As part of the KRREP, the SFWMD performed two aerial surveys (March 30, 2021 and April 21, 2021) to visit known wading bird nesting colonies on Lake Kissimmee, along the Kissimmee River, and on Lake Istokpoga. Upon arrival at each colony, the principal observer recorded nesting species and the number of active nests from a height of approximately 300 feet, while the helicopter circled around the perimeter of the active colony. The second observer took digital photographs that were later counted to improve the accuracy of initial counts made from the air. Detectability of nests during aerial surveys is typically less than 100%, so the numbers of nests reported here represent the maximum number of observed nests for each species. This is particularly pertinent for the small, dark-colored wading birds such as Little Blue Heron (LBHE), Glossy Ibis (GLIB), Tricolored Heron (TRHE), Yellow-crowned Night Heron (YCNH), and Black-crowned Night Heron (BCNH) (Frederick et al., 1996). Thus, the colony totals presented in **Tables 18** and **19** are considered conservative. Nest fate and nesting success were not monitored.

Results

The SFWMD performed two aerial surveys (March 30, 2021 and April 21, 2021) to visit known wading bird nesting colonies on Lake Kissimmee, along the Kissimmee River, and on Lake Istokpoga. Four colonies were visited during each survey: Rabbit Island (Lake Kissimmee), River Ranch C-38 Island and Chandler Slough East (Kissimmee River), and Bumblebee Island (Lake Istokpoga)(**Tables 18**, **19**, and **Figure 22**).

Figure 22. Nesting colony locations in Lake Kissimmee, Lake Istokpoga, and within the Kissimmee River Restoration Project Area (i.e., within approximately 10 kilometers of the C-38 canal backfill) during 2021.

Nests on Rabbit Island in Lake Kissimmee were composed of Great Egrets (GREG; 191 nests) and Great Blue Herons (GBHE; 65 nests). The River Ranch C-38 colony contained GREG (15 nests) and GBHE (1 nest). The Chandler Slough East colony had GREG (26 nests) and GBHE (18 nests). Bumblebee Island in Lake Istokpoga contained an exceptionally large number of White Ibis (WHIB) nests this season (2,040 nests), along with GREG (285 nests), and GBHE (25 nests).

The only colony that occurred within 10 kilometers of the partially restored portions of the Kissimmee River is the Chandler Slough East colony. It is likely that breeding birds from this colony utilized the Kissimmee River floodplain for foraging at some point throughout the nesting cycle.

Most nesting of aquatic wading bird species and Cattle Egrets (CAEG) continues to occur outside of the KRRP area on islands in the Upper Kissimmee Basin and Lake Istokpoga. To date, two colonies of aquatic bird species (S-65C Boat Ramp colony (extant) and Chandler Slough East colony) have formed within 10 kilometers of the partially restored portion of the Kissimmee River, and during most years, they have contained fewer than 50 nests of aquatic species. The continued small numbers of aquatic species nesting along the restored portion of the river suggests that prey availability on the floodplain is not yet sufficient to support the completion of breeding for these wetland-dependent birds. Interestingly, prey availability sampling on the floodplain during the interim period does indicate that prey density and biomass are adequate to support breeding wading birds during the dry season (Koebel et al. 2020), so access to this prey may be limited by water depths (i.e., too deep), habitat structure (e.g., plant species composition and density), or some other unknown factor. Another possible factor preventing breeding colony site formation within the restoration area is lack of suitable habitat conditions during the January through June breeding season (e.g., woody substrate surrounded by water, nesting materials, and nearby foraging areas) (White et al. 2005).

While foraging conditions on the floodplain can become optimal for wading birds during certain times of the year, the timing and magnitude of floodplain inundation and recession currently are not optimal for rookery formation due to operational constraints and other demands on water management. Full implementation of the HRS by 2026 will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions for wading bird nesting colonies. Survey efforts next season will focus primarily within 10 kilometers of the KRRP area and Lakes Kissimmee and Istokpoga.

Only one colony (Chandler Slough East) occurred within 10 kilometers of the partially restored portions of the Kissimmee River, but several occurred in unrestored portions of the river, north, east, and south of the restoration area (**Figures 21** and **22**). The Bumblebee Island colony is approximately 15 kilometers away from the Kissimmee River Restoration Area, which is approaching the farthest limits of regular foraging flight distances for most wading bird species. The Rabbit Island and River Ranch Island colonies (40.6 kilometers and 23 kilometers, respectively) are too far to the north of the restoration area for regular foraging by nesting species there. Based on GPS tracking data from several WHIB roosting at the Chandler Slough East colony, some of the nesting wading birds there likely used portions of the Kissimmee River Restoration Area for foraging this breeding season, although it remains unclear to what extent breeding wading birds utilize the river floodplain.

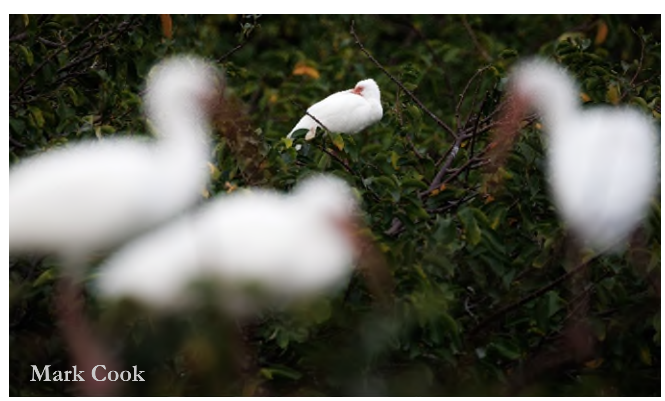

Table 18. Peak (maximum) number of wading bird nests within the Kissimmee River Restoration Project Area[a] (2003 to 2018 and 2021; sites were surveyed during March and April 2021).

Year	CAEG	GREG	WHIB	GBHE	SMDH	SMWH	WOST	ROSP	Total Nests	Total Colonies	Nests of Aquatic Species
2003	20								**20**	1	0
2004									**0**	0	0
2005		81							**81**	2	81
2006	500	133		9					**642**	4	142
2007	226				1				**227**	1	1
2008		2		4					**6**	1	6
2009	240	126		27	14				**407**	3	167
2010	891	35		31	37				**994**	2	103
2011	751	14		35	35	8			**843**	2	92
2012	1,202			18	108	18			**1346**	2	144
2013	599	33		37					**669**	5	70
2014[b]	5	23		28	1				**57**	5	52
2015		94		31					**125**	4	125
2016[c]	291	316		20					**627**	4	336
2017	540	143	50	13				1	**747**	5	207
2018	1,264	484	416	33	53	5	7		**2,262**	7	998
2021		232		84					**316**	3	316

Note: GLIB and BCNH nests were not observed (count = 0).

[a] Kissimmee River Restoration Project Area sites include Lakes Kissimmee, Cypress and Hatchineha, and colonies within approximately 10 kilometers of the C-38 Canal/backfill, including the following: Multiple Kissimmee Prairie sites, Bluff Hammock, Cypress West, Oak Creek Marsh, C-38 Caracara Run, Chandler Slough East, Chandler Slough New, Chandler Slough, Cypress West, Orange Grove, Orange Grove NW, Orange Grove SW, Pine Island Slough, S-65C Boat Ramp, S-65C Structure, S-65D Boat Ramp, and Seven Mile Slough, Pool E Spoil Island, S-65E colony.

[b] Expanded survey effort in 2014.

[c] Reduced survey effort in 2016, but results from the Rabbit Island colony in Lake Kissimmee were added to the table this year.

Table 19. Peak (maximum) number of wading bird nests within Lake Istokpoga (Bumblebee Island) (2010 to 2021; sites were surveyed during March and April).

Year	CAEG	GREG	WHIB	GBHE	SMDH	GLIB	SMWH	Total Nests	Total Colonies	Nests of Aquatic Species
2010	103	325	110	75				**613**	1	510
2011	381	200	50	45				**676**	1	295
2012	75	175		75				**325**	1	250
2013	250	343		55				**648**	1	398
2014	658	210	75	55				**998**	1	340
2015	434	180	829					**1,443**	1	1009
2016	355	171	1296	25				**1,847**	1	1492
2017	10	124	818	35	1	6	4	**998**	1	988
2018	481	450	2,089	5				**3,025**	1	2,544
2021		285	2,040	25					1	2,350

Note: BCNH and WOST nests were not observed (count = 0).

WADING BIRD FORAGING ABUNDANCE

As part of the KRREP, the following restoration expectation was developed for the abundance of foraging wading birds on the floodplain post construction:

- Mean annual dry season density of long-legged wading birds (excluding cattle egrets) on the restored floodplain will be ≥ 30.6 birds/km² (Williams and Melvin 2005).

Detailed information regarding the interim response of wading birds and waterfowl to Phase I restoration can be found in Cheek et al. (2014).

Methods

East-west aerial transects (n=218) were established at 200-meter intervals beginning at the S-65 structure and ending at the S-65D structure (see **Figure 21**). During monthly flights from November to May, a minimum of 20% of the 100-year floodplain was surveyed in both the restored and unrestored portions of the river/floodplain. Surveys were conducted via helicopter flying at an altitude of 30.5 m and a speed of 80 km/hr. A single observer counted all wading birds and waterfowl within 200 m of one side of the transect line. Because it is not always possible to distinguish TRHE from adult LBHE during aerial surveys, the two are lumped together as "small dark herons." Likewise, SNEG and immature LBHE were classified as "small white herons."

Results

Monthly aerial surveys were used to estimate foraging wading bird abundance. Prior to the restoration project, dry season abundance of long-legged wading birds in the Phase I restoration area averaged (±SE) 3.6 ± 0.9 birds/km² in 1997 and 14.3 ± 3.4 birds/km² in 1998. Since completion of Phases I, IVA, and IVB of restoration construction in 2001, 2007, and 2009, respectively, annual abundance has ranged from 102.3 ± 31.7 birds/km² to 11.0 ± 1.9 birds/km² (mean for 2002 to 2021=39.0 ± 3.0 birds/km²; **Figures 23** and **24**).

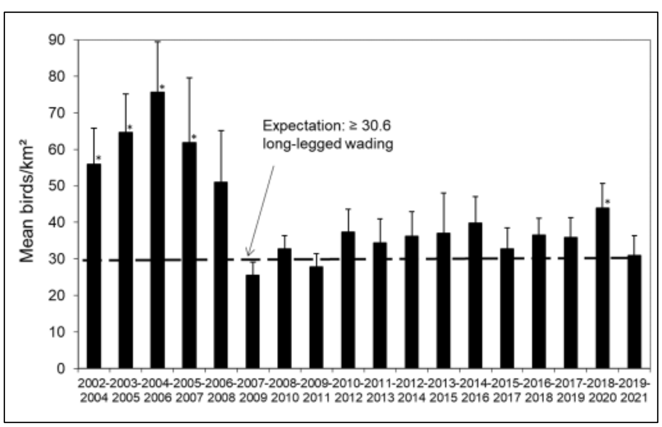

Figure 23. Baseline and post-Phases I, IVA, and IVB mean abundance ± SE of long-legged wading birds/km², excluding Cattle Egrets, during the dry season (December to May) within the 100-year flood line of the Kissimmee River.

The long-term annual 3-year running mean (2002 to 2021) is 42.2 ± 3.3 birds/km², significantly greater than the restoration expectation of 30.6 birds/km² (t-test, $p < 0.001$, Williams and Melvin 2005). Annual 3-year running means have been significantly greater than the restoration expectation of 30.6 birds/km² in only 5 of the past 18 years of the survey period 2002 to 2021. These were 2002 to 2004, 2003 to 2005, 2004 to 2006, 2005 to 2007, and 2018 to 2020.

Reports of this metric in previous *South Florida Environmental Report* (SFER) publications stated that annual 3-year running means exceeded the expectation during the periods 2002 to 2005 and 2004 to 2006. These results were based on using the annual means (n=3) to calculate the 3-year running mean rather than using the monthly means (n=10 to 55 months) for the entire 3-year period to calculate the value. It was statistically invalid to conduct a t-test comparing the three annual means to the target value of 30.6 birds/km², in contrast to the correct method, which utilizes the monthly mean values for the entire 3-year period to make the comparison. Thus, the number of 3-year periods above the restoration target reported here increased over the previous *South Florida Wading Bird Report* reporting years from 3 to 5.

Mean monthly wading bird abundance within the restored portions of the river during the 2021 season was 36.5 ± 12.0 birds/km², bringing the 3-year (2019 to 2021) running average to 30.9 ± 5.5, not significantly greater than the restoration expectation of 30.6 birds/km² (t-test, p=0.48, **Figure 24**).

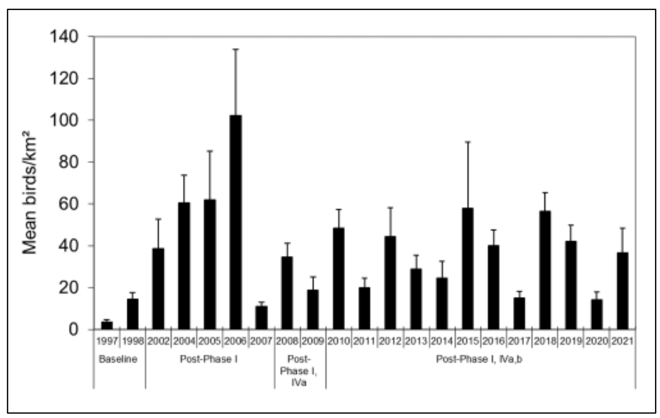

Figure 24. Post-restoration abundance as 3-year running averages ± SE of long-legged wading birds/km², excluding Cattle Egrets, during the dry season (December to May) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River.
*=significantly greater than the restoration expectation of 30.6 birds/km² [t-test, p-value<0.05].

Rainfall during the 2020-2021 dry season approximated long-term averages in both the Upper and Lower Kissimmee Basin (92% and 103% of average, respectively), while the preceding wet season rainfall was slightly above average (107% and 112% of average, respectively). A well-above average number of wading birds (163 birds/km²) was observed during the first flight of the season on November 4 following a rapid recession of water levels on the floodplain in October that led to optimal foraging conditions. Wading bird numbers declined by about one-half between the November 4 and December 2 surveys, when a reversal of water levels of approximately 0.5 feet occurred on the floodplain, bringing the average floodplain depth to approximately 1.0 foot and dispersing prey over a larger area of the floodplain (**Figure 25**). A second reversal (and subsequent recession) of water levels occurred between the December 2 and January 6 survey when bird numbers further declined by approximately two-thirds. Water levels stayed relatively flat before the next survey on February 3, and bird numbers similarly remained relatively steady (27 and 33 birds/km²) before declining further by approximately one-half by the March 3 survey following a third reversal of approximately 0.2 feet. There was a steady recession of water levels by April 7 when the floodplain average depth was 0.11 feet, and bird numbers increased by approximately two-thirds to 49 birds/km². A fourth reversal (0.21 feet) occurred prior to the May 5 survey, when bird numbers declined by almost 90%.

As in previous years, WHIB dominated the surveys numerically (1,732, 52.4%), followed in order of abundance by GLIB (455, 13.8%), small white herons (SNEG and juvenile LBHE; 428, 13.0%), GREG (285, 8.6%), GBHE (176, 5.3%), (BCNH and YCNH; 85, 2.5%), Wood Stork (WOST; 78, 2.3%), small dark herons (TRHE and adult LBHE; 38, 1.1%), and Roseate Spoonbills (ROSP; 27, 0.8%).

TRACKING WADING BIRDS NEAR THE KISSIMMEE RIVER RESTORATION AREA

The SFWMD is engaged in a project to locate, tag (GPS), and track the movements of wading birds, WHIB and SNEG, along the newly reconstructed Kissimmee River floodplain. Wading birds are integral to riverine and wetland ecosystems and can be useful bioindicators of their ecological integrity, which is a primary goal of the KRRP. This study will help determine the extent to which wading birds forage on the partially restored Kissimmee River floodplain during the breeding season (January through June), when energetic demands are greatest. This study has important implications to the long-term stability of the wading bird populations within the restoration project area, which, in turn, may affect the evaluation of restoration success (Williams et al. 2005a).

The SFWMD contractor, ARCI (Avian Research and Conservation Institute), has tagged 35 WHIB and 1 SNEG thus far and is aiming to tag and track at least five more of either species in the coming months. The cell phone-signal-based trackers on the birds are providing detailed data of their movements on a daily basis, and GPS data are downloaded weekly. The tracking devices consist of a single solar-powered unit containing a GPS receiver and a GSM (cellular phone system) transmitter attached to the bird via a small backpack harness made from a slick Teflon ribbon that is neither abrasive nor photosensitive. The units deliver GPS-derived locations accurate from 10 to 15 meters on a regular schedule of about 8 to 12 fixes per 24 hours.

All 36 tagged birds have successfully uploaded data for at least some portions of the approximate 15-month tracking period. Thirty-two of the 36 tagged birds (88%) have utilized the Kissimmee River Restoration Area during some portion of the monitoring period. Results from the first trapping event in 2020 (11 birds total) were presented in an interim report provided by ARCI on September 1, 2020. **Figure 26** from the report shows a sample of the movement data in GoogleEarth. A comprehensive final report was provided to the SFWMD by November 30, 2021, and ARCI has continued to provide the SFWMD with all tracking results for as long as GPS data are received, which can be up to 2 years following initial tagging.

Data from this study will be used to create overview maps of all bird locations, movements, nighttime locations, use of public lands, such as the Kissimmee River Restoration Area, and to possibly examine habitat use versus availability on both public and private lands. Tracking data may also help the SFWMD and partners identify regionally important foraging and breeding locations to help scientifically guide efforts to purchase, restore, or otherwise conserve critical habitat in the future.

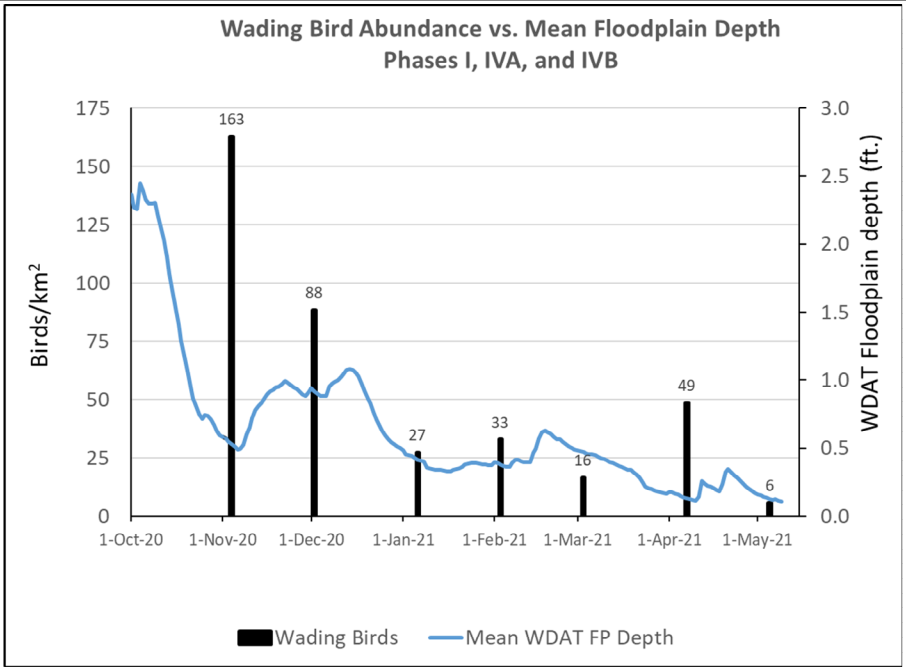

Figure 25. Wading bird abundance versus mean floodplain (FP) depth in the Kissimmee River Restoration Project Area (Phases I, IVA, and IVB) during the 2020-2021 dry season (November to May). Floodplain depth is obtained from the South Florida Water Depth Assessment Tool (SFWDAT 2021).

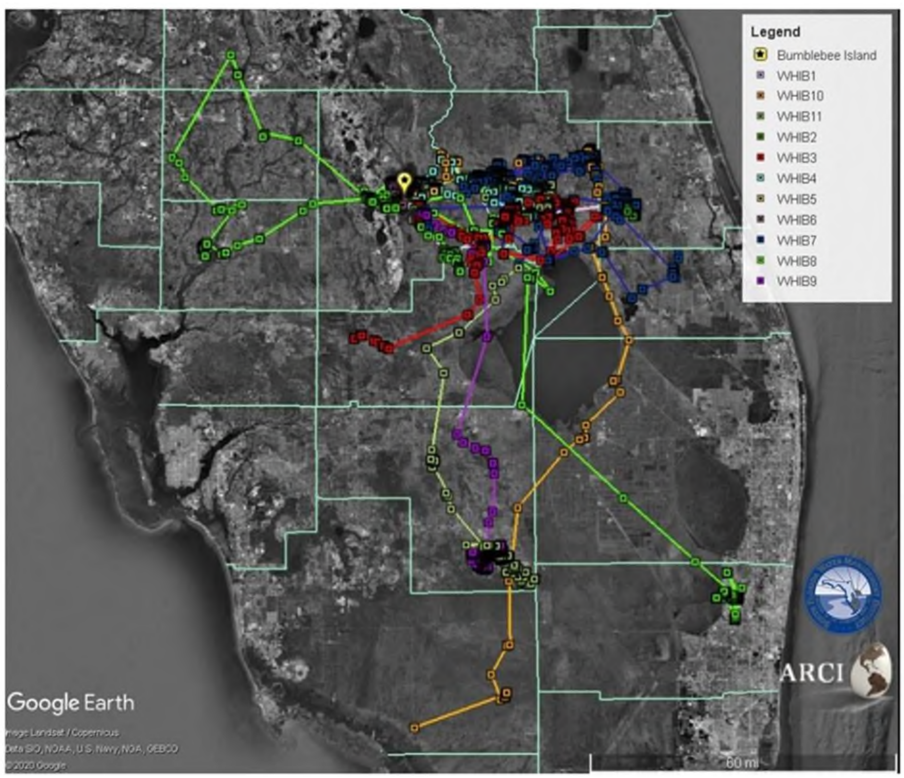

Figure 26. Movement tracks and locations of 11 GPS-tracked White Ibis tagged on Bumblebee Island, Lake Istokpoga, Highlands County, Florida from late May through August 2020.

PROPOSED CHANGES TO RESTORATION EXPECTATION 24 WADING BIRD ABUNDANCE

SFWMD scientists are currently reviewing proposed changes to Restoration Expectation 24 for the density of long-legged wading birds on the floodplain (Williams and Melvin 2005) based on information acquired during the interim period (2002 to current). One proposed modification involves adding the month of November to the data set used to calculate the dry season abundance estimates for the entire dry season (November through May), instead of using only December through May as has been used during the interim period (2002 to current). This aligns with the climatological dry season in south-central Florida and captures more of the important southward migration period in the fall, when northern migrants arrive in Florida to overwinter or stopover on their way to more southern latitudes. A second modification to the current restoration expectation is to add a frequency component by estimating the percent of survey dates throughout the season that are greater than or equal to the target value of 30.6 birds/km^2. This new expectation metric is that at least 85% of the monthly surveys will be ≥30.6 birds/km^2 each survey season. This frequency metric gives a better indication of the consistency of suitable foraging habitat within the floodplain throughout the entire dry season instead of only evaluating a single season-long mean, which can be greatly skewed by wide monthly variability in bird numbers due to intermittent floodplain inundation. Monthly evaluation of the target each survey season may provide managers a better indication of the current state of conditions on which to base adaptive management decisions. An evaluation of the proposed frequency metric (i.e., 85% of survey months ≥30.6 birds/km^2 annually) during the interim period showed that the expectation was met during 5 of the 20 years between 2002 to 2021 (interim period).

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SOUTH FLORIDA (VARIOUS LOCATIONS)

METHODS

The Florida Fish and Wildlife Conservation Commission (FWC) staff and volunteers conducted nest counts at seven wading bird colonies throughout FWC's south region in the 2021 nesting season. Nest numbers and productivity for Wood Storks (WOST) were higher this year than in the 2020 season at all colonies.

Bird Island Critical Wildlife Area (CWA; 27.190821, -80.187908) is a spoil island in the Indian River Lagoon. The island is closed to public access year-round to protect nesting and roosting birds. It is cooperatively managed with Martin County and monitored monthly throughout the year. Nest counts were conducted from a boat circling the island, and it is certain that some interior nests were not counted.

BallenIsles (26.830148, -80.109158) is a small island located on a lake within the BallenIsles Country Club golf course. Nest counts were conducted on foot from vantage points on the north and south sides of the golf course. Counts were conducted every few months throughout the breeding season.


Mark Cook

The Solid Waste Authority of Palm Beach County (26.770188, -80.125313) has multiple spoil islands in abandoned shell pits that were mined in the early 1960s. Nest counts were done by boat, and it is certain that some interior nests were not counted. Eleven different species were present during these surveys with approximately 400 WOST chicks counted in April and 800 White Ibis (WHIB) adults present in mid-May. Survey efforts were focused on WOST and state listed species.

Wakodahatchee Wetlands (26.479889, -80.142326) is a manmade wetland where many wading bird species nest. WOST and other species were counted from the boardwalk, but not all species present were recorded. Counts were conducted monthly from January through May. This colony contained the second highest number of WOST nests this season.

Sawgrass Ford (26.149837, -80.337621) is a spoil island behind the Sawgrass Ford dealership in Sunrise. Nest counts were conducted monthly throughout the breeding season by circling the island on a kayak.

Griffin (26.063633, -80.366492) is in the Emerald Estates Park. Surveys were done from the road on the south side of the colony or by kayak and foot from the north side. Twelve different species were observed here throughout the breeding season.

ABC Islands CWA (25.063633, -80.366492) encompasses three spoil islands on the eastern side of Marco Island. The islands are closed to public access year-round to protect nesting, migratory, and wintering birds. This site is cooperatively managed and monitored with Rookery Bay National Estuarine Research Reserve (NERR). Nest counts were conducted by boat circling each island, and it is certain that some interior nests were not counted.

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PALM BEACH COUNTY NATURAL AREAS

Staff at Palm Beach County's Department of Environmental Resources Management surveyed wading bird colonies in natural areas between January and May 2021. Only the Northeast Loxahatchee Slough and Central Loxahatchee Slough colonies were used this 2021 breeding season.

METHODS

Staff used flight line surveys, food deliveries, and one reconnaissance visit to time their surveys with peak nesting efforts. Within each colony, nests with chicks too young to identify and without the presence of adults were recorded as *Egretta* sp. (EGSP).

The Northeast Loxahatchee Slough colony was visited by staff on May 3. This colony is located within a matrix of pine flatwoods, marsh, and cypress swamp habitats. The 1.4-acre colony consists of two deepwater pond apple and willow heads within a larger cypress dome. From the ground, staff recorded the numbers of nests. Counts were recorded from multiple vantage points to ensure full coverage.

The Central Loxahatchee Slough colony is in a 0.5-acre pond apple stand within a matrix of cypress swamp and marsh habitats. On April 29, staff counted nests from the ground.

RESULTS

Nest count data from each colony for the 2021 breeding season are presented in **Table 20**.

Table 20. Peak number of wading bird nests by species observed in the Loxahatchee Slough Natural Area.

Colony	Latitude	Longitude	LBHE	TRHE	EGSP	Total
Northeast Loxahatchee Slough	26.89205	-80.17307	36	7	7	**50**
Central Loxahatchee Slough	26.86861	-80.1778	73	9	20	**102**

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STATUS OF WADING BIRD RECOVERY

The sustainability of healthy wading bird populations is a primary goal of the Comprehensive Everglades Restoration Plan (CERP) and other Everglades restoration programs in South Florida. A central prediction of CERP is that a return to natural flows and hydropatterns will result in the recovery of large, sustainable breeding wading bird populations; a return to natural timing of nesting; and restoration of large nesting colonies in the coastal zone (Frederick et al. 2009). There are at least two overlapping sets of measures for attaining these conditions, all based on historical conditions and thought to be representative of key ecological features of the bird-prey-hydrology relationship. The Restoration Coordination & Verification (RECOVER) program established performance measures (https://www.evergladesrestoration.gov/comprehensive-everglades-restoration-plan) that include a 3-year running average of the numbers of nesting pairs of key avian species in the mainland Everglades, the timing of Wood Stork (WOST) nesting, and the proportion of the population that nests in the coastal ecotone (Ogden et al. 1997). In addition to these three measures, the annual Stoplight Reports (https://www.evergladesrestoration.gov/progress-report-1) have added two other measures: 1) the ratio of visual to tactile wading bird species breeding in the Everglades, and 2) the frequency of exceptionally large White Ibis (WHIB) breeding events. These additional measures were added in an attempt to further capture key ecological relationships found in the historical ecosystem (Frederick et al. 2009). This section reports on the long-term trends and the current status of all the restoration performance measures. When considering the progress towards these restoration measures, it should be remembered that the hydrological system is not yet restored to provide anything like the ecological functions expected in a completed CERP. The past few years have seen both strong nesting events (as seen in 2018 and 2021) and comparatively disappointing efforts (as seen in 2019). Based on the recent status of the hydrological system, restored or even partially restored wading bird population indicators would not have been predicted.

The main indicator species are Great Egret (GREG), Snowy Egret (SNEG), WHIB, and WOST. Although the Tricolored Heron (TRHE) was originally included in this list (Ogden et al. 1997), this species has proven extremely difficult to consistently monitor due to the inability to see their dark plumage in colonies during aerial surveys. Ogden et al. (1997) combined TRHE and SNEG population targets (e.g., 10,000 breeding pairs), and it is difficult to derive an expected number for SNEG alone (Ogden 1994). Based on relative abundances in coastal colonies (Ogden 1994), roughly equal support can be derived for 1:1 ratios as for 2:1 ratios (SNEG:TRHE). This section summarizes data for the three Water Conservation Areas (WCAs) and mainland Everglades National Park (ENP).

RESTORATION METRICS

Numbers of Nesting Pairs

The 3-year running average for nesting pairs in the mainland Everglades (2019 to 2021) are 7,335 GREG pairs, 2,328 SNEG pairs, 35,902 WHIB pairs, and 1,618 WOST pairs (**Table 21**; **Figure 27**). Trends for GREG over time for this measure increased markedly from 1988 to 2004, and have been roughly stable since, with the 3-year running average meeting or exceeding restoration criteria for 25 consecutive sampling periods since 1996. Trends for SNEG also increased markedly from 1986 to 2004, dropped dramatically between 2005 and 2017, then rebounded considerably during the 2018 to 2021 nesting seasons. Generally, big nesting seasons for flock-foraging species show a large increase in SNEG nesting. Nonetheless, 3-year running averages of breeding SNEG have been consistently well below the target restoration goal since 1986 when systematic monitoring began. The 3-year running average has increased markedly (2.7 times) for WHIB between 1986 and 2001, and then remained variable but arguably stable for nearly a decade (2002 to 2011). The final period in this record (2012 to 2021) showed substantial fluctuations in WHIB nesting. WHIB nesting numbers for 8 of the 10 years were close to, or substantively below, the 2002 to 2011 average. The huge nesting effort in the 2018 nesting season pulled the running average up markedly. The 3-year running average for WHIB pairs remains high this year due to a strong WHIB nesting season in 2021, which was the second largest since 1986, exceeded only by the phenomenal 2018 breeding season. The 3-year running average for WHIB may remain high for the next 2 years simply because of the 2021 contribution. WHIB nesting populations have met or exceeded the breeding population criterion for the past 21 years. WOST showed a marked increase from averages in the 2- to 300-pair range (1986 to 1992) to averages above 1,000 in many years after 1999. WOST have equaled or exceeded the restoration population criterion during 12 of the last 21 years, including 2021.

Together, these statistics illustrate that there has been a substantial increase in numbers of GREG, WOST, and WHIB since 1986, followed by a period of relative stability during which each of these species has met restoration targets in many or even the majority of years. While SNEG appear to be rebounding in the last 2 years, this species has never met restoration targets. In addition, there is evidence from systematic ground surveys in WCA-3 (see *Water Conservation Areas 2 and 3, and A.R.M. Loxahatchee National Wildlife Refuge* section) that breeding populations of the other two small herons in the genus *Egretta* (TRHE and Little Blue Heron [LBHE]) are also declining sharply in the Everglades.

Table 21. Three-year running averages of the number of nesting pairs for four indicator species in the mainland Everglades (water conservation areas and Everglades National Park, not including Florida Bay). Bolded years are those in which the numbers of nesting pairs met the restoration criteria.

Period	GREG	SNEG	WHIB	WOST
1986-1988	1,946	1,089	2,974	175
1987-1989	1,980	810	2,676	255
1988-1990	1,640	679	3,433	276
1989-1991	1,163	521	3,066	276
1990-1992	2,112	1,124	8,020	294
1991-1993	2,924	1,391	6,162	250
1992-1994	3,667	1,233	6,511	277
1993-1995	3,843	658	2,107	130
1994-1996	**4,043**	570	2,172	343
1995-1997	**4,302**	544	2,850	283
1996-1998	**4,017**	435	2,270	228
1997-1999	**5,084**	616	5,100	279
1998-2000	**5,544**	1,354	**11,270**	863
1999-2001	**5,996**	2,483	**1,655**	**1,538**
2000-2002	**7,276**	6,455	**23,983**	**1,868**
2001-2003	**8,460**	6,131	**20,758**	**1,596**
2002-2004	**9,656**	6,118	**24,947**	1,191
2003-2005	**7,829**	2,618	**20,993**	742
2004-2006	**8,296**	5,423	**24,926**	800
2005-2007	**6,600**	4,344	**21,133**	633
2006-2008	**5,869**	3,767	**17,541**	552
2007-2009	**6,956**	1,330	**23,953**	1,468
2008-2010	**6,715**	1,723	**21,415**	**1,736**
2009-2011	**8,270**	1,947	**22,020**	**2,263**
2010-2012	**6,296**	1,599	**11,889**	1,182
2011-2013	**7,490**	1,299	**16,282**	**1,686**
2012-2014	**7,041**	1,017	**17,194**	**1,696**
2013-2015	**6,300**	710	**21,272**	**1,639**
2014-2016	**5,328**	837	**17,379**	995
2015-2017	**5,656**	639	**17,975**	1,196
2016-2018	**8,803**	1,224	**41,465**	**2,152**
2017-2019	**7,966**	1,840	**44,967**	**2,282**
2018-2020	**7,806**	2,191	**46,347**	**1,911**
2019-2021	**7,335**	2,328	**35,902**	**1,618**
Target Minima	4,000	10 - 20k	10 - 25k	1.5 - 2.5k

Coastal Nesting

More than 90% of indicator species nesting is estimated to have occurred in the southern ecotone region during the 1930s and early 1940s, likely because this was the most productive area. A major restoration hypothesis holds that the reduction of freshwater flows to this coastal region has reduced secondary productivity and resulted in the abandonment of the area by nesting wading birds. The proportion of the entire mainland Everglades nesting population that nests in the coastal zone is one of the restoration indicators, with at least 50% of nesting as the restoration target (Ogden et al. 1997). This measure has shown considerable improvement since the lows of the mid-1990s and early 2000s (2% to 10%; **Figure 28**), and during the last several years has ranged between 15% and 41%. In 2021, 34% of all nests were in ENP. For 3 of the past 4 years (2018 to 2021), >30% of mainland nesting has occurred in the coastal zone. Coastal nesting dropped to 25% in 2020, which is still a considerable improvement over the mid-1990s and early 2000s. This metric is not yet meeting the target of 50%, but the trend has been improving markedly in recent years.

Ratio of Visual to Tactile Foragers

This measure recognizes that the breeding wading bird community has shifted from being numerically dominated by tactile foragers (WOST and WHIB) during the pre-drainage period to one in which visual foragers such as GREG are numerically dominant. This shift is thought to have occurred as a result of impounded, stabilized, or overdrained marsh, which leads to the declining availability both of larger forage fishes (for WOST) and crayfishes (for WHIB). These conditions also seem to favor species like GREG that are less reliant on the entrapment of prey and can forage both in groups and solitarily under a variety of circumstances. Restoration targets are set at 32 breeding tactile foragers to each breeding visual forager, characteristic of the 1930s breeding assemblages. While this measure has shown some improvement since the mid-1990s (movement from 0.66 to 7.9 in 2018), the metric is still generally an order of magnitude less than the restoration target. In 2021, the ratio was 5.11, (**Figure 29**) which was less than seen in 2018 and 2019 (6.83 and 7.92, respectively), but higher than the ratio from 2020 (3.83). The 5-year running average was 5.36, which is still significantly below the restoration threshold for this metric.

Timing of Nesting

This parameter applies only to the initiation of nesting for WOST, which has shifted from November through December (1930s through 1960s) to January through March (1980s to present). Later nesting increases the risk of mortality of nestlings that have not fledged prior to the onset of the wet season and can make the difference between the South Florida WOST population being a source or sink population. This measure has shown a consistent trend towards later nesting between the 1930s and the 1980s, with variation around a February mean initiation date since the 1980s (**Figure 30**). Although some years in the mid-2000s stimulated earlier nesting, there has been no lasting improvement. The 2018 season start (late December) was quite early by comparison with recent years and was only one of three years in the last 30 years in which WOST have initiated nesting by the end of December. The 2021 date was late January, which was similar to recent years. The 4-year running average for 2021 was 2.57, which corresponds to an average nest initiation date of mid-January. This metric has seen steady improvement since 2016, though much of the consistency may be traced to the lagged nature of the metric being a running average.

Exceptionally Large Ibis Aggregations

Episodic, exceptionally large breeding aggregations of WHIB were characteristic of the pre-drainage system and are thought to be indicators of the wetland system's ability to produce very large pulses of prey, resulting in part from typical cycles of drought and flood. Large breeding aggregations during the recent period are defined as being above 16,977 nests each year, the 70th percentile of the entire period of record of annual nestings. The interval between large WHIB nestings in the pre-drainage period was 1.6 years, and this serves as the target for restoration. This measure has improved markedly since the 1970s. The 2020 WHIB nesting reached the restoration criterion of > 16,977 nests, and the interval averaged over the last 5 years is 1.6 years, which meets the restoration guideline.

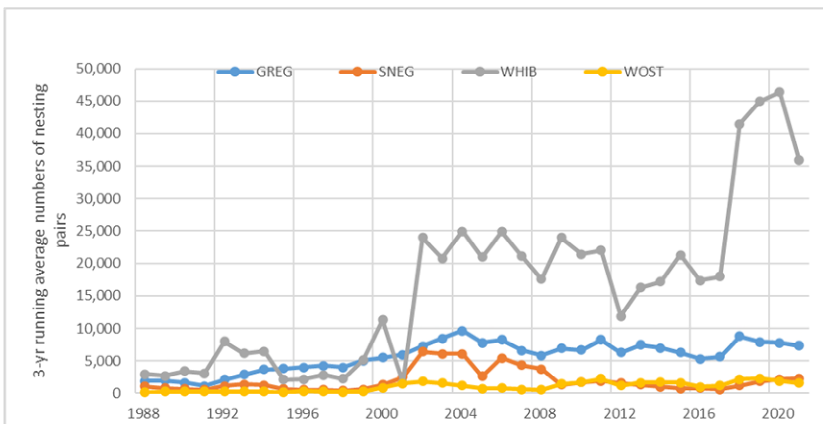

Figure 27. Trends in nesting pairs of the four target species since 1986.

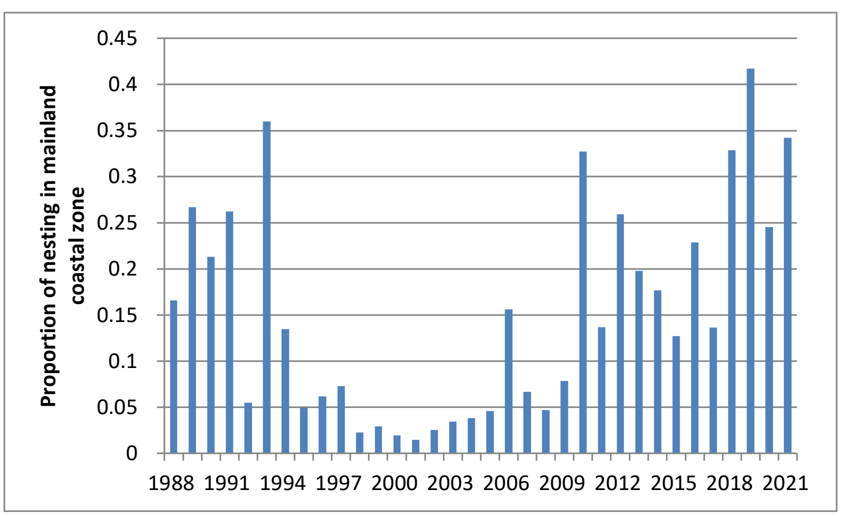

Figure 28. Proportion of all mainland Everglades nests that were located in the coastal estuarine zone, 1986 to 2021.

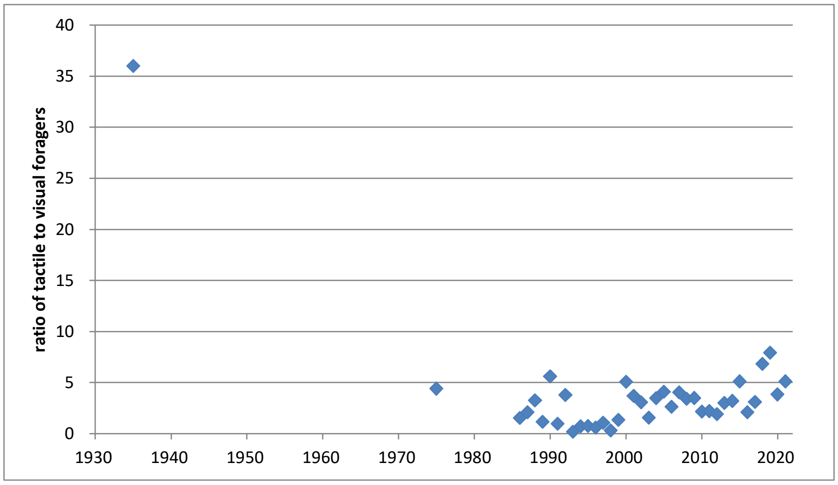

Figure 29. Ratio of tactile feeding species (WOST and WHIB) nests to sight foraging (GREG) nests in the Everglades, 1930 to 2021.

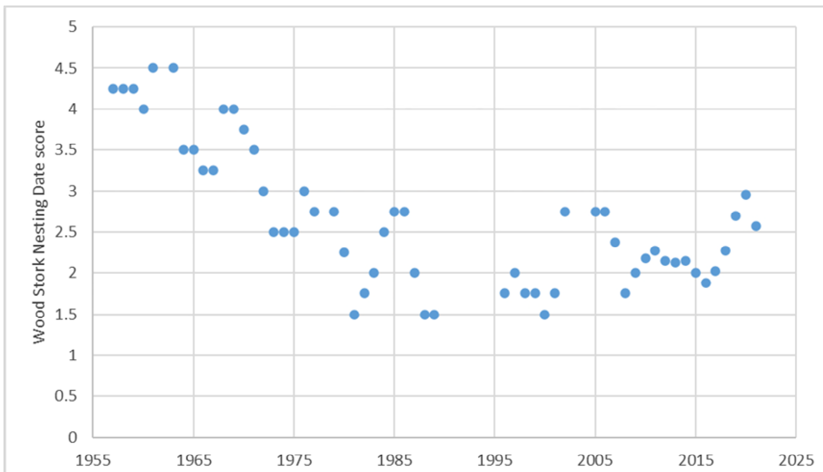

Figure 30. Four-year running average of WOST nest initiation date in the Everglades. Initiation in November is a 5, and initiation in March is a 1.

Discussion

As a whole, these measures of wading bird nesting suggest that while there have been real improvements in several of the measures during the past one to two decades, several key measures are stalled and not showing further improvement. Two measures are genuinely hopeful: numbers of nesting pairs of WHIB, WOST, and GREG in the system seem to be regularly achieving the restoration targets, and the interval between exceptional WHIB nesting seasons has consistently met the restoration target. There has been real progress in the location of nesting, with dramatic increase in 2018, 2019, and 2021, and an apparent positive trend. Nonetheless, there is much room for improvement, especially in the multiyear mean. While the numbers of SNEG have improved in the last 2 years, they remain far from restoration targets. There is little evidence that the timing of WOST nesting is improving on average, despite the early nesting from 2017 to 2019. The ratio of tactile to visual foragers has improved since the mid-2000s but remains an order of magnitude below the restoration target.

This picture illustrates clearly that the birds have responded in the last two decades to a combination of altered water management regimes, favorable rainfall patterns, and changing hydropatterns by nesting more consistently in the coastal zone, resulting in increasing populations of WHIB, WOST, and GREG. While some of the population increases may be attributable to forces outside the Everglades system, the fact that these species have been attracted to nest in the Everglades in larger numbers, and that nesting has often been successful, suggests that nesting remains a solid indicator of ecological conditions. The lack of movement of the other measures suggests that the current hydrological management regimes are not powerful enough to nudge the timing of nesting, ratio of tactile foragers, or numbers of nesting SNEG further. While this illustrates an apparent stasis, it should be remembered that full restoration of wading bird populations is predicted only as a result of full restoration of key historical hydropatterns, which has not yet occurred.

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