SOUTH FLORIDA WADING BIRD REPORT

Volume 28 Mark I. Cook, Michael Baranski, and James M. Beerens, Editors January 2025

EXECUTIVE SUMMARY

An estimated 52,532 and 46,174 wading bird nests were initiated in South Florida during the 2022 and 2023 nesting seasons, respectively. These were moderately poor nesting efforts compared to recent years and were below the 10-year (2012–2021) average annual number of nests (55,273.7 nests)

Wading bird nesting is not evenly distributed in South Florida. The Everglades Protection Area typically supports the greatest number of nests in South Florida. The Everglades Protection Area produced 45,943 nests during 2022 and 33,479 nests during 2023 (88 and 73% of all nests in South Florida, respectively). The next most important nesting area, Lake Okeechobee, produced 2,114 nests in 2022 and 2,460 during 2023, less than 5% of nests in South Florida. Both regions exhibited below average nesting effort in 2022 and 2023.

Nesting effort in the Everglades Protection Area varied among the four Comprehensive Everglades Restoration Plan (CERP) indicator species. Snowy Egret exhibited improved nesting effort in both 2022 and 2023 relative to average, Great Egret was above average in 2022 but below average in 2023, White Ibis was average in 2022 but below average in 2023, while Wood Stork was below average in both years. Great Eret, White Ibis, and Wood Stork met their Comprehensive Everglades Restoration Plan restoration targets based on the 3-year running average number of nests, but Snowy Egret did not.

An important goal of the Comprehensive Everglades Restoration Plan is to restore the hydrologic conditions that will support the return of large successful wading bird colonies to traditional estuarine rookeries. The proportions of nests located in the coastal region of the Everglades Protection Area in 2022 and 2023 were relatively low (14 and 23% respectively) compared to those recorded over the past five years (between 24 and 42%) and did not meet the 50% Comprehensive Everglades Restoration Plan restoration target.

Wood Storks have a relatively long reproductive period (4 months), which means nesting must start early in the dry season to ensure nestlings have time to fledge prior to the onset of the rainy season when water levels rise. The timing of Wood Stork nesting was relatively late in both years with egg laying starting in mid-February (2022) and late January (2023), considerably later than the November through December Comprehensive Everglades Restoration Plan target.

Nest success was poor both in 2022 and 2023 for all indicator species. Large-scale nest abandonments were evident in both years and were particularly severe for the federally listed Wood Stork, which fledged fewer than 20 birds over both years.

The relatively poor nesting during 2022 and 2023 highlights the critical role of hydrology and its effects on food availability and nesting responses. Wading birds need relatively wet conditions across the landscape prior to the nesting season (May to October) to promote the production of aquatic prey (fish and crayfish), followed by a moderately dry nesting season (November through April) that gradually reduces water levels and increases the accessibility of prey. Conditions leading into the 2022 and 2023 nesting seasons were characterized by relatively low rainfall, short hydroperiods and a small spatial extent of flooded habitat, which limited prey production across the Everglades Protection Area landscape, especially in Water Conservation Area 3A. Although the subsequent nesting seasons were characterized by a continuous drop in water level across the landscape, which were suitable for concentrating prey, the antecedent dry conditions meant resulting prey densities were low and foraging habitat was generally poor quality. Moreover, the initial shallow conditions meant that most areas dried out too early in the nesting season such that optimal foraging depths were not available at the right time and place with respect to the timing and location of nesting colonies.

This year is the 28th edition of this multiagency annual report. It continues to be an essential resource for guiding Everglades restoration strategies and weekly operational decisions and is an effective tool for communicating important information to the public.

A video explaining the annual wading bird reports is available at https://youtu.be/cPRIk-YDhTs.

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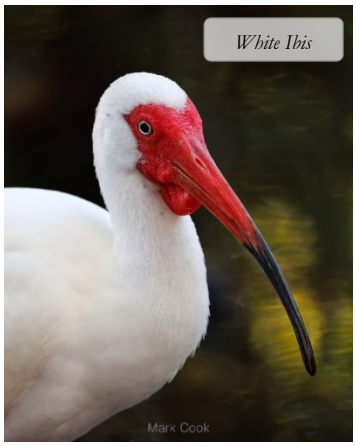
Abbreviations

Bird Species: Anhinga (ANHI, *Anhinga anhinga*), Black-crowned Night Heron (BCNH, *Nycticorax nycticorax*), Brown Pelican (BRPE, *Pelecanus occidentalis*), Cattle Egret (CAEG, *Bubulcus ibis*), Double-crested Cormorant (DCCO, *Phalacrocorax auritus*), egret species (EGSP, *Egretta* sp.), 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*), Little Blue Heron (LBHE, *Egretta caerulea*), 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 Loxahatchee National Wildlife Refuge (LNWR), birds per square kilometer (birds/km^2), centimeter(s) (cm), Charlotte Harbor Aquatic Preserves (CHAP), Combined Operations Plan (COP), Comprehensive Everglades Restoration Plan (CERP), Corkscrew Regional Ecosystem Watershed (CREW), Corkscrew Swamp Sanctuary (CSS), Critical Wildlife Area (CWA), daily survival rate (DSR), digital single-lens reflex (DSLR), Estero Bay Aquatic Preserve (EBAP), Everglades Depth Estimation Network (EDEN), Everglades National Park (ENP), Florida Atlantic University (FAU), Florida Department of Environmental Protection (DEP), Florida Fish and Wildlife Conservation Commission (FWC), Headwaters Revitalization Schedule (HRS), Holey Land Wildlife Management Area (HWMA), inch or inches per week (in/wk), kilometer(s) (km), Kissimmee River Restoration Evaluation Program (KRREP), Kissimmee River Restoration (KRRP), meter(s) (m), millimeter(s) (m), millimeter(s) per day (mm/d), National Geodetic Vertical Datum of 1929 (NGVD29), National Wildlife Refuge (NWR), North American Datum of 1983 (NAD83), Northeast Shark River Slough (NESRS), prey concentration threshold (PCT), Restoration Coordination and Verification (RECOVER program), Rotenberger Wildlife Management Area (RWMA), Savannas Preserve State Park (SVSP), sea level rise (SLR), Shark River Slough (SRS), South Florida/Caribbean Inventory and Monitoring Network (SFCN), South Florida Water Management District (SFWMD), square kilometer(s) (km^2), standard deviation (SD), standard error (SE), University of Florida (UF), unmanned aerial vehicle (UAV), Water Conservation Area (WCA), Water Management Area (WMA), Water Year (WY).



SYSTEMWIDE SUMMARY

This volume of the South Florida Wading Bird Report combines nesting information from the last two nesting seasons, 2022 and 2023.

NESTING IN SOUTH FLORIDA 2022 AND 2023

An estimated **52,532** and **46,174** wading bird nests (excluding Cattle Egrets [CAEG], which do not rely on wetlands) were initiated in South Florida during the 2022 and 2023 nesting seasons (November to July), respectively. These were moderately poor nesting efforts compared to recent years; both annual estimates were below the 10-year (2012–2021) average annual number of nests (55,273.7 nests) and 2.6 and 3.0 times smaller, respectively, than the banner nesting effort of 2018 (138,834 nests), which was the largest nesting effort observed since comprehensive systemwide nesting surveys began in South Florida in 1996.

Most wading bird species exhibited either reduced or close to average nesting effort during 2022 and 2023 relative to the 10-year annual averages (2012–2021). White Ibis (WHIB) produced 31,848 and 22,003 nests in 2022 and 2023, respectively, declines of 5 and 38% compared to the ten-year average, and considerably lower than the 2018 count (100,784 nests). Given that WHIB is the most numerous nesting species in South Florida (typically between 45 and 78% of all wading bird nests), this decrease accounted for much of the reduction in the total nest count in both years compared to recent large nesting years. Great Egrets (GREG) produced 9,684 and 8,070 nests during 2022 and 2023, which are close to the 10-year average (9,560.3 nests) but approximately half the nesting effort of 2018 (17,960 nests). The federally threatened Wood Stork (WOST) produced 1,716 nests in 2022 and 2,876 nests in 2023. The 2022 WOST nesting effort was about 1,000 nests lower than the ten-year average (2,727.3 nests) while the 2023 estimate was an average nesting effort; nesting effort in both years were considerably lower than in 2018 (5,777 nests). Roseate Spoonbills (ROSP) produced 730 and 617 nests in 2022 and 2023, which were comparable to the decadal average (707.5 nests).

The smaller *Egretta* heron species have exhibited consistent and steep declines in nest numbers over the past two decades, such that relatively few of these birds now nest in South Florida. In 2022, 3,116 Snowy Egret (SNEG) and 795 Little Blue Heron (LBHE) nests were counted, representing a 10 and 62% increase in nesting effort, respectively, relative to the decadal annual averages (2012–2021; SNEG: 2,834.4 nests; LBHE: 489.6 nests). Tricolored herons (TRHE) produced 956 nests, which is a decline of 24% on the 10-year average (1,252.9 nests). In 2023, 4,249 SNEG, 904 LBHE, and 1,515 TRHE nests were counted, representing a 48, 62 and 19% increase in nesting effort, respectively, relative to their decadal annual averages. While counts of small heron nests have generally improved in 2022 and 2023, they remain considerably lower than the 10,000 or so pairs of each species that historically nested in South Florida. A relatively large number of small white heron nests (1,459 and 2,245 nests in 2022 and 2023, respectively) could not be identified to species (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**).

Figure 1. Locations of wading bird colonies with 50 or more nests in South Florida during the 2022 and 2023 nesting seasons.

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%, respectively, of all nests annually. Wading birds initiated an estimated 45,943 nests in the Everglades during 2022, 88% of all nests in South Florida. This nesting effort is within 2% of the decadal average (45,372.1 nests), but 27% lower than the 5-year average (63,353.0 nests) and 63% lower than the 2018 banner nesting effort when a record 122,571 nests were produced. In 2023, 33,479 nests were counted in the Everglades, 73% of all nests in South Florida. This is a decline of 30 and 49% on the 10-year (47,547.7 nests) and 5-year average (65,516.2 nests), respectively, and 73% lower than the 2018 nesting season. The next most important nesting region is Lake Okeechobee, which typically supports approximately 10% of South Florida's nests. The lake accounted for only 4 and 5% of nests in South Florida during 2022 and 2023, respectively. In 2022 the lake produced an estimated 2,114 nests, a 47% decrease on the 10-year average (4,023.0 nests) and about half the number of nests produced in 2021 (3,793 nests). In 2023, it supported 2,460 nests, a 37% decrease on the 10-year average (3,926.5 nests). Another regionally important nesting area is Florida Bay, which supported 1,244 nests in 2022 and 2,188 nests in 2023 (9-year average: 2229.6 nests).

In terms of the spatial distribution of individual species in South Florida in 2022, the Everglades supported most of the nesting WHIB, GREG, WOST, SNEG, LBHE, Black-crowned Night Heron (BCNH), and ROSP (96, 86, 36, 77, 80, 94, and 64% of their total nests, respectively), but only 11% of TRHE nests. Florida Bay supported most of the nesting TRHE (44%). Lake Okeechobee was a relatively important nesting area for SNEG (17% of nests). A similar pattern was evident in 2023. The Everglades supported most of the nesting WHIB, GREG, WOST, SNEG, LBHE, BCNH, and ROSP (82, 77, 52, 61, 69, 90, and 60% of their total nests, respectively), but only 5% of TRHE nests. Florida Bay and Lake Okeechobee supported most of the nesting TRHE (39 and 34%, respectively). Lake Okeechobee and Kissimmee (upper basin lakes) were relatively important nesting areas for SNEG (14 and 13% of nests, respectively).

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, attracted only 36 WOST pairs to nests in 2023, did not support nesting during 2022, and has failed to support nesting during 11 of the past 18 years. The last notable nesting event was 2009 (1,120 nests). 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 IN 2022 AND 2023

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.saj.usace.army.mil/Missions/Environmental/Ecosystem-Restoration/RECOVER/RECOVER-Performance-Measures/) 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: the ratio of visual to tactile foraging wading bird species breeding in the Everglades, and the frequency of exceptionally large WHIB breeding events (Frederick et al. 2009).

Nest Numbers

Nesting effort varied among the four indicator species and between years in 2022 and 2023. SNEG exhibited improved nesting effort in both 2022 and 2023 relative to the decadal average, GREG was above average in 2022 but below average in 2023, WHIB was average in 2022 but below average in 2023, while WOST was below average in both years (**Figure 2**).

The regional declines of *Egretta* herons over the last decade have been particularly acute in the Everglades (**Figure 2**). The number of nests in 2022 and 2023 continues a moderate improvement in nesting effort 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 2022 (2,412 nests) and 2023 (2,600) were both 1.7 times the average for the previous ten years, and an order of magnitude more nests than in 2017 (228 nests), which was the lowest recorded since 1990. TRHE nesting was extremely limited, only 105 nests in 2022 and 78 nests in 2023, a decline on the average from the 2012–2021 period (196.1 nests). The cause of the limited *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 157 nests in 2022 and 153 in 2023, which is below the 10-year average from 2012 to 2021 (266.4 nests), and only 12% of the target 1,258 nests per year. From a historical perspective, 2022 was only 38% of the average number of nests counted in surveys since 1984 (412.8 nests, n = 31 annual surveys including 2022 and 2023) and 2023 was slightly less at 37%.

Counts remain 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 increased nesting effort (468 and 368 nests in 2022 and 2023, respectively).

Annual nesting effort is assessed in CERP 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. 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 14 times since 2000, including 2022 and 2023. SNEG and TRHE have been consistently below target since 1986 (**Table 1**).

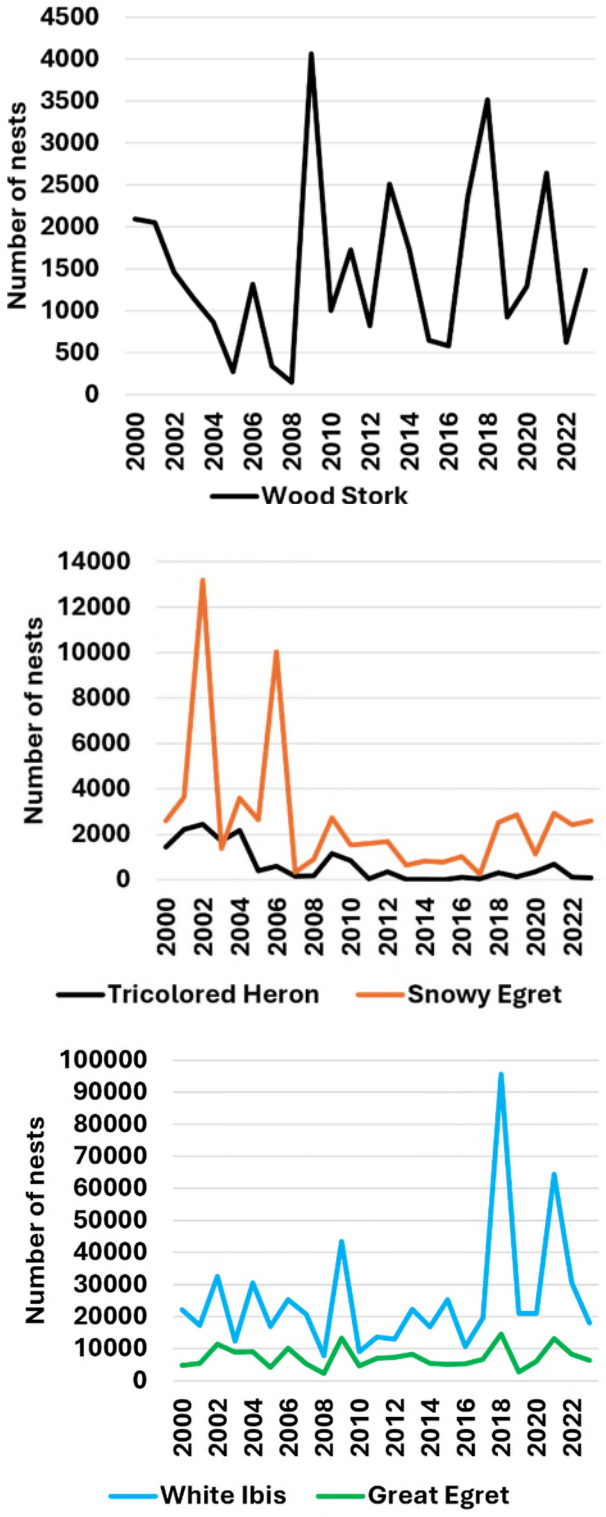


Figure 2. Wading bird nest numbers in the EPA for individual species from 2000 to 2023.

Table 1. Three-year running averages of numbers of nesting pairs of GREG, SNEG, WHIB, and WOST in the mainland Everglades (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**
2020-2022	**9,178**	2.180	**39,051**	**1,503**
2021-2023	**9,221**	2,648	**37,693**	**1,583**
Target Minima	**4,000**	**10,000**	**10,000**	**1,500**

Spatial Distribution of Nests

The coastal region of ENP, especially the southwest coast adjacent to the Gulf of Mexico, 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 and elsewhere in the southeastern United States. An important goal of CERP is to restore the hydrologic conditions that will reestablish 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 2022, ENP supported only 14.6% of nests, while WCA-3A and WCA-1 supported 68.9 and 16.6%, respectively. The proportion of nests in the coastal region in 2022 and 2023 (14 and 23% respectively) were short of the 50% restoration target and a little lower than those recorded over the past five years (between 24 and 42%) but they were greater than the lows of the 1990s and early 2000s (2 to 10%).

The locations of ROSP nesting colonies have shifted away from Florida Bay to the freshwater Everglades in recent years. 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 2020 and 2021 with 986 and 809 nests found in Everglades inland colonies. In 2022 and 2023, 368 and 468 nests were recorded, respectively.

Nesting White Ibis in coastal Everglades National Park

Timing of Nesting

WOST are tactile feeders; their foraging involves touching an aquatic prey animal (primarily fish) with an open bill and using an extremely rapid reflex closure of the bill to capture the animal. For this to be effective, prey need to be present at relatively high densities in the water column, greater than it does for species that forage visually, such as herons and egrets. The occurrence of high densities of prey requires relatively deep conditions in the wet season prior to nesting to promote the production of large fish populations, followed by a consistent decline in water level during the dry season, which concentrates the prey at high densities in shallow water. 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), which means nesting must start early in the dry season to ensure nestlings have time to fledge and gain independence prior to the onset of the rainy season when water levels rise, fish move into deeper water and disperse across the landscape, and availability declines. WOST nesting historically started in November or December but 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 coastal and high elevation wetlands (6- to 10-month hydroperiod) that provide foraging habitat early in the nesting season. The 2022

and 2023 initiation dates were mid-February and late January. These are a little later than the December/early January start dates of 2017 and 2018 but were considerably earlier than in 2016 (late March). The likely reason for this late nesting and poor nesting success was the relatively dry conditions in the coastal and high-elevation inland marshes during the late wet seasons (fall) of 2021 and 2022 that limited prey production and suitable forging habitat early in the nesting season.

Nesting Success

Nest success of CERP indicator species in the Everglades is generally low but highly variable in time and space. In both 2022 and 2023, overall nest success was very poor. Two years of relatively dry conditions limited prey productivity and the availability of foraging habitat at the right time and place in key foraging habitats such as WCA-3A, Big Cypress National Preserve, and coastal areas. In 2023, the poor conditions were further compounded by large rain-driven water level reversals during April, the peak of nesting. For more information on nesting success see the *Water Conservation Areas 2 and 3, and A.R.M. Loxahatchee National Wildlife Refuge* and *Everglades National Park Mainland* sections).

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).

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 centimeters [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. Successful nesting years are characterized by deeper than average conditions during the antecedent wet season, which extends hydroperiods and increase populations of prey animals, followed by a relatively dry winter/spring nesting season (dry season), which allows for a consistent drop in water level that concentrates the prey at high densities in shallow water at the right time and place.

Wading bird foraging flock May 2022 in WCA-3A

The relatively poor nesting responses during 2022 and 2023 were the result of unfavorable hydrologic conditions that were not conducive for promoting prey availability both prior to and during the nesting season (for more information and hydrological figures referenced in this section see the *Hydrologic Patterns for Water Years 2022 and 2023* section). The 2022 nesting season was preceded first by relatively dry conditions during the wet season (June–November 2021) in the primary foraging habitats (WCA-3A, Big Cypress Basin and Lostmans Slough, and the coastal habitats in ENP) but relatively wet conditions in Northeast Shark River Slough (NESRS) in ENP (**Figures 5** and **6** in the *Hydrologic Patterns for Water Years 2022 and 2023* section. This was due to lower-than-average rainfall (**Table 2** in the *Hydrologic Patterns for Water Years 2022 and 2023* section) but was *possibly also influenced by* the recently implemented Combined Operations Plan (COP) that increases flows to ENP by reducing stages in WCA-3A. These led to long periods of dry or very shallow conditions across large areas of the central Everglades for extended periods that limited prey (fish and crayfish) production. Following the dry 2021 summer and fall, the 2021-2022 winter–spring breeding season was also drier than average. This led to a relatively continuous drop in water level across the Everglades landscape with recession rates suitable for concentrating aquatic prey; however, given the limited antecedent prey production, the resulting prey densities were low and foraging habitat was generally poor quality. Moreover, the initial shallow conditions meant most areas dried down too early in the nesting season such that optimal foraging depths were not available at the right time and place in relation to the timing and location of nesting colonies. These ideas were

supported by weekly aerial surveys during which relatively few foraging birds were observed across the Everglades landscape for much of the nesting season, especially in the key habitats of WCA-3A and western ENP (M. Cook, personal observation). The extensive drying of WCA-3A did provide excellent foraging habitat during May in the ponded areas close to the southern and eastern levees that typically rarely dry, support large fish populations, but are typically too deep for foraging. When these areas became shallow enough, they supported many thousands of foraging birds (**Figure 3**) and even triggered dozens of wood storks to start nesting.

Figure 3. WOST foraging in concentrated pools in central WCA-3A.

However, this foraging bonanza lasted just three weeks, and the extremely late stork nesting promptly failed. Water levels continued to decline in the central Everglades into June 2022 when stages dropped below or at ground level across all WCA-3A (**Figure 4**). This extreme drying likely had significant impacts on fish and other aquatic prey populations and limited prey resources for the 2023 nesting season.

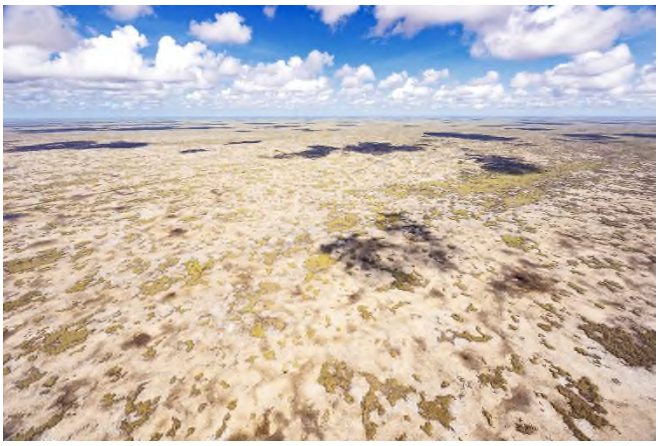


Figure 4. Same location as **Figure 3** three weeks later.

Hydrological conditions leading up to and during the 2023 nesting were similar to those in 2022 (**Figures 7** and **8** in the *Hydrologic Patterns for Water Years 2022 and 2023* section). The 2023 nesting season was preceded by relatively dry conditions during the wet season (June–November 2022) in the key foraging regions for wading birds (WCA-3A, Big Cypress Basin and Lostmans Slough, and the coastal habitats in western ENP) but were very wet in Shark River Slough (SRS) in ENP. A late wet season November rainfall event did raise water levels slightly above average in most regions by the start of the dry season but not enough to produce sufficient depths and hydroperiods conducive to optimal prey production. The 2023 winter–spring breeding season was relatively dry leading to a relatively continuous drop in water level across the Everglades landscape but as in the 2022 nesting season, the initial shallow depths and limited prey production reduced overall prey availability and disrupted the timing of habitat availability. A large rainfall event in early April caused rapid reversals in water levels leading to widespread abandonment of nesting in some areas, but it did spare central WCA-3A from another season of excessive drying at the end of the dry season. Despite increases in stages, hydroperiods, and area of suitable foraging habitat in NESRS during both 2022 and 2023, this area supported very few foraging birds, suggesting this region is not conducive to wading bird foraging. This might be related to the recent establishment of non-native swamp eels in eastern ENP which have been correlated with precipitated population crashes of crayfishes (*Procambarus fallax* and *P. allenі*) and significant population reductions of several small fishes (Pintar et al. 2023).

Communications among ecologists and water managers at weekly operations meetings play an important role in maintaining suitable hydrological conditions for wading birds during the nesting season. Water management played a particularly important role during the 2022 and 2023 nesting seasons by maintaining appropriate depths 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 two nesting seasons and ensured hydrological conditions remained suitable for nesting (M. Cook, personal observation).

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 years 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 nesting SNEG, TRHE, and LBHE remain very low (**Figure 2**), and the causes of this are not fully understood. 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 necessary levels 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. Further improvements in these nesting responses will be contingent upon rehydration of critical wading bird foraging regions such as the coastal ecotone, short-hydroperiod habitats in western ENP and Big Cypress National Preserve, and northern and central WCA-3A. 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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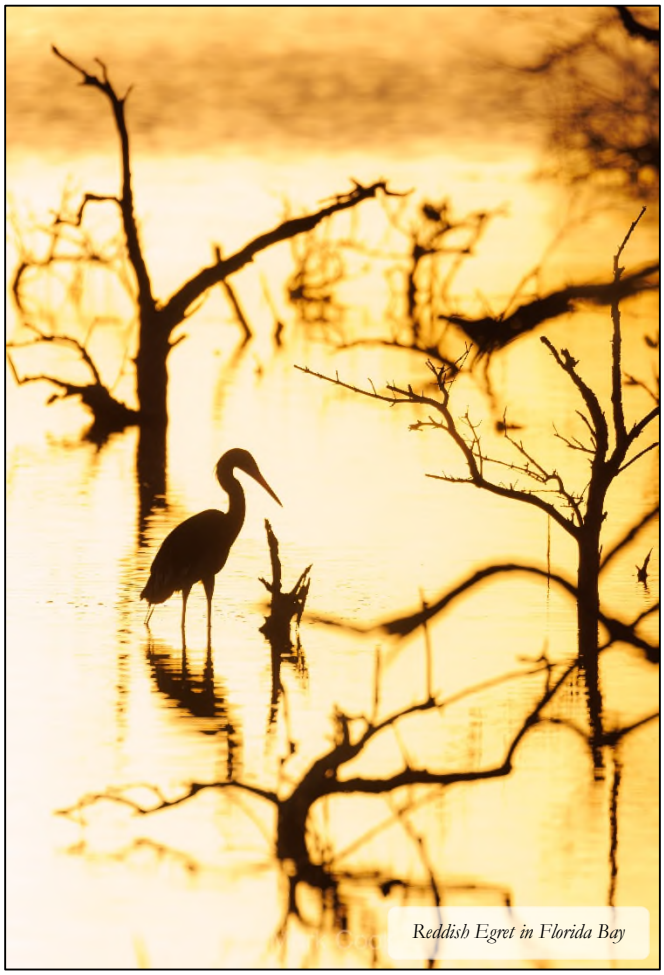
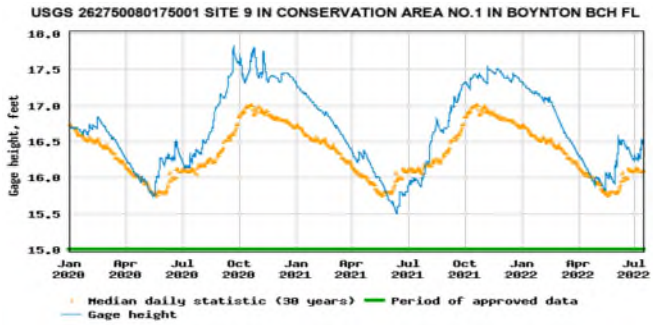


Reddish Egret in Florida Bay

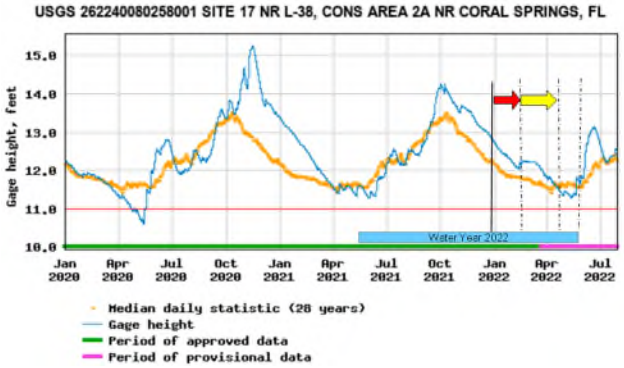
HYDROLOGIC PATTERNS FOR WATER YEARS 2022 AND 2023

This section summarizes the hydrological conditions during water years 2022 (WY2022; June 2021 through May 2022) and 2023 (WY2023; June 2022 through May 2023). **Figures 5** and **6** show stage data in the Everglades (WCAs and ENP) for a 2.5 year period relative to historical average stages and ground elevation (in feet [ft] National Geodetic Vertical Datum of 1929 [NGVD29]) and cover hydrological conditions during WY2022 and WY2023, respectively. They also show 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 too shallow or too deep and/or recession rates 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 gage 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 7** and **8** for the 2022 and 2023 nesting seasons, respectively. 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 (m) by 400-m scale using the Everglades Depth Estimation Network (EDEN) (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 dry season and then rewet again at the beginning of the wet season.

A. WCA-1 – Site 9



B. WCA-2A – Site 17



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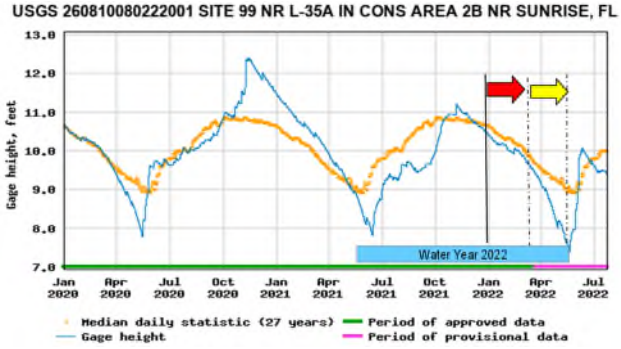
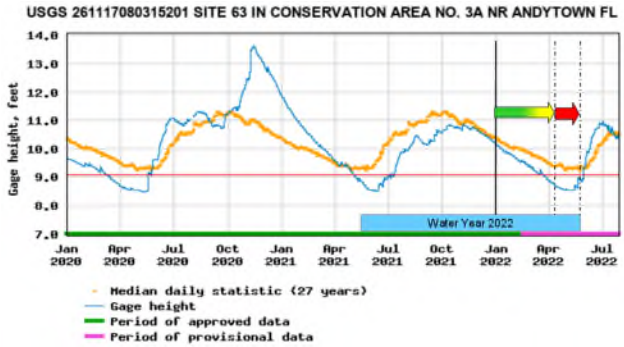
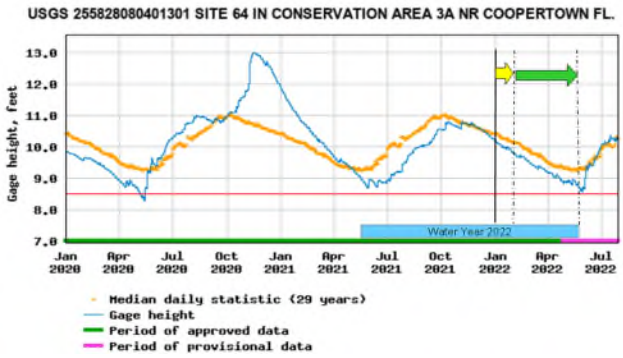


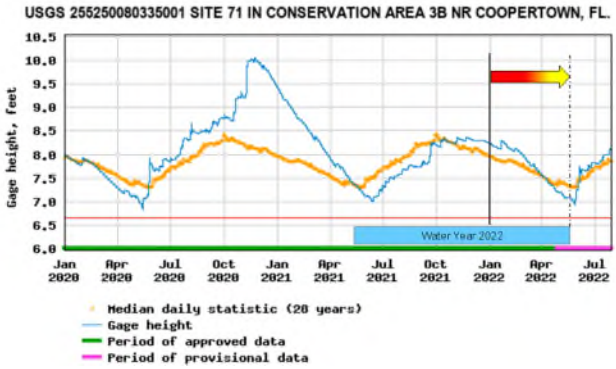
D. WCA-3A – Site 63



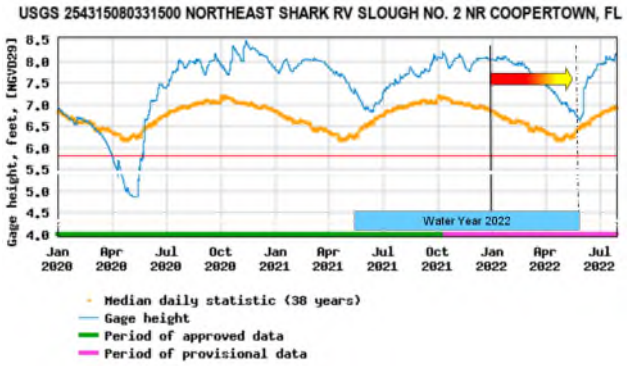
E. WCA-3A – Site 64



F. WCA-3B – Site 71



G. Northeast Shark River Slough



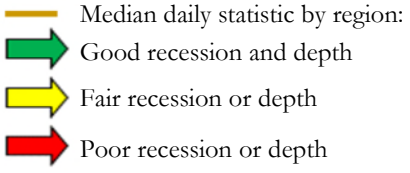
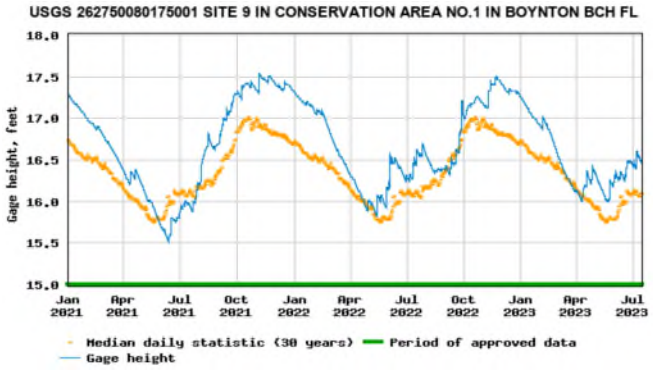
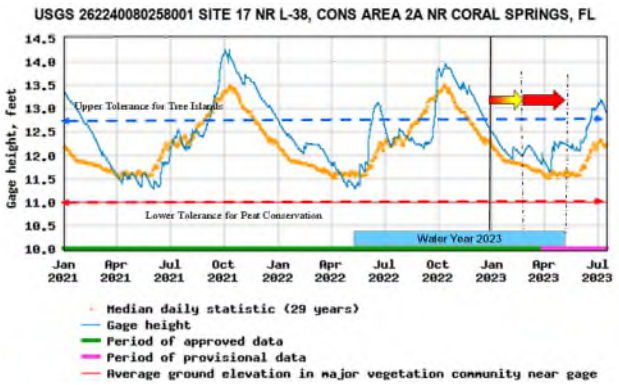


Figure 5. Hydrology (feet NGVD29) in the WCAs and ENP in relation to average water depths (A: 30-year average, B: 27-year average, C: 27-year average, D: 27-year average, E: 29-year average, F: 28-year average, and G: 38-year average) and indices for wading bird foraging.

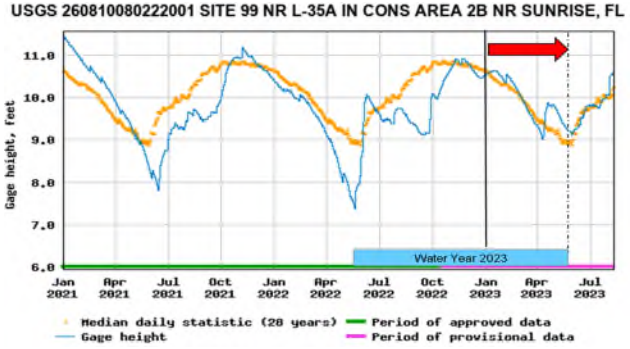
A. WCA-1 – Site 9



B. WCA-2A – Site 17



C. WCA-2B – Site 99



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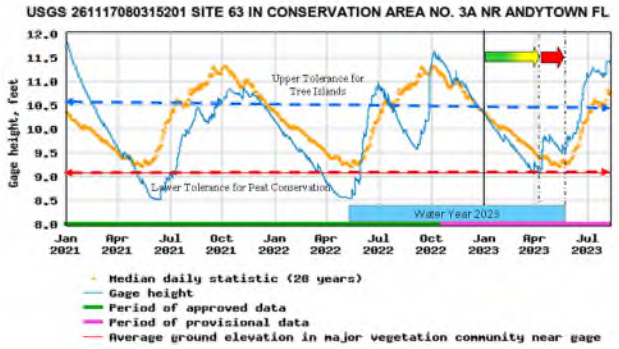
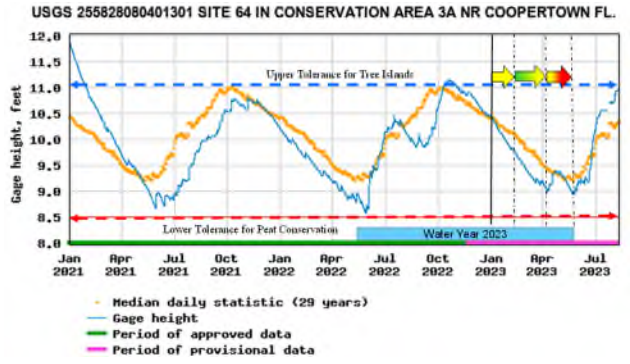
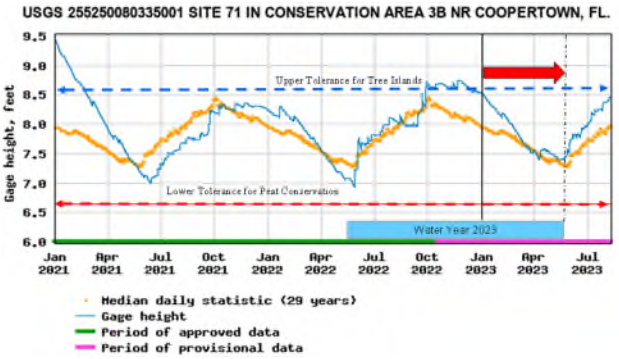


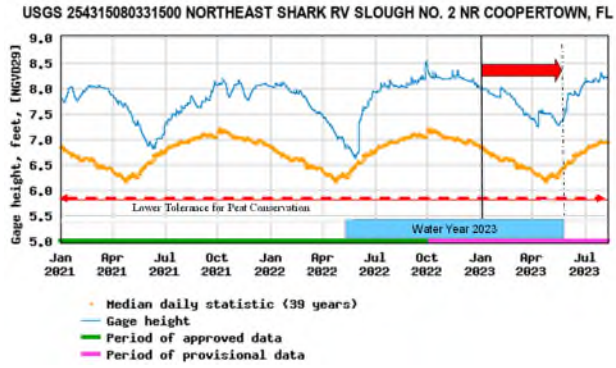
E. WCA-3A – Site 64



F. WCA-3B – Site 71



G. Northeast Shark River Slough



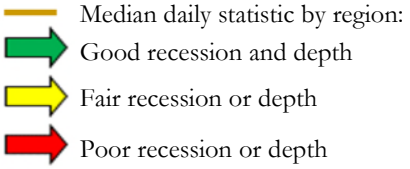


Figure 6. Hydrology (ft NGVD29) in the WCAs and ENP in relation to average water depths (A: 30-year average, B: 29-year average, C: 29-year average, D: 29-year average, E: 29-year average, F: 30-year average, and G: 40-year average) and indices for wading bird foraging.

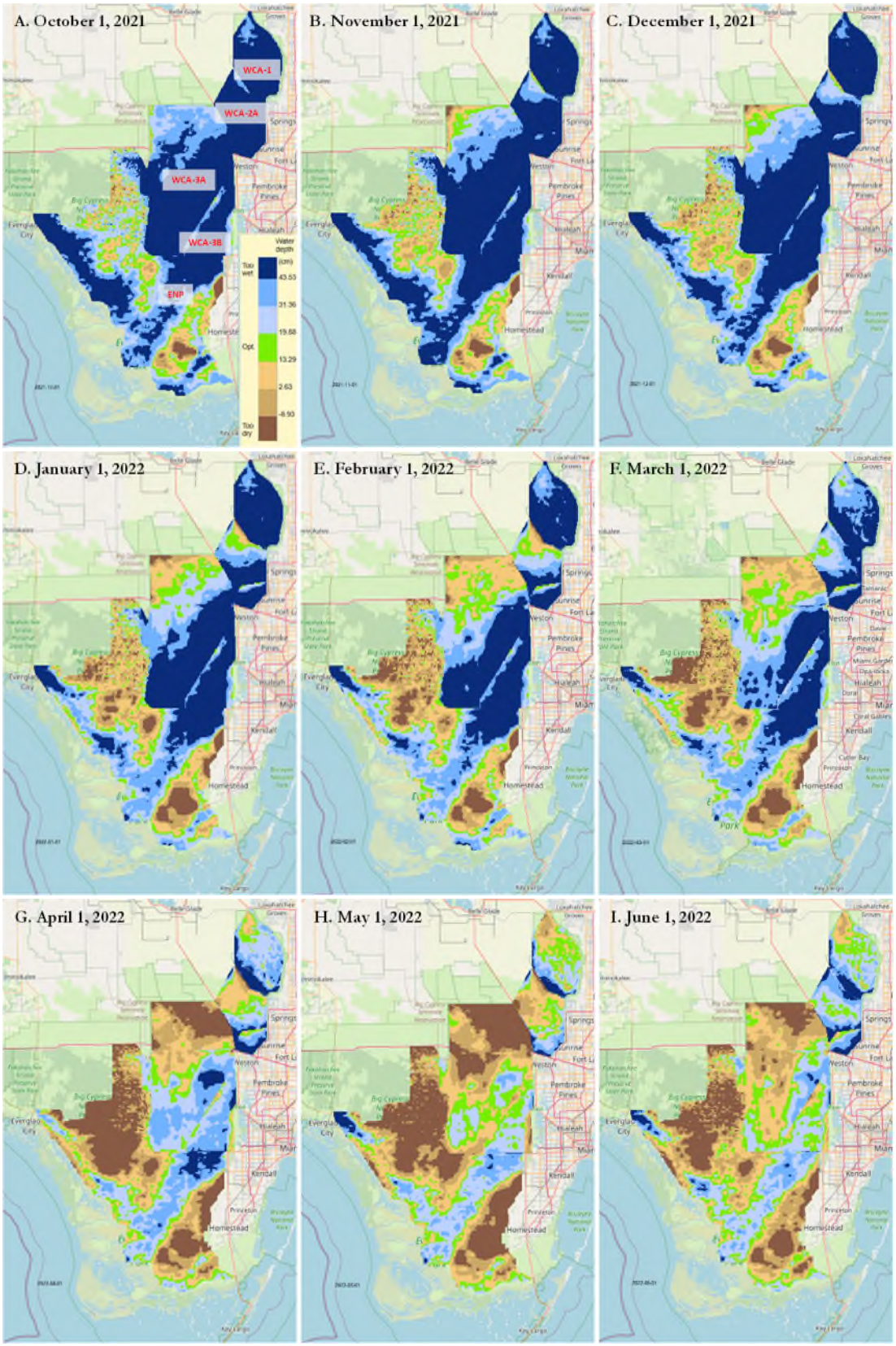


Figure 7. Habitat suitability index maps representing the suitability of water depths for wading bird foraging across the Greater Everglades landscape on the first day of each month from October 2021 through June 2022. Water depths are categorized to represent conditions that are optimal (green), too dry (shades of brown), or too wet (shades of blue) for foraging and are calculated at a 400-meter by 400-meter scale using EDEN.

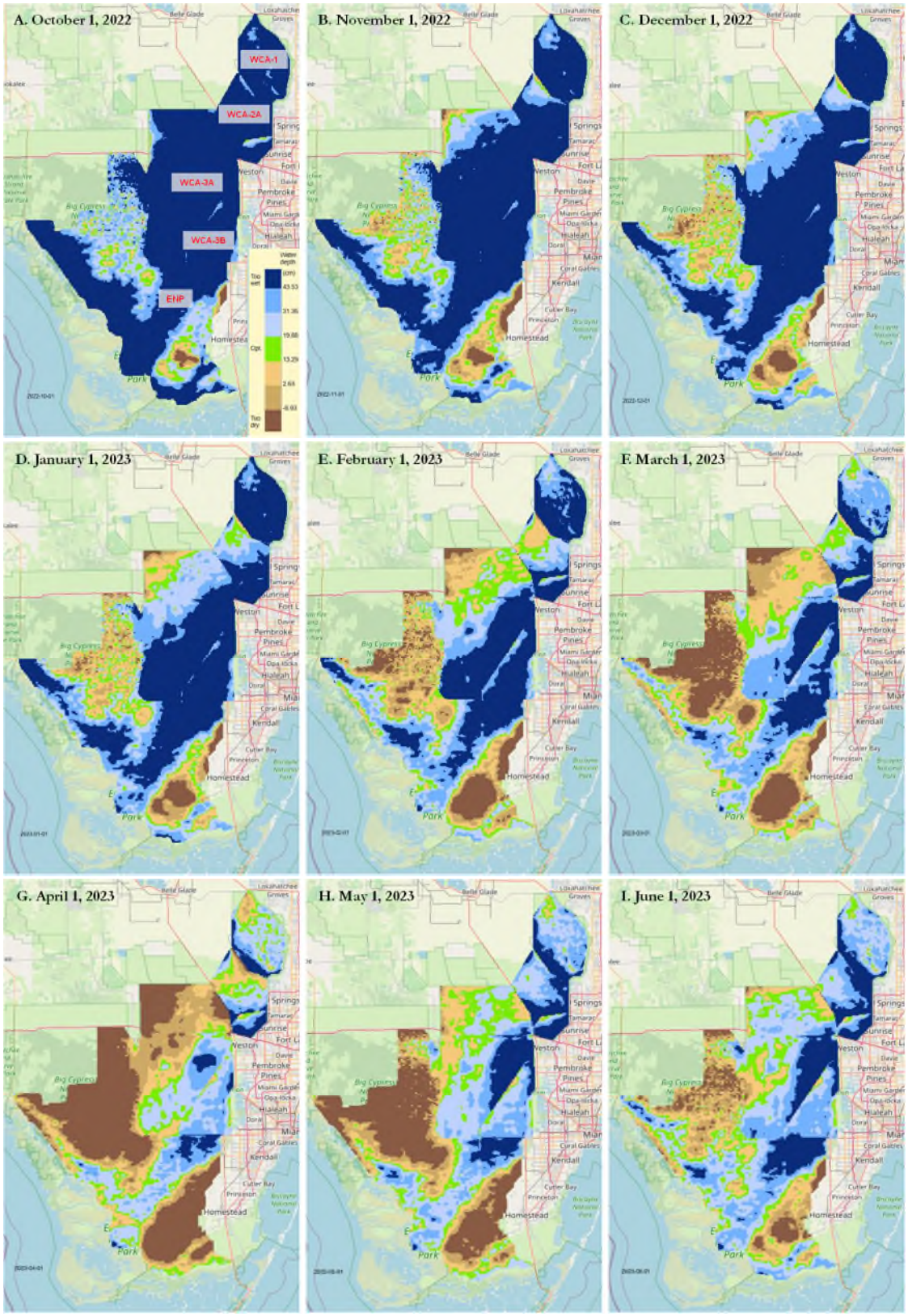


Figure 8. Habitat suitability index maps representing the suitability of water depths for wading bird foraging across the Greater Everglades landscape on the first day of each month from October 2022 through June 2023. Water depths are categorized to represent conditions that are optimal (green), too dry (shades of brown), or too wet (shades of blue) for foraging and are calculated at a 400-meter by 400-meter scale using EDEN.

WATER CONSERVATION AREAS AND NORTHEAST SHARK RIVER SLOUGH HYDROLOGY, 2022

Annual rainfall totals in the Everglades during WY2022 were below long-term average historical conditions. Rainfall for the year was approximately 6.6 inches (12.3%) below the historical averages in the Everglades WCAs 1 and 2, 8.3 inches (15.8%) below average in WCA-3, and 14.2 inches (25.7%) below average in ENP. Despite below average rainfall, stages were generally above average across the Everglades with the exception WCA-3. Annual average stage was 0.4 ft above average in WCA-1, 0.2 ft above historical average in WCA-2, 0.5 ft below historical average in WCA-3, and 0.3 ft above average in ENP (**Table 2**).

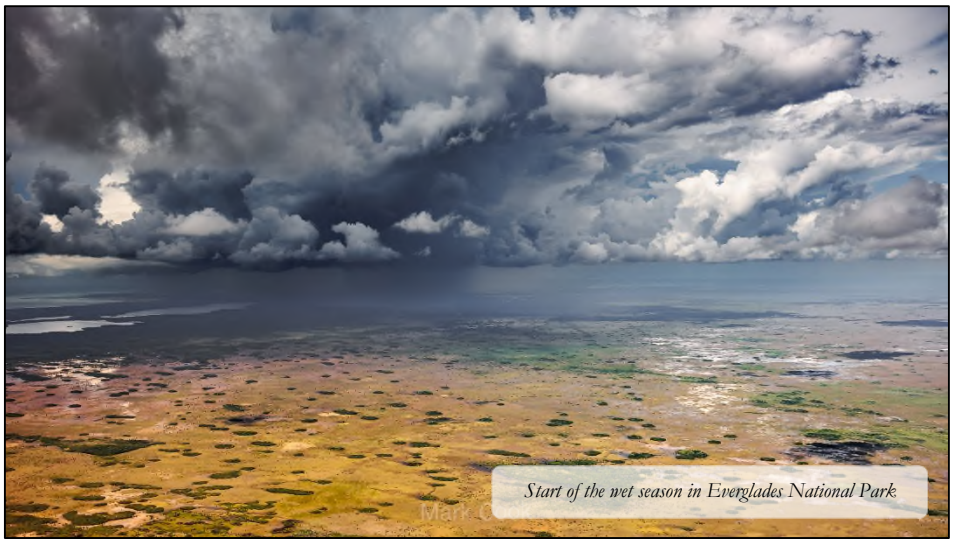
Water depths across the Everglades at the beginning of WY2022 were generally below average historic stages except in ENP where they were higher than average. The wet season began on May 28, 2021, and was notable for its below average rainfall through early November. These relatively dry conditions were not conducive to producing the large populations of fish and other aquatic prey animals across the Everglades landscape that wading birds need to support reproduction during the subsequent nesting season. Wet season water levels climbed to, and generally followed or exceeded, the median stage in WCA-1, WCA-2A, and NESRS, but remained below the median stage in WCA-3A and WCA-3B. WY2022 was the first time that COP was implemented throughout the entire water year, and its influence on water levels is evident from the relatively high stages in NESRS compared to the dryer conditions throughout the rest of the ecosystem. Recession rates across the EPA during the WY2022 dry season generally exceeded the ecologically-based recommended rate of stage change of 0.05 to 0.12 ft per week. This rapid recession rate in combination with the generally low stages throughout much of the Everglades meant many areas dried down relatively early in the breeding season, optimal foraging conditions did not become available to birds at the right time and place, and nesting was largely limited and unsuccessful. Indeed, the central Everglades became so dry by the end of May 2022 that stages were at or below ground surface across all WCA-3A with catastrophic consequences for populations of aquatic fauna in that area (**Figure 4**).

On a positive note, these dryer than average conditions meant tree islands could recover from the previous year's above average depths (**Table 2**). In summary, lower than average rainfall and water depths in WY2022 limited the production of prey and the availability of foraging habitat for wading birds resulting in limited nesting effort and reduced reproductive success. This is in stark contrast to the much wetter conditions in WY2021, which promoted near record-breaking nesting output.

Table 2. Average, minimum, and maximum stage in ft NGVD29 and total annual rainfall in inches for WY2022 in comparison to historic stage and rainfall.[a] (Average depths calculated by subtracting elevation from stage.)

Area	Rainfall (inches)		Mean (Minimum; Maximum) Stage (ft NGVD29)		Elevation (feet NGVD29)
	WY2022	Historic / Period	WY2022	Historic / Period	
WCA-1	47.32	53.93 / WY1991–WY2020	16.7 (15.3; 17.5)	16.3 (14.0; 18.1) / WY1991–WY2021	15.1
WCA-2	47.34	53.93 / WY1991–WY2020	12.5 (11.3; 14.2)	12.3 (9.45; 15.4) / WY1991–WY2021	11.2
WCA-3	44.67	53.0 / WY1991–WY2020	9.5 (8.4; 10.6)	10.0 (7.0; 12.8) / WY1991–WY2021	8.2
ENP Slough at P33	40.93	55.09 / WY1991–WY2020	6.7 (6.1; 7.2)	6.4 (3.2; 8.1) / WY1991–WY2021	5.4

a. Historical averages are based upon varying lengths of records at gages.


Start of the wet season in Everglades National Park

Water Conservation Area 1

At the start of WY2022, the water level in WCA-1, part of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (A.R.M. LNWR), was well below the 28-year daily median (**Figure 5A**) primarily because rainfall in May 2021 was less than half of its historical average as measured by South Florida Water Management District (SFWMD) Raindar estimates (https://www.sfwmd.gov/weather-radar/rainfall-historical/seasonal). Depths began to rise steadily in June 2021 in response to above average June precipitation, and by August, 2021 stage was above the 28-year daily median. The stage peaked in late October 2021 and did not begin a sustained drawdown until January 2022. Stage remained above average during most of WY2022 and finished close to the long-term median in May 2022. Above average depths during most of the wet season resulted in suitable conditions for prey production. Stage was too deep for wading bird foraging at the beginning of the nesting season but falling water depths provided better foraging conditions by March in the northern portion of WCA-1 and continued as the drying front and optimal foraging depths progressed south for the remainder of the wading bird nesting season (**Figures 7D to 7I**). Recession rates were generally near optimal to slightly faster than ideal during the nesting season. The high water prior to the start of the nesting season, along with a sustained drawdown in WCA-1, provided some of the better foraging conditions of the season compared to the rest of the EPA.

Water Conservation Area 2A

Foraging habitat in WCA-2A is limited to the open water slough habitats of its central and southern regions because dense vegetation in northern WCA-2A generally precludes foraging. Stage at the 2-17 gage in WCA-2A at the start of WY2022 was close to the 28-year daily median and thereafter ascended along the historical median depth until going above the median in mid-September (**Figure 5B**). Water depths peaked at slightly less than 1 ft above the median peak depth in October 2021. Stage then receded at a rate that was generally faster than the ideal range of between 0.05 and 0.12 ft per week. Stage remained above the 28-year daily median until early April. Suitable foraging depths became available in central WCA-2A in late February 2022, with suitable depths in southern and eastern WCA-2A lasting through May.

Water Conservation Area 2B

WCA-2B tends to be too deep for wading bird foraging and becomes available habitat only during the driest years. During WY2022, water depths in this basin started well below average and remained below the 27-year daily median until peaking in early November 2021 (**Figure 5C**). Stage remained near the median values until April 2021, when a rapid recession rate drew water depths well below the median. Despite this drop in water level, conditions generally remained too deep for foraging in this basin (**Figure 6**) and very few birds were observed foraging here.

Wading bird foraging flock in Water Conservation Area 2A

Water Conservation Area 3A

WCA-3A is one of the primary foraging areas in the EPA. For the sixth year in a row, water levels in northeastern WCA-3A at the beginning of the water year began below the historical median (**Figure 5D**). Stages rose slowly and remained below the median for the remainder of the water year. Although there are few tree islands left in northern WCA-3A, some, like Alley North, can support extremely large nesting events when hydrological conditions are appropriate. Large successful nesting events here require relatively high peak stages (a minimum of 11.5 ft NGVD29) in the marsh during the fall to promote prey production and to allow for a consistent dry down throughout the nesting season. Relatively high stages in the fall are also associated with relatively high stages in the spring, when the birds start nesting; this maintains standing water around the colony, which protects nesting birds by excluding terrestrial predators like racoons. Birds will only nest at colonies with this protective standing water. During WY2022, stage peaked in mid-October 2021 but it was well below the the threshold 11.5 ft (**Figure 5D**). While depths were sufficient to support large foraging flocks in northern WCA-3A during December, by March, much of the WCA-3A north of I75 was dry, with insufficient surface water to provide foraging habitat or protect the Alley North colony from predators.

The hydrologic mechanisms supporting wading bird foraging and nesting in central and southern WCA-3A are similar to those in the northern region; high peak stages are needed in the fall to produce sufficient prey resources across the landscape, and to allow for sufficient depths for foraging starting in the early spring (March to May). Peak stages in November 2021 were too shallow to produce sufficient prey populations and, although recession rates were generally optimal (**Figure 5E**), water depths dropped too low by March and April 2022 to support foraging at the right time and place for nesting birds. Reduced prey production and limited foraging habitat meant that very few birds were observed foraging in this region at this critical time (compare WY2022 peak and spring depths with those in WY2021, which supported banner numbers of foraging and nesting birds, **Figure 5E**). However, continued extensive drying into May allowed the ponded areas of WCA-3A, which are typically too deep for foraging, to attain suitable depths and support a late surge in foraging activity (**Figure 3**). While large numbers of birds took advantage of these excellent conditions, it was too late in the nesting season to trigger or support nesting. By late May 2022 the area was too dry for foraging and few birds were observed there. On June 1, a SFWMD survey flight revealed extensive drying below ground level across the breadth of WCA-3A (**Figure 4**). These observations were inconsistent with gage stage-data and model output (**Figure 7I**), which suggests some stage gages were registering depths deeper than reality (**Figure 9**). This extreme drying resulted in the widespread loss of aquatic animal communities thereby limiting the production of future prey resources for birds in WY2023.

Figure 9. Stage gage registering deeper water than reality.

Water Conservation Area 3B

Water levels in WCA-3B began WY2022 below the historic median (**Figure 5F**) and remained below average until peaking in October. Stages remained close to the median until April, and then fell below average. Depths were too great for foraging for most of the nesting season, but foraging habitat did become available in late April (**Figure 7A to 7H**).

Northeast Shark River Slough

At the beginning of WY2022, water levels in NESRS were above the historic median (**Figure 5G**). Water levels rose steadily and peaked in October well above the 38-year median. Depths remained high and above the historic median for the remainder of the water year and did not begin to steadily draw down until February. While suitable foraging depths did become available along the western and eastern edges of SRS, no birds were observed foraging there in 2022 (**Figure 7E to 7I**).

Wading bird foraging flock in Water Conservation Area 3A December 2022

WATER CONSERVATION AREAS AND NORTHEAST SHARK RIVER SLOUGH HYDROLOGY, WY2023

Rainfall across the Everglades during the WY2023 wet season (May 12–September 28, 2022) was close to the historical average (106% of the long-term mean). Heavy rains in September associated with tropical activity caused increases in water depths and higher late wet season peak stages. Dry season rainfall was also just above average, with WCA-1 and WCA-2A receiving 121% of average, while WCA-3A received 111% of average.

In accordance with the above-average annual total-rainfall, mean stages in the Everglades during WY2023 were marginally above average historical conditions in WCA-1 and WCA-2A (**Table 3**). This was not the case in WCA-3A where stages were below mean annual stage despite the average rainfall, perhaps a reflection of the changes in operations brought about by the COP that is designed to lower stages in the deep, ponded regions of southern WCA-3A and send that water to the overdrained northern region of SRS in ENP (**Table 3**). Although WCA-1 and WCA-2A had above average stages, a necessary prerequisite for optimal prey production, wading bird nesting effort was below average for the second consecutive year, highlighting the importance of optimal hydrology across the larger Everglades landscape for sustaining South Florida's nesting wading bird populations.

Water depths across the WCAs at the beginning of WY2023 began below median historic stages and in northern WCA-3A were below ground level. When water levels decline below ground, this can significantly reduce aquatic prey populations and result in oxidation (loss) of the essential peat substrate. The wet season began on May 12, 2022, at which point stages were generally below average. Thereafter, average rainfall produced rapid increases in water levels and by June stages were generally above average and stayed that way through June. In early July stages dropped rapidly to the long-term median in WCA-1 and WCA-2A, and considerably below it in WCA-2B and WCA-3A. The stage at gage 63 dropped as low as 9.6 ft, meaning that large areas across northern WCA-3A, a critical foraging area, were at or below ground surface in the middle of the wet season. In

stark contrast, depths remained relatively stable and well above ground surface at this time in SRS. The dry marshes of the WCAs were subsequently rehydrated by a large tropical rainfall event in September 2022, which caused rapid and substantial increases in water levels and generally pushed stages above the long-term median across the WCAs. The dry season began on September 28, 2022, but stages continued to rise in most of the WCAs until they peaked a little higher than normal in mid-October. Water depths then receded across the system at an appropriate rate of around 0.05 ft per week until a series of rainfall-driven reversals in April largely ended wading bird foraging and nesting. (**Table 3**).

Water Conservation Area 1

At the start of WY2023, the water level at Site 9 in the southern half of WCA-1 was close to the 29-year daily median (**Figure 6A**). As the wet season progressed, depths and rates of increase were generally similar to the long-term average but then exceeded the average depth starting in November until February. This late November peak stage was about a month later than average and a sustained drawdown did not begin until January. Depths at Site 9 fell to average during most of the remainder of the water year but finished with reversals in April due to unseasonably high rainfall. Stage was too deep for wading bird foraging in WCA-1 at the beginning of the nesting season but water level recession provided suitable conditions in northern WCA-1 by March (**Figure 8F**). New foraging habitat became available further to the south as drying continued until rainfall-driven reversals in April resulted in an untimely end to wading bird foraging and nesting.

Water Conservation Area 2A

At the start of WY2023, water levels at Site 17 in south central WCA-2A were close to the median then exhibited a highly variable pattern going both well above and well below average before ascending rapidly by over a foot in September to peak at about 0.5 ft above the median depth in October (**Figure** 6**B**). During the dry season, stages receded at a rate that was generally optimal for wading birds between 0.01 and 0.10 ft per week and remained above the median for the remainder of the water year. Depths were generally too deep to provide wading bird foraging habitat until February (**Figure 8E**) when condition became favorable for foraging in central WCA-2A. Reversals in late February and early March (**Figure 6B**) prevented further foraging in this region.

Table 3. Average, minimum, and maximum stage in ft NGVD29 and total annual rainfall in inches for WY2023 in comparison to historic stage and rainfall. [a] Average depths calculated by subtracting elevation from stage.

Area	Rainfall (inches)		Mean (Minimum; Maximum) Stage (ft NGVD29)		Elevation (feet NGVD29)
	WY2023	Historic / Period	WY2023	Historic / Period	
WCA-1	60.49	53.93 / WY1991–WY2020	16.7 (15.7;17.5)	16.4 (14.0;18.1)/ WY1991-WY2022	15.1
WCA-2A	60.49	53.93 / WY1991–WY2020	12.5 (11.3;13.9)	12.3 (9.5;15.4) / WY1991-WY2022	11.2
WCA-3A	56.63	53.00 / WY1991–WY2020	9.8 (8.4;11.0)	10.0 (7.0;12.8) / WY1991-WY2022	8.2
ENP Slough at P33	54.98	55.09 / WY1991–WY2020	7.0 (6.2;7.5)	6.4 (3.2;8.1)/ WY1991-WY2022	5.4

a. Historical averages are based upon varying lengths of records at gages.

Nesting White Ibis in Water Conservation Area 3A

Water Conservation Area 2B

WCA-2B tends to be too deep for wading bird foraging in most years. During WY2023, water depths at gage 99 started well below average and remained so until reaching peak depth in mid-November (**Figure 6C**). Thereafter, stage receded quickly but remained near the median until April when rainfall pushed stages well above the median for the remainder of the water year. Depths at or above the median in this sub-basin have limited potential to provide wading bird foraging habitat and few wading birds were observed in this sub-basin throughout the nesting season (**Figure 8**).

Water Conservation Area 3A

For the seventh year in a row, water levels in Northeastern WCA-3A at site 63 began the water year below the historical median and below ground level (**Figure 6D**). Shortly thereafter, stages rose rapidly to above the long term median and remainded there through June. In early July, depths started dropping sharply until September when they were about 1.5 ft below the long-term median resulting in very dry condtions during this part of the wet season. In September, a significant tropical rainfall event replenished water levels such that water levels exceeded the long-term average by early October. Stage peaked in mid-October and reached the 11.5 ft minimum threshold depth needed to support wading bird foraging and nesting in the region of WCA-3A north of I75. The dry season recession started in early October but stages descended at a rate that was generally faster than average. Excellent foraging conditions were available starting in December (**Figure 8C**) but the rapid recession rate meant the area dried down too quickly to support sustained foraging throughout the nesting season, and by March much of northern WCA-3A was too dry for foraging (**Figure 8F**).

The hydrologic pattern in central WCA-3A (gage 64) was similar to that in northern WCA-3A. At the start of WY2023, water depth was about 1 foot below the long-term average and very close to the soil surface such that the landscape in this area was largely dry (**Figure 6E**). However, water-level rose rapidly in early June and by July it was above the long-term average stage. As in northern WCA-3A, stage then rapidly dropped to below average until tropical rainfall in September pushed the stage to peak slightly above average in October (**Figure 6E**). The dry season decline in water level started in November with recession rates that were largely optimal for wading bird foraging (**Figures 8F** to **8G**). This lasted until April when rainfall-driven reversals significantly increased water level and reduced available foraging habitat. While depths and recession rates were generally conducive to wading bird foraging in central WCA-3A, the relatively dry antecedent conditions during both the WY2022 dry season and the WY2023 wet season likely severely limited prey production. This is supported by the relatively low number of foraging and nesting birds observed in this area in 2023.

Water Conservation Area 3B

Water levels in WCA-3B began WY2023 below the historic median but rose quickly thereafter rising along the median until peaking in early October. During the dry season, stages remained considerably above the median (**Figure 6F**) for about three months. Depths were too deep during the wading bird nesting season for foraging and relatively few birds were observed within this basin (**Figure 8A** to **8H**).

Northeast Shark River Slough

Since the implementation of COP in 2021, water levels in NESRS have started every water year well above the historic daily median (**Figure 6**) and WY2023 was no exception. Water levels rose quickly in June and peaked in October well above the 39-year median. Depths remained high and above the median for the remainder of the water year and did not begin to steadily draw down until February. A combination of wet antecedent conditions to produce aquatic prey, and optimal recession rates and foraging depths along the margins of SRS in the dry season (**Figures 6E** to **6I**) should have provided excellent foraging habitat for wading birds. Despite this, very few wading birds were observed in this region and the reason for this remains to be determined; the documented recent incursion of the invasive Asian swamp eel, which has been associated with considerably reduced populations of wading bird prey populations, may be a factor.

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Snowy Egret and Laughing Gull

REGIONAL NESTING

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

The University of Florida (UF) Wading Bird Project continued its long-term monitoring of wading bird reproduction throughout WCA-2, WCA-3 and A.R.M. LNWR (WCA-1) during both the 2022 and 2023 nesting seasons. Monitoring focused primarily on counts for GREG, WHIB, SNEG, and WOST, the species that serve as bioindicators for 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 from visits to nesting colonies and more intensive studies of nest success.

METHODS

Aerial and ground surveys were performed in 2022 and 2023 to locate and characterize nesting colonies. Standardized aerial surveys occurred on or around the 15th of each month from January through June and were performed to find active colonies using observers seated on both sides of a Cessna 185. Surveys were conducted from an altitude of 800 ft above ground level along east-west oriented flight transects spaced 1.6 nautical miles apart. These techniques have been used since 1986 and they result in overlapping coverage under a variety of weather and visibility conditions. In addition to contemporaneous visual estimates of nesting birds by the two observers, digital aerial photos were taken of all colonies and nesting birds in the photos were counted. Individual colony nest starts were derived from a combination of information sources, including peak estimates of nests in any colony, supplemental information from monthly SFWMD helicopter surveys staggered by two weeks from the UF survey, ground visits, unmanned aerial vehicle (UAV) flights (2022 only), and inference from observations across the season.

In 2022, a UAV was used to augment the standard aerial survey sampling method in WCA-3. Surveys were conducted over as many well-known active colony locations as possible to obtain maximum nest starts. However, because of abnormally dry conditions in 2022, not all active colonies could be accessed by boat at peak nesting for all species. Additionally, UAV flights were conducted over 7 colonies (6th Bridge, Cypress City, Jetport New, Joule, Jerrod, and Vacation) in WCA- 3 to determine nest turnover and success. A UAV quadcopter fitted with a Zenmuse X7 35-millimeter (mm) equivalent camera lens was used to conduct aerial surveys. Images captured via UAV were shot from an altitude of 250 ft above ground level at an angle of 15 degrees 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 have a different overall detection of wading bird species as compared to imagery collected via Cessna due to several factors including higher resolution photos, lower flight heights (250 ft above ground level versus 800 ft above ground level), and angle of imagery. In particular, visibility of subcanopy and understory nesting species such as WHIB, *Egretta herons*, and ROSP may differ in UAV imagery. Therefore, the long-term standardized fixed-wing survey method was used to derive final maximum numbers of nest starts and UAV imagery was used to enhance overall colony information. A comparison between the two methods is in progress.

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-m-wide belt transects comprising a total of 336 square kilometers (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 LBHE, TRHE, and GBHE herons. Note that because the ground counts are not differentiated from the aerial counts in **Tables 4** to **7** the estimates for these species discussed in the *2022 Results* and *2023 Results* sections do not necessarily match those in the tables.

2022 RESULTS

Nesting Effort

An estimated total of 39,275 wading bird nests were initiated at colonies within WCA-1, WCA-2, and WCA-3 in 2022 (**Tables 4** and **5**). The total estimated number of nests was 96% of the 5-year average and 1.3 times the 10-year average nesting effort suggesting this was an average nesting event. Nesting effort by all species individually were just above or below the 5 and 10-year averages with the exception of WOST, which was lower.

While nesting effort for ROSP was slightly down with 88% of the 5-year average, the overall trend continued to increase with 1.4 times the 10-year average. Numbers of nesting WOST were just 6% of 5-year average and only 10% of the 10-year average. While storks are relatively philopatric, nesting did not occur at regular colonies such as Tamiami West and Jetport South but WOST did initiate nesting in a nearby colony (Jetport New). Additionally, a flurry of late WOST pre-nesting behavior occurred in three new locations in central WCA-3 including Horus, Vulture, and Kinich. Several hundred WOST were observed constructing platforms and pairing up for several weeks, but only 12 nests were observed with eggs. WHIB nesting effort was 99% of the 5-year average, which included both the 2018 and 2021 large nesting events. An overall upward trend of WHIB nesting continued with 1.3 times the 10-year average. GREG nesting effort was steady with 1.1 and 1.2 times the 5- and 10-year average, respectively.

Table 4. Number of nesting pairs found in LNWR (WCA-1) during aerial surveys, January through June 2022. [a]

Latitude	Longitude	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	CAEG	YCNH	SMDH	SMWH	ANHI	Total
26.4954173	80.22458667	LoxRamp/011	39	2601		10	339	2	***	***						39	***	3030
26.5499199	80.44268574	LoxWest	137	1168		20			***	***						518	***	1843
26.4379554	80.39053094	Lox99	424	152		1	106	1	***	***		6			6	183	***	879
26.616904	-80.30672	63/No name	27				136	1	89	30			6			86		375
26.540262	-80.233283	71/Canal Junction	1				40		82	16			4			60		203
26.5605671	-80.2480679	78/Canal North					95		70	12			10					187
26.57228	-80.2722	Yamir	40				3	1	24	4			7			80		159
26.51123	-80.43767	43	37			1	62	1	38									139
26.3718694	80.31037834	Utu	93													4		97
26.5307667	80.29476667	CookLox11	91			1											***	92
26.5595003	-80.2840501	105	50													34		84
26.475439	-80.28161	10	59				14	2										75
26.45047	-80.24233	38	49	7					10									66
Colonies > 50 nests[b]			1047	3928	0	33	795	8	313	62	0	6	27	0	6	1004	0	7229
Colonies < 50 nests[b]			**320**	**0**	**0**	**0**	**3**	**15**	**5**	**3**	**0**	**1**	**0**	**0**	**0**	**57**	**0**	**404**
Total nests by species			1367	3928	0	33	798	23	318	65	0	7	27	0	6	1061	0	7633[c]
Total nests excluding ANHI																		**7633**

a. *** indicates the species was present but not counted.
b. Includes count of wading bird nesting pairs from ground surveys.
c. Totals by species including ANHI.
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Nesting White Ibis in Water Conservation Area 3A

Table 5. Number of nesting pairs found in WCAs 2 and 3 during aerial surveys, January through June 2022.[a]

Latitude	Longitude	WCA	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	CAEG	YCNH	SMDH	SMWH	ANHI	Total
26.23779014	80.31280335	2	Rhea	373	20		1	61	9									***	464
26.24561676	-80.43234	2	Shamash	191			1										5		197
26.2830658	-80.4565018	2	102	34			4	23	2	2									65
26.20129687	80.52873259	3	Alley North	1089	21018		124	687	3	***	***							***	22921
26.12376586	80.54149724	3	6th Bridge	699	1286		135	487	6	***	***		***					***	2613
25.96035998	80.57207845	3	Horus	242	125	4	5	4	88								62		530
26.10469265	80.49729765	3	Nanse	258			31	20	26	***							50	***	385
26.012208	-80.608635	3	47	5	155			20	6				12						198
25.77761133	80.83851862	3	Hidden	170			11		1										182
25.96063997	80.75135498	3	962					100		40	25							4	169
25.970175	-80.774804	3	1181					45		110	2								157
25.84182004	80.84296196	3	Jetport New/64	111		35	3		1										150
26.02544389	80.53904168	3	Vulture/007	108			3		33										144
25.779	-80.509781	3	3B Ramp/80	122					15										137
25.85011333	80.52234942	3	Diana	131					5										136
26.02300996	-80.734287	3	997										100						100
26.01536816	-80.56273529	3	Jupiter	90					11										101
25.880099	-80.595255	3	72	82			1		15										98
25.973928	-80.772588	3	1180					30		65	2							1	98
26.12392223	-80.50417714	3	Cypress City	63			20		10									***	93
26.01229868	-80.63095974	3	Joule	87					2										89
25.770234	-80.724434	3	18	88									***					***	88
25.9800583	-80.7566797	3	98					46									42		88
25.9154794	-80.63022321	3	Vacation	77					10									***	87
25.86856	-80.806532	3	Enki					10		70	5								85
26.04029845	-80.59991604	3	Kidlow	68					7				5						80
26.0424178	-80.50309107	3	Kinich	44		8	1		23									***	76
26.00003075	-80.59513643	3	Jerrod	46				22	5										73
25.97012803	-80.71734399	3	1106		60								10						70
25.9753243	-80.6257803	3	99	29				38											67
25.85014896	-80.67413804	3	1219/Draco	24					3				4					23	54
26.014299	-80.456849	3	51	47					3										50
Colonies > 50 nests[b]				**4278**	**22664**	**47**	**340**	**1593**	**284**	**287**	**34**	**0**	**131**	**0**	**0**	**0**	**159**	**28**	**29845**
Colonies < 50 nests[b]				**556**	**5**	**0**	**0**	**6**	**180**	**32**	**6**	**0**	**996**	**0**	**6**	**0**	**38**	**255**	**2080**
Total nests by species				**4834**	**22669**	**47**	**340**	**1599**	**464**	**319**	**40**	**0**	**1127**	**0**	**6**	**0**	**197**	**283**	**31925[c]**
Total nests excluding ANHI																			**31642**

a. *** indicates the species was present but not counted.
b. Includes count of wading bird nesting pairs from ground surveys.
c. Totals by species including ANHI.

Based on yearly standardized ground surveys, there has been a trend towards fewer TRHE and LBHE nests in the study area since 2000. Despite an overall decrease in TRHE and LBHE trends for the period of record, there has been an uptick in LBHE presence starting in 2015. This upward trend continued in 2022 with the fourth highest nesting effort (247 nesting pairs) in the last 22 years, and 1.9 times the 10-year average. In contrast, TRHE nest numbers remained low with only 35 nesting pairs observed. TRHE nesting effort was 2.1 times the 10-year average, but still only 60% of the overall average since standardized surveys began in 1996. 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 or in coastal areas. For logistical reasons, *Egretta* herons are difficult to count in large colonies. However, some nesting TRHE and many LBHE were observed in large mixed colonies including 6th Bridge, Lox Ramp, and Alley North, as well as several *Egretta* dominated colonies in WCA-1. Competing predictions about the overall trends include a potential decline or shifts in composition of the prey base, displacement by BCNH, or movement to coastal colonies. BCNH may depredate *Egretta* heron nests, and have been increasing as nesters, roosters, and foragers during the past ten years. The upward trend of BCNH nesting continued in 2022 (1,108 nests) representing 1.1 and 1.5% of the 5- and 10-year averages.

Reproductive Success

Nest success was monitored at seven colonies in WCA-3: Cypress City, 6th Bridge, Joule, Jerrod, Hidden, and Vacation. Individual nests of GREG (n = 267 at all seven colonies), WHIB (n = 63 at 6th Bridge), ROSP (n = 50 at 6th bridge, Hidden, and Cypress City), BCNH (n = 16 at 6th Bridge) and *Egretta* herons (n = 59 at 6th Bridge) were monitored during ground-based nest checks every 5 to 7 days throughout the season. While WHIB and *Egretta* heron nests are usually monitored until nest fate is known, extremely dry hydrological conditions eventually inhibited colony access by the field team. Therefore, overall nest success is not known for these species in 2022, and incubation success rates may be biased towards earliest nest initiations.

System-wide nest success, measured as the probability of fledging at least one young (P), Mayfield method, with standard deviation (SD), showed considerable variation by species and across colonies: GREG (P = 0.33; SD = 0.030), BCNH (P = 0.07; SD = 0.055), and ROSP (P = 0.63; SD = 0.086). Nestling success (62 to 91%) was higher than incubation success (12 to 82%) across species and colonies. This reflects several colony-wide abandonments and suspected failed nesting attempts early in the season for GREG and BCNH. Initially low water levels followed by several rain events early in the season also resulted in late initiation of nesting for some species including GREG and WOST (for more information on Everglades hydrology see the *Hydrologic Patterns for Water Years 2022 and 2023* section). Notably, many GREG began nesting or renesting in mid-March, which is at least a month later than normal. The small number of WOST nests initiated in early March in Jetport New (35 nests) were abandoned in early April. A few nests were initiated in mid-April in Horus and Kinich (4 and 8, respectively). However, those nests were also abandoned within a few weeks. ROSP overall success was higher than other species, and many young fledged before rains began. ROSP nesting effort was asynchronous as compared to other species, and some fledglings were observed during initial ground visits to colonies in early March. While WHIB and *Egretta* herons nested in large numbers, overall nest success was not determined due to limited access to those colonies.

While the maximum number of nests starts was relatively average, overall nest success was poor. General dry conditions throughout the system were followed by small water level reversals during the season and were not favorable for rearing nestlings. The onset of the rainy season in late-May resulted in a large water level reversal. which likely limited post-fledgling survival.

2023 RESULTS

Nesting Effort

An estimated total of 25,775 wading bird nests were initiated at colonies within the WCAs in 2023 (**Tables 6** and **7**). The total estimated number of nests was just 59% of the 5-year average and 79% of the 10-year average nesting effort, suggesting this was a below-average nesting event.

Nesting effort by species varied widely with low effort by GREG, WHIB, and ROSP, and notably higher effort from TRHE and LBHE. Nesting effort for ROSP decreased compared to recent years with only 50% of the 5-year average, and 83% of the 10-year average. WHIB and GREG nesting efforts were also below both the 5- and 10-year averages. WHIB nesting effort was just 45% of the 5-year average, which still includes both the 2018 and 2021 exceptionally large nesting events. WHIB effort was also only 59% of the 10-year average and 65% of the average over the last 23 years. GREG nesting effort was 72 and 86% of the 5 and 10-year averages, respectively. WOST were the exception to below average nesting effort with 1.2 and 1.4 times the 5- and 10-year averages. WOST continued to nest in Jetport South, within WCA-3, but have failed to nest in a long-term colony, Tamiami West, located just south of WCA-3 for the last 3 years.

Table 6. Number of nesting pairs found in LNWR (WCA-1) during aerial surveys, January through June 2023.[a]

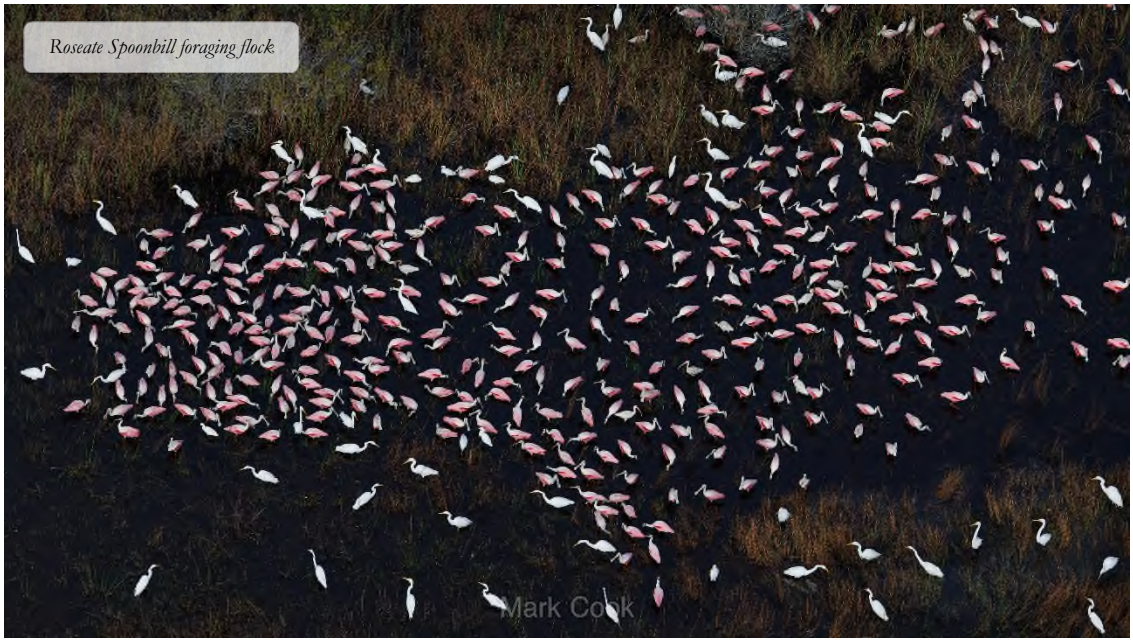
Latitude	Longitude	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	CAEG	YCNH	SMDH	SMWH	ANHI	Total
26.475439	-80.28161	10	48				5										***	53
26.45047	-80.24233	38	5	128												5		138
26.51123	-80.43767	43	35				32		29	5								101
26.616511	-80.306931	63		88			31		5	2						83		209
26.564815	-80.248118	77					48		4									52
26.623934	-80.322354	112					20		13	1						111	1	146
26.579465	-80.263294	113	4				38		9							55		106
26.591677	-80.274291	115							1	2						48		51
26.621988	-80.315339	116				1	5		1	7			210			10		234
26.540262	-80.233283	71/Canal Junction														100		100
26.5605671	-80.2480679	78/Canal North	21				85		6	6								118
26.49511	-80.22533	Lox Ramp	18	1597		6	362	1	***	***								1984
26.55014	-80.44268	Lox West	70	70		10	210		***	***							204	564
26.51733	-80.2645	Lox11	55					1								13		69
26.3737609	-80.25886536	Lox73	37					4								15		56
26.43821667	-80.39053333	Lox99	251	1724			117		***							200	5	2297
26.37196667	-80.31035	Utu	88															88
Colonies > 50 nests[b]			632	3607	0	17	953	6	68	23	0	0	210	0	0	640	210	6366
Colonies < 50 nests[b]			**230**	**0**	**0**	**0**	**5**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**17**	**0**	**259**
Total nests by species			862	3607	0	17	958	13	68	23	0	0	210	0	0	657	210	6625[c]
Total nests excluding ANHI																		**6415**

a. *** indicates the species was present but not counted.
b. Includes count of wading bird nesting pairs from ground surveys.
c. Totals by species including ANHI.

Table 7. Number of nesting pairs found in WCAs 2 and 3 during aerial surveys, January through June 2023.a

Latitude	Longitude	WCA	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	CAEG	YCNH	SMDH	SMWH	ANHI	Total
26.23779014	-80.31280335	2	Rhea	112			2	183	3		***							***	300
26.24561676	-80.43234	2	Shamash	150					2									***	152
26.012208	-80.608635	3	47	57				14										2	73
25.880099	-80.595255	3	72	103					6										109
25.76339099	-80.81530002	3	610					3		71	3							1	78
25.93648902	-80.78179797	3	1362					29		79	5								113
25.97418596	-80.77247998	3	1379					9		69	4								82
25.97052097	-80.77467201	3	1380					30		72	10								112
25.968325	-80.761956	3	1461					6		34	2		12						54
25.98047398	-80.756621	3	1470					22		50	20		6						98
25.978435	-80.74204001	3	1573					1	1	10	1		46						59
25.779	-80.509781	3	3B Ramp	151					6										157
26.12376586	-80.54149724	3	6th Bridge	396	1200		65	558	10	3							85	28	2345
25.77158333	-80.70871667	3	Aerie	52															52
26.20129687	-80.52873259	3	Alley North	577	8025		107	556	12	5							770	22	10074
25.85011333	-80.52234942	3	Diana	134					1										135
25.86881898	-80.805906	3	Enki	4	6			16		85	3								114
25.87413333	-80.65365	3	Enlil	105					5								9		119
25.88653333	-80.70168333	3	Forseti	77														1	78
25.77761133	-80.83851862	3	Hidden	226	138		9	63	6										442
25.96035998	-80.57207845	3	Horus	116					23									31	170
25.8051	-80.84902	3	Jetport South	142		690	15											***	847
26.0123	-80.63233333	3	Joule	65															65
26.01536816	-80.56273529	3	Jupiter	146					11										157
26.04029845	-80.59991604	3	Kidlow	36				21	7		***							***	64
26.0424178	-80.50309107	3	Kinich	66					22										88
26.10469265	-80.49729765	3	Nanse	230			16		26	***							151	***	423
25.9154794	-80.63022321	3	Vacation	55					2									***	57
26.02544389	-80.53904168	3	Vulture	204			1		50									***	255
Colonies > 50 nests[b]				**3204**	**9369**	**690**	**215**	**1511**	**193**	**478**	**48**	**0**	**64**	**0**	**0**	**0**	**1015**	**85**	**16872**
Colonies < 50 nests[b]				**360**	**2**	**0**	**1**	**56**	**242**	**80**	**7**	**0**	**1819**	**0**	**6**	**0**	**0**	**273**	**2846**
Total nests by species				**3564**	**9371**	**690**	**216**	**1567**	**435**	**558**	**55**	**0**	**1883**	**0**	**6**	**0**	**1015**	**358**	**19718[c]**
Total nests excluding ANHI																			**19360**

a. *** indicates the species was present but not counted.
b. Includes count of wading bird nesting pairs from ground surveys.
c. Totals by species including ANHI.



Based on yearly standardized ground surveys, there has been an overall trend towards fewer numbers of TRHE and LBHE nests in the study area since 2000. This decline has been accompanied by a large increase in numbers of BCNH presence in the same colonies. Despite an overall decrease in TRHE and LBHE trends for the period of record, there has been an uptick in LBHE presence starting in 2015. This upward trend continued in 2023 with the highest nesting effort (462 nesting pairs) in small tree islands in the last 28 years, and 3.1 times the 10-year average. TRHE nest numbers also increased with 52 nesting pairs observed. TRHE nesting effort was 2.1 times the 10-year average and 91% of the overall average since standardized surveys began in 1996. BCNH are likely to prey upon nestlings of *Egretta* herons and have been increasing as nesters, roosters, and foragers during the past ten years. This upward trend continued in 2023 with a record high of 1,882 adults counted. This was 1.9 and 2.2 times the 5- and 10-year averages respectively during systematic ground surveys in 2023.

Reproductive Success

Nest success was monitored at five colonies in WCA-3: Vacation, Jerrod, Hidden, Little A, and 6th Bridge. Individual nests of GREG (n = 250 at all five colonies), WHIB (n = 186 at Hidden and 6th Bridge), ROSP (n = 10 at Hidden and 6th Bridge), BCNH (n = 46 at Hidden and 6th Bridge) and *Egretta* herons (n = 101 at Hidden and 6th Bridge) were monitored during ground-based nest checks every 5 to 7 days throughout the season (**Table 8**). While WOST nests are usually monitored until nest fate is known, extremely dry hydrological conditions coupled with high nest heights inhibited colony access by the field team. Therefore, overall nest success is not known for WOST in 2023. However, aerial observations strongly suggest all but 10 of 690 initiated nests failed before chicks successfully fledged. ROSP nesting effort was asynchronous as compared to other species, and some hatched chicks were observed during initial ground visits to colonies in early February.

Table 8. Nest success metrics of wading birds monitored in 5 colonies throughout WCA-3 in 2023.[a]

Incubation	GREG	BCNH	SMHE	WHIB	GLIB	ROSP	WOST
N	250	46	101	186	57	10	NA
Success	0.427271	0.716896	0.862654	0.451722	0.311044	0.697213	NA
SD	0.036153	0.079534	0.038428	0.037633	0.058933	0.177811	NA

Nestling	GREG	BCNH	SMHE	WHIB	GLIB	ROSP	WOST
N	148	35	83	85	19	8	NA
Success	0.766213	0.449487	0.558496	0.665115	0.127741	0.743951	NA
SD	0.034007	0.08718	0.051443	0.049522	0.060358	0.155597	NA

Overall Success (P)	GREG	BCNH	SMHE	WHIB	GLIB	ROSP	WOST
Success	0.327381	0.322235	0.481789	0.300447	0.039733	0.518693	NA
SD	0.031305	0.072334	0.049334	0.033622	0.020538	0.1733	NA

Mean Clutch Size	GREG	BCNH	SMHE	WHIB	GLIB	ROSP	WOST
N	183	35	93	146	39	8	NA
Mean Clutch Size	2.546448	2.771429	3.44086	2.273973	2.820513	3.25	NA
SD	0.529745	0.483187	0.663363	0.567626	0.38376	0.433013	NA

Mean Number of Chicks Fledged	GREG	BCNH	SMHE	WHIB	GLIB	ROSP	WOST
N	113	16	41	54	0	6	NA
Mean Number of Chicks	1.769912	1.5625	2.390244	1.425926	0	2	NA
SD	0.479839	0.704339	0.851915	0.564435	0	1	NA

a. System-wide nest success was relatively poor by species and across colonies: GREG (P = 0.33; SD = 0.031), BCNH (P = 0.32; SD = 0.072), small herons (SMHE; P = 0.48; SD = 0.049), WHIB (P = 0.30; SD = 0.033), and ROSP (P = 0.52; SD = 0.173).

This suggests fewer than half of the nests initiated in 2023 were successful. Nestling success ranged from 45 to 77% across species while incubation success was similar with a range of 43 to 86%. Initially dry water conditions followed by a significant rain event and water depth increase in early April resulted in widespread nest abandonment for all species. Brood reduction was also observed for most remaining nests. However, it is of note that large numbers of fledgling *Egretta* herons including LBHE, SNEG, and TRHE, were observed in colonies in the mid- to northern portions of WCA-1 in early June. Nesting pairs in these colonies may have been foraging in suitable conditions north of the WCAs.

In 2023, the maximum number of nest starts was below average, and overall nest success was poor. A second consecutive year of dry conditions throughout the system was followed by a large water level reversal during peak nesting for most species in early April. These conditions were not favorable for wading bird nest success. While the drydown resumed after the rain event in April, the onset of the rainy season began in late-May and most likely decreased post-fledgling survival for those that remained.

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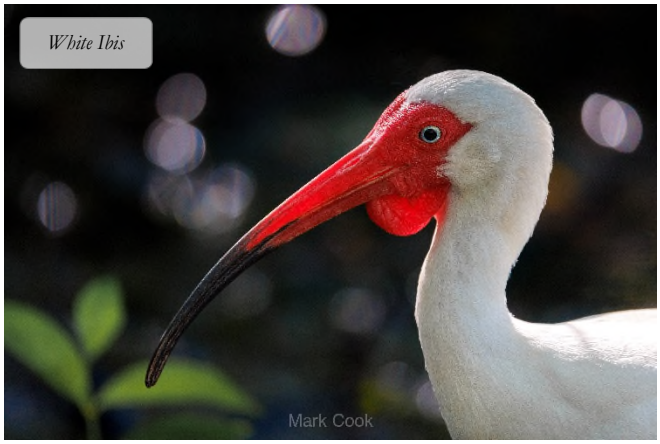


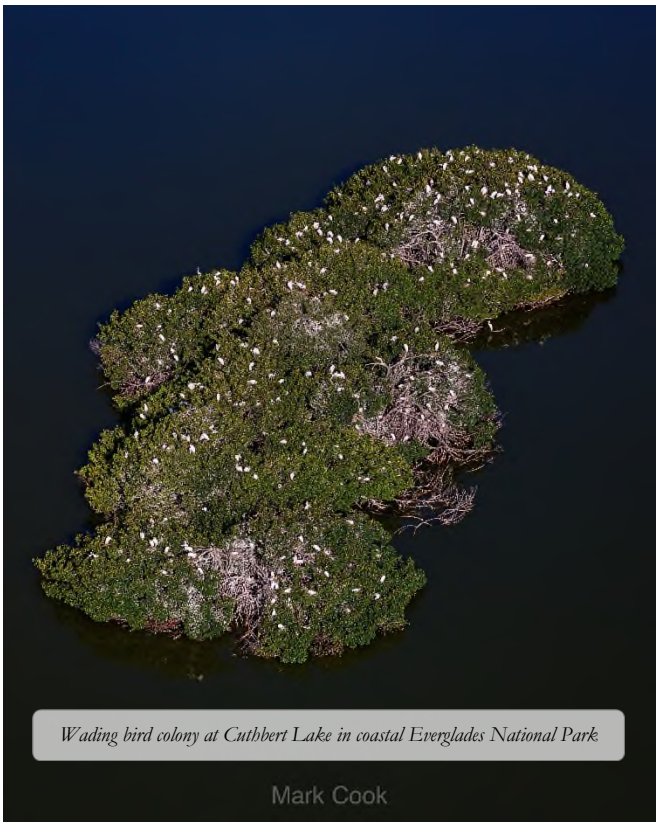
EVERGLADES NATIONAL PARK MAINLAND

This summary report addresses wading bird colony monitoring within the slough and estuarine areas of Everglades National Park (ENP) using data collected during the 2022 and 2023 wading bird breeding seasons. 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 goal of restoring and sustaining wading bird populations in the Everglades.

METHODS

Floatplane and helicopter surveys of known colony locations were conducted from January to August 2022 and January to July 2023. Flight dates during 2022 were January 24, February 24, March 22, April 6, 8, 12, and 20, May 17, 18, and 19, June 13, and August 1 and 16. Flight dates during 2023 were January 20, February 27, March 20 and 21, April 17 and 25, May 22, June 26, and July 20. Flight altitude was maintained at 600 to 800 ft above ground level during all surveys. During each flight, visual estimates of nest numbers by species were made and photos or video were taken using a digital single-lens reflex (DSLR) camera with a 100- to 400-mm lens or a Sony 4K resolution digital video camera. Photos and video clips were compared to visual estimates to assist with determining nest numbers, nesting stage, and species composition. A systematic reconnaissance flight to search for new colonies was conducted during 2022 (April 13, 14, and 15) but not during 2023 because of limited aircraft availability. Focal species included GREG, WOST, WHIB, SNEG, ROSP, TCHE, and LBHE. Locations of nesting colonies during the 2022 and 2023 nesting seasons are shown in **Figure 10**.



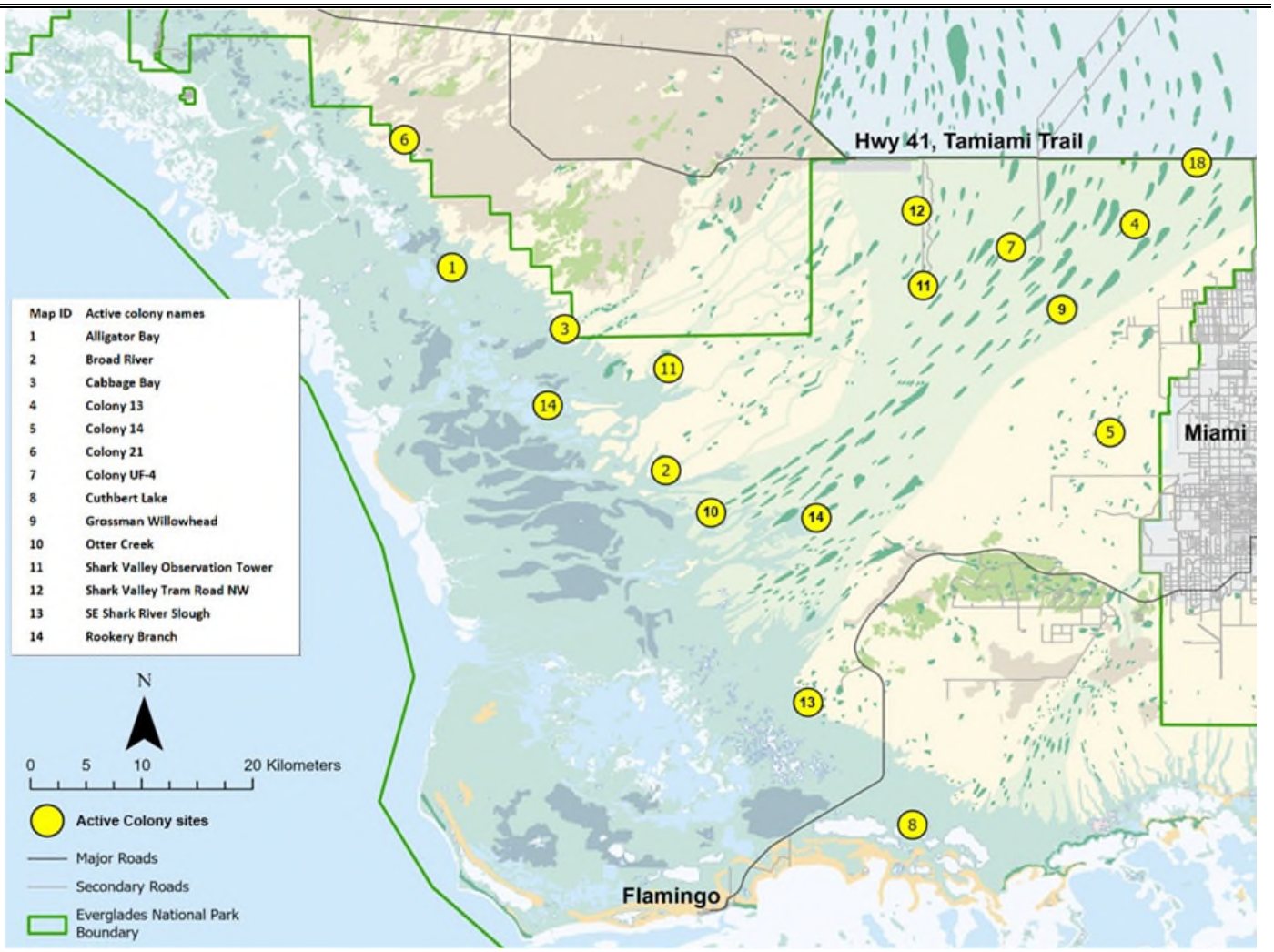


Figure 10. Wading bird nesting colonies in ENP, 2022-2023. **Table** 9 contains colony details.

2022 RESULTS

An estimated 6,695 wading bird nests were surveyed in 2022 (**Table 9**), an 81% decrease from the 2021 season. More than half of this total comprised WHIB nests at the Cabbage Bay colony. Only 12 active wading bird colonies were evident in 2022 compared to 24 in 2021. Compared to the 2021 season, the 2022 WOST peak nest count decreased by 67%, GREG nesting was down 51%, WHIB was down by 89%, and SNEG was down 81%.

On February 24, most GREG pairs were incubating along with some ROSP at Broad River and Cabbage Bay colonies. A few WOST were paired at Cabbage Bay, but nests were not yet built. The first WOST seen incubating were at Broad River on March 11 (SFWMD survey) but the birds had initiated sometime between this date and the earlier SFWMD survey on March 4. Cuthbert Lake WOST were first seen incubating on March 22. When checked again on April 20, a small section of the WOST nests at Broad River had been abandoned. During the May 17 survey, WOST at both Cabbage Bay and the remaining nests at Broad River were in all stages, containing small-, medium- and large-sized young. Many nests had WOST young that were near-fledgling size. However, the Broad River and Cuthbert Lake WOST mostly failed. On June 13, most nests were empty and just a few adult birds remained on the treetops at both colony sites. The Cabbage Bay colony may have had a better outcome, as most nests were still active, some still with smaller young in June (which probably failed due to very late nesting), however the majority of nests contained large young that looked ready to fledge. Other wading bird species seemed to do well as many GREG, ROSP, WHIB, and TRHE young were seen fledging into and near the colony sites in April and May.

Colonies were not surveyed in July, but when they were surveyed again on August 16, the Alligator Bay colony had a late nesting of approximately 350 additional GREG (not included in the peak seasonal totals), with most brooding small young on nests. Due to aircraft unavailability, Alligator Bay was not subsequently checked to document the outcome.

2023 RESULTS

An estimated 7,914 wading bird nests were surveyed in 2023 (**Table 10**), an 18% increase from the 2022 season. Only 12 active wading bird colonies were evident in 2023, the same number as in 2022 but only half the 24 observed in 2021.

Table 9. Peak nest counts for Everglades National Park, January 24 through August 16, 2022.[a]

Map ID	Colony Name	Latitude	Longitude	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	TRHE	BCNH	Total
1	Alligator Bay	25.67099	-81.14714	150	600		+	+					750
2	Broad River	25.50292	-80.97440	335		245	+						580
3	Cabbage Bay	25.62000	-81.05612	200	3000	250	75						3525
4	Colony 13	25.70660	-80.59504	175									175
5	Colony 14	25.53434	-80.61508	80									80
6	Colony 21	25.77663	-81.18559	39									39
7	Colony UF-4	25.68739	-80.69530	142									142
8	Cuthbert Lake	25.20933	-80.77500	156		83							239
9	Grossman Ridge West (not active)	25.63627	-80.65275										0
10	Grossman Willowhead	25.62613	-80.64582	40									40
11	Lostmans Creek (not active)	25.58723	-80.97204										0
12	Otter Creek	25.46780	-80.93772	318	300		20	15					653
13	Paurotis Pond (not active)	25.28150	-80.80300										0
14	Rodgers River Bay Large Island (not active)	25.55667	-81.06984										0
15	Rookery Branch (not active)	25.46356	-80.85256										0
16	Shark Valley Observation Tower	25.65581	-80.76640	125									125
17	SW Shark River Slough	25.31090	-80.85932	347			+	+					347
18	Tamiami West (not active)	25.75745	-80.54502										0
19	Alligator Bay	25.67099	-81.14714		600		+	+					750
20	Broad River	25.50292	-80.97440			245	+						580
	Total			**2107**	**3900**	**578**	**95**	**15**	**0**	**0**	**0**	**0**	**6695**

a. + indicates the species was present and nesting but numbers are unknown.

Table 10. Peak nest counts for Everglades National Park, January 20 through July 20, 2023.[a,b]

Map ID	Colony Name	Latitude	Longitude	GREG	WHIB	WOST	ROSP	SNEG	LBHE	TRHE	Total
1	Alligator Bay	25.67099	-81.14714	320	50						370
2	Broad River	25.50292	-80.97440	75		100	25				200
3	Cabbage Bay	25.62000	-81.05612	340	4000	475	60	50	+	+	4925
4	Colony 13	25.70660	-80.59504	180							180
5	Colony 14	25.53434	-80.61508	75							75
6	Cuthbert Lake	25.20933	-80.77500	150		219					369
7	Grossman Ridge West (*not active*)	25.63627	-80.65275								0
8	Grossman Willowhead	25.62613	-80.64582	45							45
9	Lostmans Creek (*not active*)	25.58723	-80.97204								0
10	Otter Creek	25.46780	-80.93772	300	700		25	25			1050
11	Paurotis Pond (*not active*)	25.28150	-80.80300								0
12	Rodgers River Bay Large Island (*not active*)	25.55667	-81.06984								0
13	Rookery Branch[c] *(active, abandoned)*	25.46356	-80.85256	30							0
14	Shark Valley Observation Tower	25.65581	-80.76640	60							60
15	Shark Valley Tram Road NW	25.72023	-80.76894	160	300						460
16	Shark River Slough SE	25.31090	-80.85932	125			25	+			150
17	Tamiami West (*not active*)	25.75745	-80.54502								0
	Total			**1860**	5050	794	135	75	+	+	**7914**

a. Most WOST nests failed this season and no data for GBHE and BCNH.
b. + indicates the species was present and nesting but numbers are unknown.
c. Rookery Branch, GREG had 30 nests but then abandoned.

Compared to the 2022 season, this season's WOST peak nest count increased by 37% (although most nests later failed). GREG nesting was down 12% and WHIB nesting was up by 29%. SNEG produced 75 nests, an increase of 400% compared to 2022. Some TCHE and LBHE nests were present in several colonies but not in large numbers. Few adult birds were seen in foraging flight lines entering or leaving colonies with the other species.

GREG, ROSP, and WHIB appeared to be successful this season except at Rookery Branch (active in March with eggs only, abandoned by April). Unfortunately, WOST were unable to fledge many chicks before abandoning nests at Broad River, Cabbage Bay, and Cuthbert Lake. About 30 GREG were seen (SWFMD survey flight) at Cabbage Bay on January 7 along with a few ROSP at Broad River, but none appeared to be nesting. WOST were not seen in any colonies on that date. On January 20, Cabbage Bay had approximately 250 GREG and about 200 WOST, many setting up nests but not yet incubating. Broad River also had about 260 WOST paired up with nests but were not yet incubating. On February 3, SFWMD reported 20 WOST nests at Cuthbert Lake. On February 27, at least half the WOST at Broad River had abandoned their nests and were roosting in the colony. No birds were seen incubating or tending young. Meanwhile, the Cabbage Bay WOST had approximately 475 nests with eggs and small chicks. At some point between February 27 and the next flight on March 20, all but 20 of the WOST nests were abandoned at Broad River. Cabbage Bay WOST were still active on March 20 with 2 to 3 medium- and large-sized chicks in most nests. On March 21, Cuthbert Lake WOST nests had medium-sized chicks but at least 20 of the nests were abandoned. On April 17, Cuthbert nests were still active with adults and chicks and no further nests appeared to have been abandoned. On April 25, many WOST nests at Cabbage Bay were abandoned, however the remaining nests had larger young with many adults present. On May 22, the Cabbage Bay WOST still had large young in nests and did not appear to have suffered additional abandonment. Cuthbert Lake WOST nests were mostly empty except for 5 large chicks. During a SFWMD survey flight in mid-May, approximately 70 WOST chicks were seen in a creche outside of Cabbage Bay. By June 26, the remaining WOST at Cabbage Bay were all abandoned but the colony was still active with WHIB and their fledged chicks. No WOST were seen at Cuthbert except for a couple nests with remains of chicks. It appears that out of the estimated 794 WOST nests this season, only 80 to 100 chicks were able to fledge from Cabbage Bay.

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ROSEATE SPOONBILL NESTING IN FLORIDA BAY

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 11**). These colonies are divided into five distinct nesting regions based on primary foraging locations used by the birds (**Figure 11**; Lorenz et al. 2002). ROSP are tactile foragers, requiring water depths no greater than 20 cm to forage effectively (Powell 1987, Dumas 2000). ROSP time breeding efforts in tune with seasonally declining water levels on their primary coastal 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. This report covers ROSP nesting effort and success during the 2022 and 2023 nesting seasons.


Florida Bay

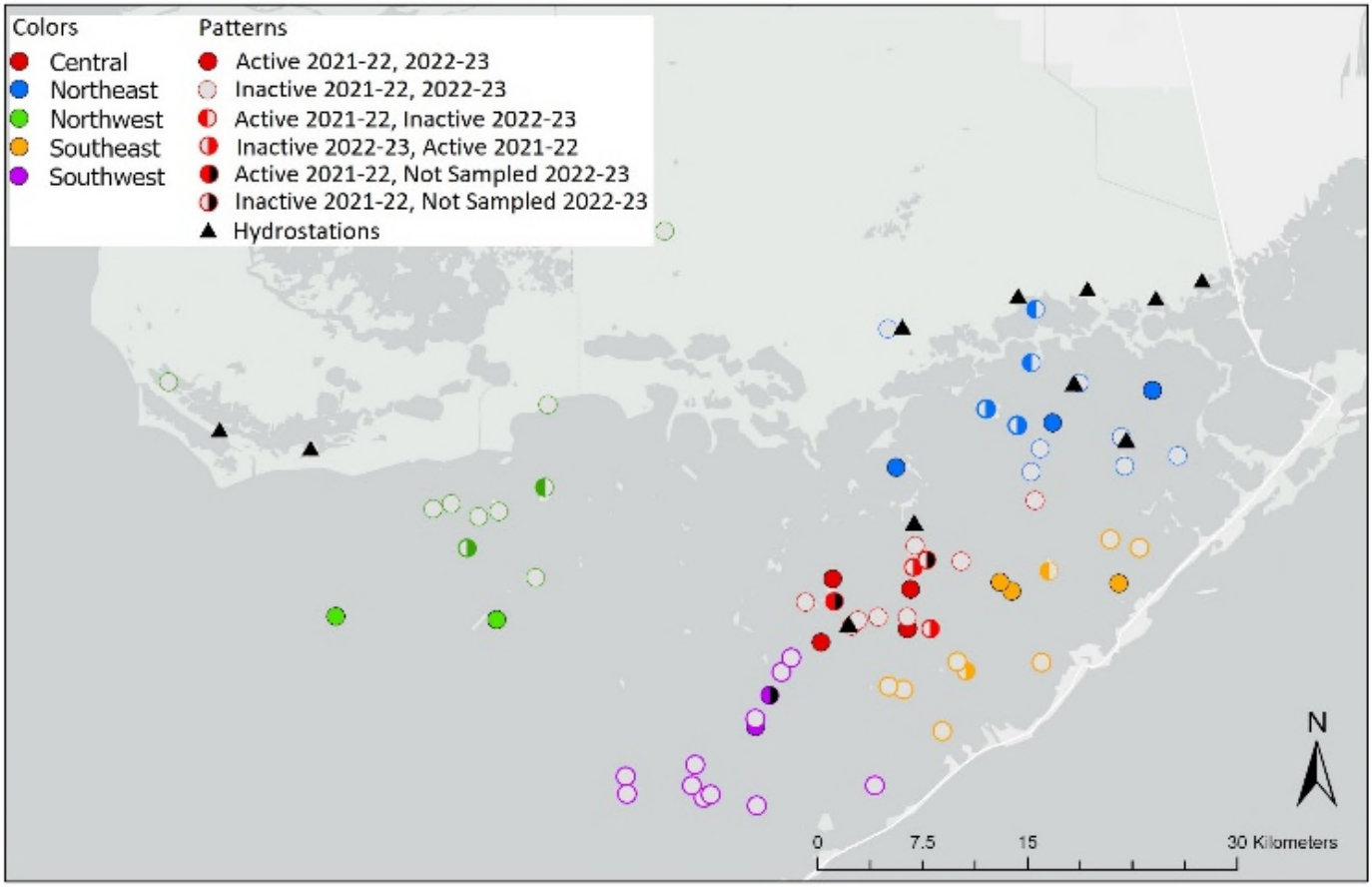


Figure 11. Location of hydrostations and ROSP colonies (color and pattern coded according to region and annual nesting activity, respectively) during the 2022 and 2023 nesting seasons.

METHODS

During the 2022 nesting season (December 2021–May 2022), complete nest counts were performed on 64 mangrove islands within Florida Bay and three adjacent colony sites on the mainland. During the 2023 nesting season (November 2022–June 2023), nest counts were performed on 64 mangrove islands within Florida Bay and three adjacent colony sites on the mainland. In both years, each colony was entered on foot or by kayak, and all nests were counted. If no ROSP were detected, the key was revisited on a 28-day cycle or, if deemed unlikely to host ROSP, keys were not revisited during the season.

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 7- to 10-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. Water depth was measured hourly at 13 locations throughout the mangrove coastal zone and, starting in 2023, six keys in Florida Bay (**Figure 11**), using Eureka water probes and Campbell Scientific dataloggers. For locations of individual keys in Florida Bay see **Figure 15** in the *Nesting Activity of Water Birds on Roseate Spoonbill Colony Keys in Florida Bay and Bay-wide Aerial Survey Results* section below.

2022 RESULTS

Northeast Region

The Northeast region supported the largest regional nesting effort with five colonies supporting a total of 58 nests (**Table 11**). All 58 nests had known fates but only 17.2% were successful at rearing at least one chick to 21 days old, and average production was 0.28 chicks per nest. The per-colony data indicated the four smaller colonies (Alligator Point, Duck, Tern, and Little Betsy) had substantially higher success rates than the one large colony (Diamond; **Table 11**). Nesting was relatively late; the estimated mean lay date was February 28, and the mean hatch date was March 23.

Table 11. Production and success of ROSP in regions and colonies in the Florida Bay for the 2022 nesting season. Each colony has coordinates (latitude and longitude). Shown in the table are numbers for observed nests, nests with known fate, chicks reaching 21 days, chick production per nest, nests with at least one chick, percent success, and average estimated hatch and lay dates for each colony and subtotals for regions as well as the total numbers for the bay.

Region	Colony	Latitude	Longitude	# Nests Observed	# Nests with Known Fate[a]	# Chicks Reaching 21 days	Chicks produced per nest	Nests Producing at Least One Chick	% Success	Mean Hatch Date	Mean Lay Date
Northeast	Diamond	25.2320	-80.5645	37	37	1	0.03	1	2.7%	3/30/2022	3/9/2022
	Alligator Point	25.1977	-80.5673	2	2	3	1.5	2	100%	3/26/2022	3/5/2022
	Tern	25.159	-80.5534	1	1	2	2	1	100%	3/26/2022	3/5/2022
	Duck	25.1801	-80.4893	10	10	3	0.3	2	20%	3/7/2022	2/14/2022
	Little Betsy	25.1306	-80.6539	8	8	7	0.88	4	50%	3/27/2022	3/6/2022
	Regional Subtotal			***58***	58	***16***	***0.28***	**10**	***17%***	**3/23/2022**	**2/28/2022**
Northwest	Sandy Nesting 1	25.0347	-81.014	3	3	3	1.00	1	66.7%	1/26/2022	1/5/2022
	Sandy Nesting 2	25.0347	-81.014	3	1	1	1.00	1	100%	3/29/2022	3/8/2022
	Palm (interior)	25.1134	-80.8782	15	15	0	0.00	0	0%	1/10/2022	12/20/2021
	Man-o-war	25.0326	-80.9107	17	17	2	0.12	2	11.7%	1/11/2022	12/21/2021
	Regional Subtotal			**38**	***36***	***6***	***0.17***	**5**	**14%**	**1/12/2022**	**2/2/2022**
Central	Central Jimmie	25.052	-80.6449	2	2	1	0.50	1	50%	2/6/2022	1/28/2022
	Calusa	25.0589	-80.6947	4	3	2	0.67	2	66.7%	1/27/2022	1/6/2022
	Little First Mate	25.0268	-80.6469	5	5	3	0.60	3	60%	1/25/2022	1/14/2022
	Little Calusa Nesting 1	25.0442	-80.6937	3	3	2	0.67	2	66.7%	1/27/2022	12/18/2021
	Little Calusa Nesting 2	25.0442	-80.6937	7	7	2	0.29	1	14.3%	3/28/2022	3/7/2022
	Pollock	25.0180	-80.7025	4	4	6	1.50	4	100%	3/28/2022	3/7/2022
	Regional Subtotal			**25**	***24***	***16***	***0.67***	**13**	***54%***	***2/17/2022***	**1/27/2022**
Southeast	Pigeon Nesting 1	25.0559	-80.5112	11	10	0	0.00	0	0%	1/19/2022	12/29/2021
	Pigeon Nesting 2	25.0559	-80.5112	8	8	10	1.25	5	62.5%	3/29/2022	3/8/2022
	Bottle	25.0637	-80.5558	3	2	0	0.00	0	0%	1/23/2022	1/2/2022
	Stake Nesting 1	25.0567	-80.5872	4	4	0	0.00	0	0%	1/15/2022	12/25/2021
	Stake Nesting 2	25.0567	-80.5872	3	3	4	1.33	3	100%	4/2/2022	3/12/2022
	Low	25.0509	-80.5796	1	1	0	0.00	0	0%	1/19/2022	12/29/2021
	Regional Subtotal			**30**	***28***	***14***	***0.50***	**8**	***27%***	***2/11/2022***	**1/21/2022**
Southwest	South Twin Nesting 1	24.9636	-80.7445	5	5	1	0.20	1	20%	12/28/2021	12/6/2021
	South Twin Nesting 2	24.9636	-80.7445	1	1	2	2.00	1	100%	4/5/2022	3/15/2022
	Regional Subtotal			**6**	***6***	***6***	***0.50***	**0.50**	***2***	***2/15/2022***	***1/24/2022***
	BAYWIDE TOTAL			**157**	**152**	**55**	**0.36**	**38**	**25%**	**2/20/2022**	**1/30/2022**

a. 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.

Northwest Region

A total of 38 nests from four colonies were observed throughout the Northwest region, including the second record of nesting at Man-o-War Key. Two asynchronous colonies occurred at Little Calusa and were treated separately. Of the 36 nests having known fates, 14% were successful, yielding an average 0.17 chicks per nest (**Table 11**). Nesting activity in this region centered on the average lay date of January 12 and a mean hatch date of February 2. The colonies on Palm and Man-o-War keys were initiated earlier than the others in the Northwest region, among the earliest nesting colonies in the entire bay, and suffered total or near total nest failures.

Central Region

The central region produced a total of 25 nests at six colonies. Of the 24 nests with known fates, 54.2% were successful yielding an average of 0.67 chicks per nest (**Table 11**). Notably, ROSP nested on the Pollock Keys for the first time in over 10 years. Two asynchronous nesting events occurred at Little Calusa and were treated separately. The mean lay date was January 27, and the mean hatch date was February 17.

Southeast Region

The Southeast region contributed 30 nests from six colonies. Of the 28 nests with known fates, 27% produced at least one chick that survived to 21 days old, and the mean estimated production for the region was 0.50 chicks per nest. Both Stake and Pigeon keys had two temporally distinct colonies; the first colonies on Stake and Pigeon failed to produce any chicks, whereas the mean productivity in subsequent colonies were 1.25 and 1.33 chicks per nest, respectively. The mean lay date was January 21, and the mean hatch date was February 11.

Southwest Region

The Southwest region continues to attract low numbers of nesting ROSP (**Table 11**). This season, six nests were discovered on a single colony, South Twin Key. Of the six nests with known fates, at least three nestling survived to age 21 days, and total production was 0.50 chicks per nest. The average lay date was January 24, and the mean hatch date was February 15.

Roseate Spoonbill collecting nesting material.

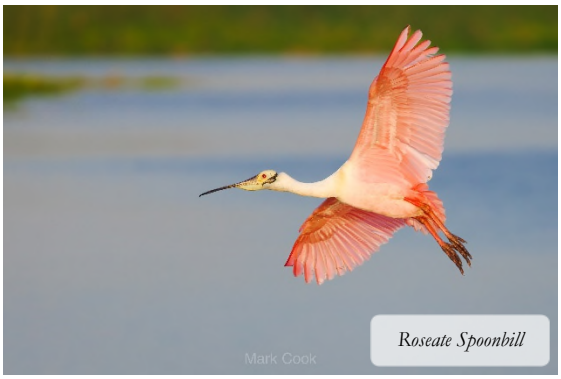
2023 RESULTS

Northeast

The Northeast region supported the greatest number of ROSP nests (60 nests). Nesting occurred on five keys with two keys (Tern and Duck) supporting the majority of nests. Mean percent nest success was 85.7% with 1.85 chicks produced per nest. Mean lay and hatch dates were January 16 and February 7, respectively (**Table 12**).

Northwest

The total nest count for the three colonies in the Northwest region of the bay was 26. Notably, Clive Key hosted nests for the first time since the 2017 nesting season, and Palm Key hosted no nests for the first time since 2012. The majority of nests (16 nests) were located on Sandy Key. Overall, 54.2% of nests in the region were successful at rearing at least one chick to 21 days old and the average production was 0.77 chicks per nest. There was considerable variability in nest success among keys with Sandy having higher success (73.3%, 1.40 chicks per nest) than Man-o-War and Clive keys (20 and 25%, 0.4 and 0.5 chicks per nest, respectively). Mean lay and hatch dates for the region were January 14 and January 30 (**Table 12**).



Roseate Spoonbill

Central

The Central region supported seven colonies with a total of 36 nests (**Table 12**). Mean percent success for the region was 61.1% with 0.91 chicks produced per nest on average. Mean lay and hatch dates were January 16 and February 3, respectively. Three of the seven colonies had success well above 50% (Central Jimmie, Little First Mate, and North Jimmie) and produced at least 1.00 chicks per nest on average, whereas the other four had success rates below 50%. Interestingly, Captain Key supported a nest for the first time in four seasons.

Southeast

The Southeast region hosted four nesting colonies with a total of 28 nests, the majority of which were located on Pigeon Key (17 nests). Mean nest success was 89.2% with an average production of 1.43 chicks per nest. Regional mean lay and hatch dates were January 23 and February 13, respectively.

Southwest

Nesting in the Southwest region occurred on only one key, South Twin. This colony had the earliest mean lay and hatch dates in the bay this season (December 8 and December 29, respectively). It only supported 3 nests, but all three were successful (100% success rate) and produced an average of 2.00 chicks per nest (**Table 12**).

Florida Bay

Table 12. Production and success of ROSP in regions and colonies in the Florida Bay for the 2023 nesting season. Each colony has coordinates (latitude and longitude). Shown in the table are numbers for observed nests, nests with known fate, chicks reaching 21 days, chick production per nest, nests with at least one chick, percent success, and average estimated hatch and lay dates for each colony and subtotals for regions as well as the total numbers for the bay.

Region	Colony	Latitude	Longitude	# Nests Observed	# Nests with Known Fate[a]	# Chicks Reaching 21 days	Chicks produced per nest	Nests Producing at Least One Chick	% Success	Mean Hatch Date	Mean Lay Date
Northeast	Pass	25.1574	-80.5762	1	1	2	2.00	1	100.0%	2/8/2023	1/18/2023
	Eagle	25.1680	-80.5963	1	1	2	2.00	1	100.0%	1/23/2023	1/2/2023
	Tern	25.159	-80.5534	16	14	29	2.07	13	92.9%	2/9/2023	1/19/2023
	Duck	25.1801	-80.4893	35	33	48	1.45	28	84.8%	2/7/2023	1/17/2023
	Little Betsy	25.1306	-80.6539	7	7	12	1.71	5	71.4%	2/19/2023	1/29/2023
	Regional Subtotal			**60**	**56**	**93**	**1.85**	**48**	**85.7%**	**2/7/2023**	**1/16/2023**
Northwest	Sandy	25.0347	-81.014	16	15	21	1.40	11	73.3%	1/26/2023	1/5/2023
	Clive	25.0785	-80.9296	5	4	2	0.50	1	25.0%	1/24/2023	1/3/2023
	Man-o-war	25.0326	-80.9107	5	5	2	0.40	1	20.0%	2/11/2023	2/4/2023
	Regional Subtotal			**26**	***24***	***25***	***0.77***	**13**	**54.2%**	**1/30/2023**	**1/14/2023**
Central	Central Jimmie	25.052	-80.6449	1	1	1	1.00	1	100.0%	2/28/2023	2/7/2023
	Calusa	25.0589	-80.6947	7	7	4	0.57	3	42.9%	1/25/2023	1/8/2023
	Little First Mate	25.0268	-80.6469	13	13	24	1.85	12	92.3%	2/9/2023	1/20/2023
	Little Calusa	25.0442	-80.6937	6	6	1	0.17	1	16.7%	1/24/2023	1/3/2023
	North Jimmie	25.0663	-80.6429	3	3	6	2.00	3	100.0%	2/7/2023	1/17/2023
	Pollock	25.0180	-80.7025	5	5	4	0.80	2	40.0%	1/21/2023	1/14/2023
	Captain	25.0266	-80.6321	1	1	0	0.00	0	0.0%	unknown	unknown
	Regional Subtotal			**36**	**36**	**40**	**0.91**	**22**	**61.1%**	**2/3/2023**	**1/16/2023**
Southeast	Pigeon	25.0559	-80.5112	17	17	21	1.24	17	100.0%	2/9/2023	1/19/2023
	East	24.9994	-80.6092	5	5	5	1.00	3	60.0%	2/27/2023	2/6/2023
	Stake	25.0567	-80.5872	2	2	4	2.00	2	100.0%	2/4/2023	1/14/2023
	Low	25.0509	-80.5796	4	4	6	1.50	3	75.0%	2/12/2023	1/22/2023
	Regional Subtotal			**28**	**28**	**36**	**1.43**	**25**	**89.2%**	**2/13/2023**	**1/23/2023**
Southwest	South Twin	24.9636	-80.7445	3	3	6	2.00	3	100.0%	12/29/2022	12/8/2022
	Regional Subtotal			**3**	**3**	**6**	**2.00**	**3**	**100.0%**	**12/29/2022**	**12/8/2022**
	BAYWIDE TOTAL			**153**	**147**	**200**	**1.39**	**111**	**75%**	**2/3/2022**	**1/15/2022**

a. 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 shrub mangrove wetlands north of Florida Bay, that were historically the primary foraging grounds of ROSP nesting in the Northeast and Northwest regions of Florida Bay (**Figure 11**; (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 move "downhill" from drying wetlands to deeper habitats. The threshold occurs at approximately 13-cm in depth (the PCT). Successive prey concentrations happen in different locations as waters recede across the coastal landscape and drop below the PCT, while simultaneously, overall prey numbers decrease in a given location from increased predation or increasingly poor environmental conditions (unfavorable temperatures, oxygen concentrations, and salinities for aquatic prey). During these concentration events, foraging ROSP capitalize on the concentration event to capture enough prey to meet the high energetic demands of their rapidly growing chicks.

Historically, water levels would continually decline throughout the Florida Bay coastal wetlands from November through April (Powell et al. 1989) creating a drying front shallower than the PCT that moved across the landscape. This enabled ROSP to efficiently capture enough prey throughout the breeding cycle to feed their rapidly growing chicks (Lorenz 2014). In 2011, however, a relatively rapid increase in sea surface elevation caused by changing climatic conditions led to higher water levels in mangrove habitats of ENP (Dessu et al. 2018, Blochel and Lorenz 2023). As a result of this sea level rise (SLR), PCT events are occurring much later in the year than historically and have become much shorter; lasting days instead of months as was recorded prior to 2011 (Rafferty et al. 2021, Welsh et al. 2023, Blochel and Lorenz 2023). The associated loss of foraging habitat has led to declining ROSP nesting effort and success in recent years (Welsh et al. 2023).

2022 Nesting Season

During the 2022 nesting season, water levels did not fall below the PCT until mid-late March, two months later than they did historically (Powell 1987) and only lasted from 0 to 30 days depending on location (**Figures 11** and **12**; Blochel and Lorenz 2023). The notably low total number of ROSP nests this season (157; **Table 11**) is likely tied to the higher-than-average water levels and the relatively late drying period. In the previous nine nesting seasons, total nests have ranged from 191 to 367 (**Table 13**). Additionally, nesting in 2022 occurred later than average with a baywide mean lay date of January 30 (**Table 11**). Nest success (% of nests with at least one nestling surviving to 21 days old) was relatively low, with a baywide success rate of 25%. The Central, Northeast, and Southwest regions had slightly higher nest success rates but had production rates well below the target mean of 1.0 chicks per nest (**Table 11**). Throughout much of the bay, birds attempted to initiate nesting in the early dry season (December–February) but were unsuccessful because of the high water levels. A second wave of nesting occurred in the late season (March–May), which promoted higher success, probably due to water level decreases in the region. For example, Pigeon and Stake keys both hosted two asynchronous nesting attempts, both of which were more successful on their second attempt later in the season when water levels were lower (**Table 11**). Similarly, Palm and Man-o-War keys initiated nesting early in mid-December (**Table 11**) and both suffered near synchronous collapses soon after hatching, resulting in success rates of 0 and 11.7% respectively.

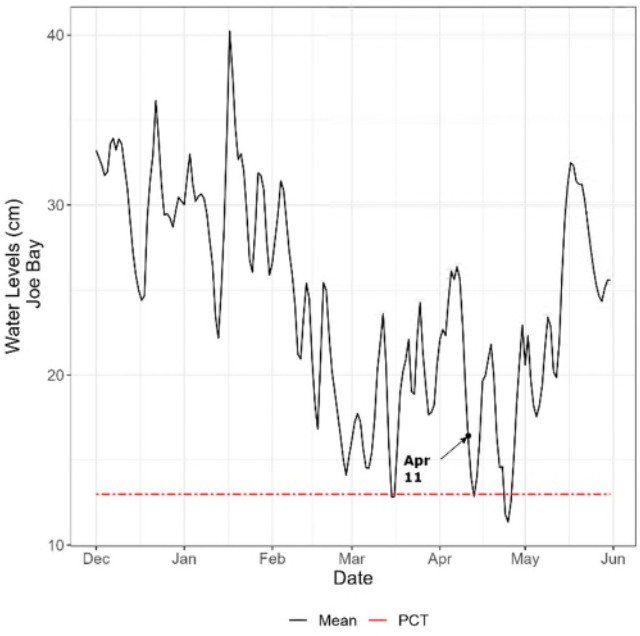


Figure 12. Mean daily water levels in Joe Bay from December 1, 2021, through May 31, 2022. The 13-cm PCT is indicated by the dashed red line. The April 11, 2022, mortality event noted in the text is indicated on the graph.

Table 13. Numbers for regional and Florida Bay nesting ROSP, for the time periods 2014 to 2023, showing the ten-year averages for the bay and each region in the bay.

Season	Northeast	Northwest	Central	Southeast	Southwest	Baywide Total
2014	76	85	19	10	1	191
2015	158	173	24	4	6	365
2016	189	141	29	6	2	367
2017	56	103	13	34	3	209
2018	58	140	55	23	2	278
2019	24	202	27	28	0	281
2020	57	66	40	39	1	203
2021	78	75	53	34	6	246
2022	38	58	25	30	6	157
2023	60	26	36	28	3	153
Average	79.4	106.9	32.1	23.6	3	245

Compared to other colonies in the Northeast region of the bay, Diamond Key, located in Joe Bay, had a significantly lower level of success, despite initiating nesting at similar dates to the other colonies in the region (**Table 11**). Measurements at the nearby Joe Bay hydrostation (**Figure 12**) indicate that water levels dropped below the PCT for the first time in mid-March, before rapidly increasing again. Thereafter, water levels receded twice more below the PCT for short periods. High numbers of dead chicks and failed nests were noted during a routine colony check on April 11, but not at previous routine colony checks. This suggests water levels rose to such a point adults could no longer find sufficient prey to meet the energetic demands of chicks (**Figure 12**).

Colonies in the Central region had generally moderate levels of success throughout the entire season (early and late season). Tracking data indicates these birds were likely feeding in the interior lakes and ponds on the keys in Florida Bay. It has been suggested that due to SLR, many of these interior foraging areas no longer completely dry out seasonally (as they did historically), providing more and appropriate foraging for ROSP, when traditional foraging grounds are becoming less reliable with SLR (Rafferty et al. 2021).

In conclusion, the current high-water levels resulting from SLR are posing a great challenge to successful ROSP nesting. Traditional foraging grounds are becoming less viable, forcing ROSP to seek out novel foraging areas. In the past we have noted ROSP breeding in Florida Bay show great resiliency in response to environmental pressures. However, this year, the lack of access to and availability of high-quality food in adequate quantities to maintain the current population created a pressure not only to nest later in comparison to the historical nesting season but also generated some of the lowest nest success rates ever recorded.

2023 Nesting Season

As in the 2022 nesting season, ROSP in Florida Bay exhibited reduced nesting effort in 2023 (153 nests, 10-year average: 245 nests; **Table 12**). This might suggest ROSP are moving out of Florida Bay and nesting elsewhere due to climate change-driven SLR. This year featured water levels dropping further than the previous season and following what is considered a normal drawdown pattern (November–April; Powell et al. 1989, Lorenz 1999). Also, nesting occurred on average much earlier than the mean hatch and lay dates of last season, indicating a more normal season as compared to the 2022 nesting season (**Table 12** and **Figure 13**). In contrast to the 2022 nesting season, nest success was relatively high such that 75.5% of nests successfully reared at least one chick per nest and the mean production was 1.39 chicks per nest (**Table 12**). Within all regions of the bay, nest successes was above 50%. Though nests were largely successful this season, several keys that have reliably been active in the past failed to produce colonies in 2023. The two most notable keys were Palm and Diamond. It is possible that the past two years of widespread failure at Palm Key dissuaded birds from nesting there this season. The potential reasons for not using Diamond Key are less clear.

One possibility is that due to the near complete failure of the colony last season, individuals chose not to utilize it this season. Alternatively, it could be that most ROSP colonies across the bay experienced successful nesting this season and fewer birds needed to attempt a second nesting at a new location later in the season. Additionally, the colony at Diamond Key is traditionally a late season nesting colony (March–May). Water levels in the surrounding foraging areas (Joe and West Joe bays) were above the PCT during those months in the 2023 nesting season (**Figure 14A**).

This season, it was possible to monitor water levels on four keys in Florida Bay that were identified as ROSP foraging sites (**Figure 14B**). These sites exhibited water-level drawdown patterns similar to those recorded by the hydrostations at the historical foraging grounds in the mangrove coastal zones (**Figure 14A**), but experienced depths near the PCT for longer periods of time. Significantly, this emphasizes the importance of interior foraging zones on keys for ROSP success during the breeding season, when traditional foraging grounds in the mangrove coastal zones are no longer as reliable due to SLR (Rafferty et al. 2021).

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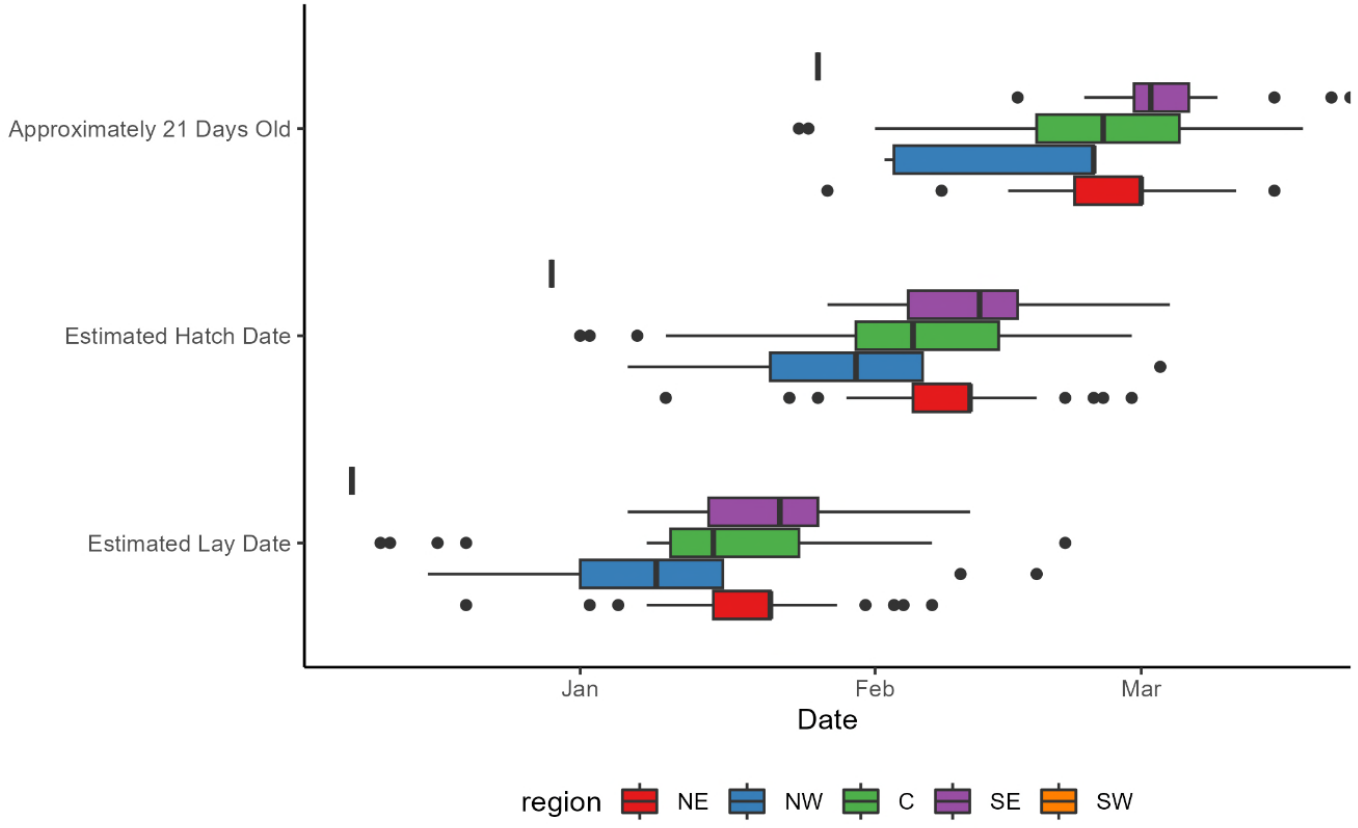

Figure 13. Boxplots displaying mean estimated lay dates, estimated hatch dates, and dates when spoonbill chicks were approximately 21 days old for five regions in Florida Bay. Solid bars in the middle of boxes indicate the median; outliers are indicated by black circles.

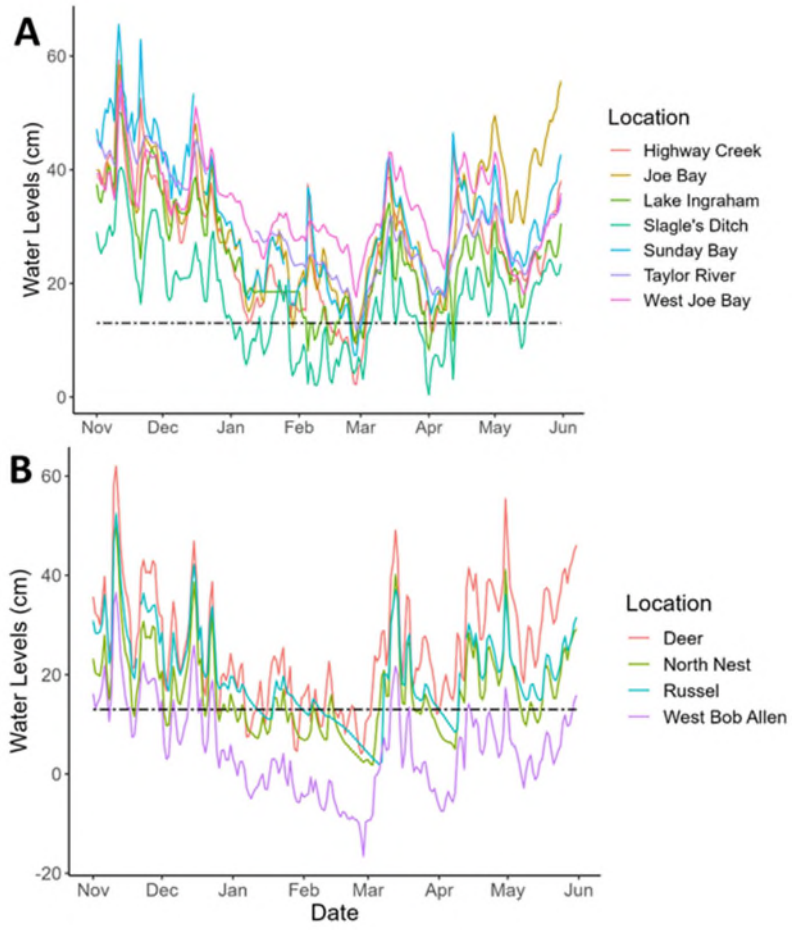

Figure 14. Mean daily water levels measured by seven hydrostations in the mangrove coastal zone of Florida Bay (A) and four hydrostations at keys in Florida Bay (B) from November 01, 2022, through May 31, 2023. Dashed black line indicates the 13-cm PCT.

Reddish Egret with white morphology in Florida Bay

NESTING ACTIVITY OF WATER BIRDS ON ROSEATE SPOONBILL COLONY KEYS IN FLORIDA BAY AND BAY-WIDE AERIAL SURVEY RESULTS

Surveys of nesting water birds in Florida Bay and adjacent habitats were conducted by Audubon Florida, ENP, and Lignumvitae Key Aquatic Preserve in both the 2022 and 2023 nesting seasons. 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.

METHODS

Figure 15 shows the location of nesting colonies.

Audubon Florida

While surveying known ROSP colonies throughout Florida Bay during the nesting seasons of 2022 and 2023, 12 other species of water birds were observed nesting on the islands (**Figure 15**). 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.

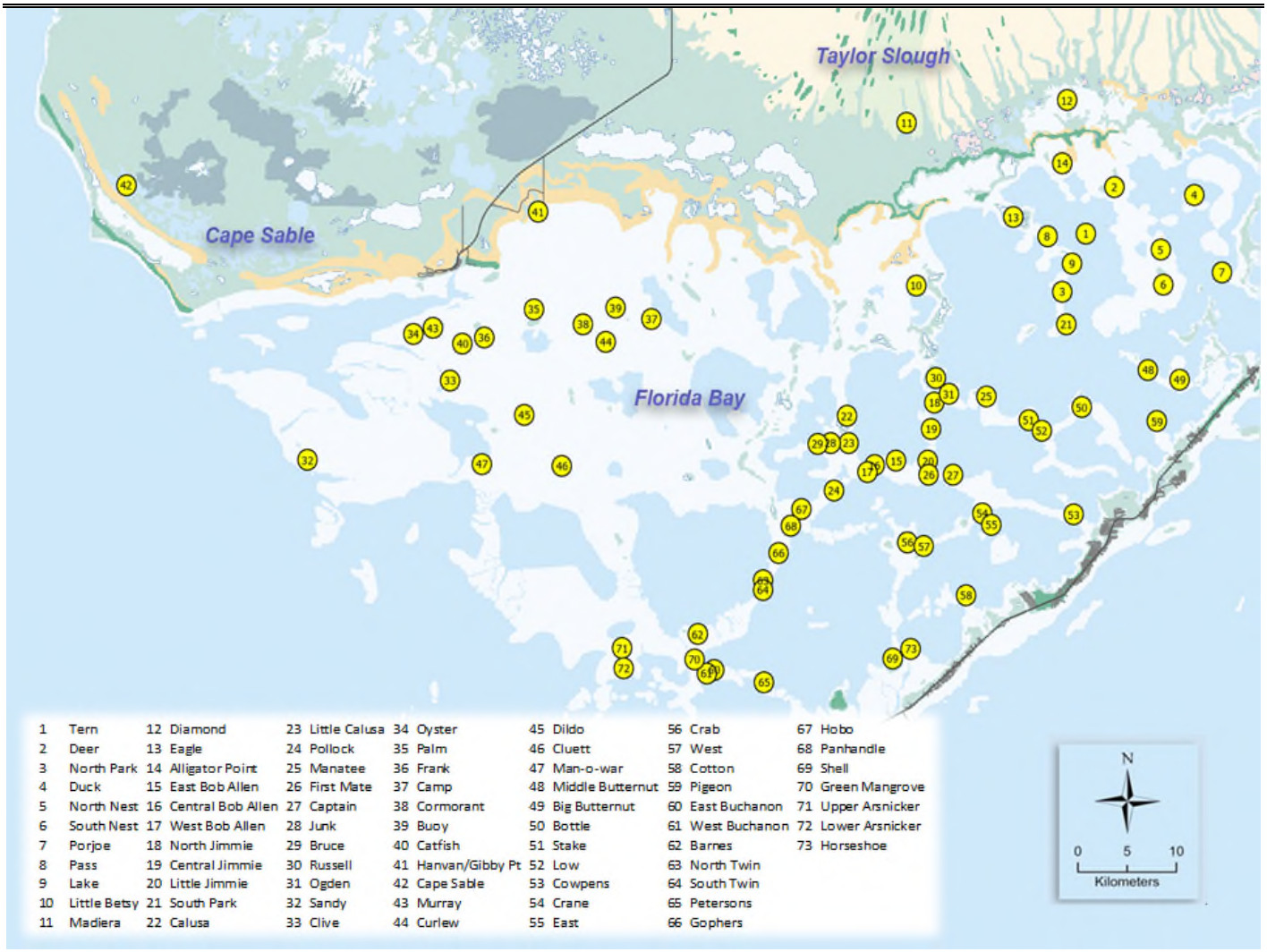

Figure 15. Active nesting colony sites in Florida Bay for the 2022 and 2023 breeding seasons.

Everglades National Park

During the 2022 nesting season, ENP staff conducted late-season partial Florida Bay aerial surveys on April 8 and 12, May 18, June 13, and August 1, 2022, using a high-wing Cessna 206 on floats. During the 2023 nesting season, aerial surveys were conducted on December 16, 2022, and February 27, March 21, April 25, Mary 22, June 26, and July 20, 2023, using a National Park Service Cessna 206 high-wing float aircraft and a Bell 206 B III EU helicopter. Peak nest counts for wading birds and Brown Pelicans (BRPE) were recorded by island or island group. The survey area in 2023 included most islands and island groups within Florida Bay.

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 ft from the island such that species and nesting outcomes could be identified.

RESULTS

Tables 14 and **15** present 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 for the 2022 and 2023 nesting seasons, respectively. **Table 16** presents annual totals for each species since Audubon Florida began collecting these data and reporting them as part of the South Florida Wading Bird Report in 2015. These results may differ from those reported in these reports from 2014 through 2020 because data sets were unified and corrected as noted in Lorenz et al. (2023). Note TRHE nest numbers are well below those observed in recent years, but this might be because nest counts were not conducted during peak TRHE nesting period at Clive and Palm keys, which are typically two of the largest TRHE colonies.

Table 14. Peak nest numbers found in Florida Bay wading and water bird colonies for the 2022 nesting season. Underlined numbers are estimates collected from ENP aerial surveys. Underlined numbers are estimates collected from Lignumvitae Key Aquatic Preserve kayak surveys. Plain text numbers are estimates collected from Audubon Florida ground surveys. **Figure 15** shows the location of active nesting colony sites in Florida Bay for the 2022 season.

		Waders													Non-waders				
Region	Colony	GBHE	GWHE	GB/GWHE [a]	GREG	TRHE	SNEG	TRHE/SNEG [b]	BCNH	GRHE	WHIB	REEG	ROSP	Total Waders	BRPE	DCCO	BAEA	CLRA	Total Waterbirds
Northeast	Tern					236	1				34	2	1	**274**					**274**
	Deer													**0**					**0**
	North Park													**0**					**0**
	Duck				11							12	10	**33**		10			**43**
	North Nest		7											**7**					**7**
	South Nest											1		**1**					**1**
	Porjoe													**0**					**0**
	Pass		1											**1**					**1**
	Lake													**0**					**0**
	Little Betsy		4									1	8	**13**					**13**
	Madiera													**0**					**0**
	Diamond				207	6		52					37	**302**					**302**
	Eagle											1		**1**					**1**
	Alligator Point		2										2	**4**					**4**
Central	East Bob Allen													**0**					**0**
	Central Bob Allen													**0**			3		**3**
	West Bob Allen	1	1									1		**3**			1		**4**
	North Jimmie													**0**					**0**
	Central Jimmie		3									1	2	**6**			4		**10**
	Little Jimmie													**0**					**0**
	South Park													**0**					**0**
	Calusa				2							1	4	**7**			1		**8**
	Little Calusa											1	10	**11**					**11**
	Pollock		8							1		2	4	**15**		25			**40**
	Manatee													**0**					**0**
	First Mate												5	**5**					**5**
	Captain													**0**			2		**2**
	Junk											1		**1**					**1**
	Bruce											6		**6**			1		**7**
	Russel													**0**					**0**
	Ogden													**0**					**0**
Northwest	Sandy		12	57	3	81	9	28	1		108	18	6	**323**		15	5	1	**344**
	Clive	2	3		28	71	11	7			110			**232**	8	60	4		**304**
	Oyster		1										15	**16**		1	1		**18**
	Palm	1	5											**6**					**6**
	Frank													**0**					**0**
	Catfish													**0**					**0**
	Hanvan													**0**					**0**
	Cape Sable													**0**					**0**
	Murray		3											**3**					**3**
	Dildo		6	4										**10**					**10**
	Cluett													**0**			3		**3**
	Man-o-war												17	**17**					**17**

Table 14. Continued

Region	Colony	Total Waders													Non-waders						
		GBHE	GWHE	GB/GWHE [a]	GREG	TRHE	SNEG	TRHE/SNEG [b]	BCNH	GRHE	WHIB	REEG	ROSP	Total Waders	BRPE	DCCO	OSPR	BAEA	CLRA	Total Waterbirds
Southeast	Middle Butternut													**0**						**0**
	Big Butternut													**0**						**0**
	Bottle												3	**3**						**3**
	Stake		1		2	19						6	7	**35**		2				**37**
	Low		2										1	**3**						**3**
	Cowpens		2											**2**		45				**47**
	Crane											1		**1**						**1**
	East		4	5	1									**10**						**10**
	Crab													**0**						**0**
	West													**0**						**0**
	Cotton													**0**						**0**
	Pigeon		2		2	4				3		1	19	**31**		36				**67**
Southwest	East Buchanan													**0**		2				**2**
	West Buchanan													**0**	11	7				**18**
	Barnes													**0**			2			**2**
	North Twin													**0**			1			**1**
	South Twin											2	6	**8**						**8**
	Petersons		1											**1**						**1**
	Gophers													**0**						**0**
	Hobo													**0**						**0**
	Horseshoe Ashby		*7*				*3*							**10**		*28*				**38**
	Panhandle													**0**						**0**
	Shell													**0**						**0**
	Green Mangrove													**0**		30				**30**
	Upper Arsnicker													**0**		65				**65**
	Lower Arsnicker													**0**						**0**
	Total	**4**	**75**	**66**	**256**	**417**	**24**	**87**	**1**	**4**	**252**	**58**	**157**	**1401**	**19**	**326**	**28**	**1**	**1**	**1776**

a. Nests that were either GBHE or GWHE but parentage could not be distinguished.
b. Nests that were either TRHE or SNEG but parentage could not be distinguished.

Roseate Spoonbills along coastal ENP

Table 15. Peak nest numbers found in Florida Bay wading and water bird colonies for the 2023 nesting season. Underlined numbers are estimates collected from ENP aerial surveys. Underlined numbers are estimates collected from Lignumvitae Key Aquatic Preserve kayak surveys. Plain text numbers are estimates collected from Audubon Florida ground surveys. **Figure 15** shows the location of active nesting colony sites in Florida Bay for the 2023 season.

		Waders															Non-waders				
Region	Colony	GBHE	GWHE	GB/GWHE	GREG	TRHE	SNEG	TRHE/SNEG	LBHE	BCNH	YCNH	GRHE	WHIB	REEG	ROSP	Total Waders	BRPE	DCCO	ANHI	MAFR	Total Waterbirds
Northeast	Tern					293	1						15		16	325					325
	Deer															0					0
	North Park															0	9				9
	Duck				31	34	4	12						6	35	122		21			143
	North Nest															0					0
	South Nest															0					0
	Porjoe															0					0
	Pass		3			2								1	1	7			1		8
	Lake															0					0
	Little Betsy		3		3									4	7	17					17
	Madiera															0					0
	Diamond				30		20									50					50
	Eagle													1	1	2					2
	Alligator Point		8		1											9					9
Central	East Bob Allen															0					0
	Central Bob Allen													1		1					1
	West Bob Allen													2		2					2
	North Jimmie				1	6								1	3	11					11
	Central Jimmie		3											1	1	5					5
	Little Jimmie		1													1					1
	South Park															0					0
	Calusa		2			6								2	7	17					17
	Little Calusa													1	6	7					7
	Pollock		5		1									4	5	15		51			66
	Manatee															0					0
	First Mate														13	13		10			23
	Captain	3	1												1	5					5
	Junk															0					0
	Bruce					2								5		7					**7**
	Russell															0					**0**
	Ogden															0					**0**
Northwest	Sandy	1	59	1	11	103	11	55		1	3		25	18	16	304		100			**404**
	Clive	17	8	4	40	61	40	105					400	2	5	682	71	134			**887**
	Oyster		5											1		6	34				**40**
	Palm		16	4	1	29	42	345				2		6		445		50			**495**
	Frank															0					**0**
	Camp		4													4					**4**
	Cormorant		26													26					**26**
	Buoy		9													9					**9**
	Catfish		2													2					**2**
	Hanvan/Gibby Pt															0					**0**
	Cape Sable															0					**0**
	Murray															0					**0**

Table 15. Continued.

Region	Colony	Waders															Non-waders				
		GBHE	GWHE	GB/GWHE	GREG	TRHE	SNEG	TRHE/SNEG	LBHE	BCNH	YCNH	GRHE	WHIB	REEG	ROSP	Total Waders	BRPE	DCCO	ANHI	MAFR	Total Waterbirds
Northwest	Curlew		1		-	-										1		-	-	-	**1**
	Dildo	3	25		-	-										28		5	-	-	**33**
	Cluett	1	6		-	-			-	-	-	-	-	-	-	7		25			**32**
	Man-o-war	5	1		-	-			-	-	-	-	-	-	5	11		160	-	-	**171**
Southeast	Middle Butternut				-	6			-	-	-	-	29	-	-	35		-	1	-	**36**
	Big Butternut				-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	Bottle				-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	Stake		1		-	32			-	-	-	-	-	7	2	42		-	-	-	**42**
	Low		2		-	-			-	-	-	-	-	-	4	6		-	-	-	**6**
	Cowpens		-		-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	Crane		-		-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	East		4		-	-			-	-	-	-	-	3	5	12		-	-	-	**12**
	Crab		-		-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	West		-		-	-			-	-	-	-	-	-	-	0		-	-	-	**0**
	Cotton		-		-	-			-	-	-	-	-	-	-	0		4	-	-	4
	Pigeon		3		1	5			2	-	-	2	-	2	17	32		190	-	-	222
Southwest	East Buchanon		4	8	-	-			-	-	-	-	-	-	-	12	8	12			32
	West Buchanon				-	13			-	-	-	-	-	-	-	13					13
	Barnes				-	-			-	-	-	-	-	-	-	0					0
	North Twin				-	-			-	-	-	-	-	-	-	0					0
	South Twin				-	1			-	-	-	1	-	3	3	8		10			18
	Petersons		13						-	-	-	-	-	-	-	13		-			13
	Gophers															0		-			0
	Hobo															0		-			0
	Panhandle															0		-			0
	Shell															0		-			0
	Green Mangrove															0		-			0
	Upper Arsnicker															0		10			10
	Lower Arsnicker		1													1		60			61
	Horseshoe Ashby		*6*		*13*		*7*									26	*2*	*57*		*23*	108
	Total	**30**	**222**	**17**	**133**	**593**	**125**	**517**	**2**	**1**	**3**	**5**	**469**	**71**	**153**	**2341**	**124**	**899**	**2**	**23**	**3389**

Table 16. Summary of nest counts since Everglades Science Center began collecting this data in 2014-2015 as corrected in the 2020-2021 SFWBR. [a]

Year	Nesting Waders															Other Water Birds								Total Nests
	GBHE/ GWHE[b]	GREG	REEG	LBHE	SNEG	TRHE	TRHE/ SNEG[c]	BCNH	YCNH	GRHE	ROSP[d]	WHIB	GLIB	LEBI	Total Waders	BRPE	DCCO	NECO	ANHI	OSPR	BAEA	Total		
2014-2015		133	66	1	34	518			2	6	365	65	3		**1925**	68	247		55	34	1	**460**		**2385**
2015-2016		177	74		45	642				3	367	160			**2190**	797	12		1	0	26	**836**		**3026**
2016-2017		208	51	3	49	246				38	209	281			**2014**	376	569		22	23	0	**990**		**3004**
2017-2018		253	62	1	34	684		29			278	40			**2612**	114	282	2	16			**430**		**3042**
2018-2019		200	30	2		835					282	180			**3012**	169	171					**340**		**3352**
2019-2020		137	65	6	193	1317					203	353			**2485**	127	365		2			**494**		**2979**
2020-2021	154	299	69	2	324	1115		8			246	95		1	**1860**	59	683	2	2	57	3	**806**		**2666**
2021-2022	66	256	58		21	417	87	1		4	157	252			**1739**	19	298			28	1	**346**		**1738**
2022-2023	17	133	71	2	125	593	517	1	3	5	153	469			**2341**	124	899		2	No data	No data			**3389**

a. Blank species may not be zero but that nests were simply not identified in some of the rarer and more cryptic nesting species.
b. Nests that were either GBHE or GWHE but parentage could not be distinguished
c Nests that were either TRHE or SNEG but parentage could not be distinguished
d ROSP is the only species where nests counts include those at the Paurotis Pond colony so as to be consistent with our sister report on ROSP nesting in Florida Bay

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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 2022 and 2023 nesting years.

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), GREG, Great White Herons (GWHE), Great Blue Herons (GBHE), WHIB, and 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 the timing of peak nest counts for the focal species.
- Changes in an annual nesting index (sum of monthly nest counts) for the focal species.

METHODS

The 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. SFCN 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 indices were compared to the ten previous nesting years' mean, maximum, and minimum. Complete methods are described by Muxo et al. (2015).

Surveys occurred July 2022–January 2023, as well as March–June 2023. A survey did not take place in February 2023. The nine colonies surveyed during the routine monthly flights were 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 16**). 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.

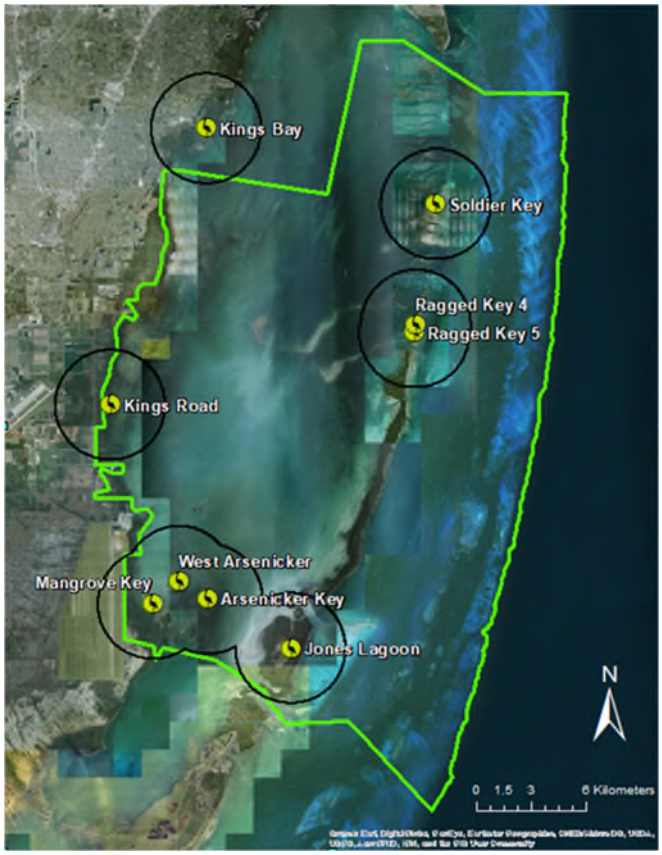

Figure 16. Nine island colonies monitored within Biscayne National Park and the estimated foraging areas.

2022 Results and Discussion

With the 2022 nesting year, the SFCN completed the twelfth full nesting year of monitoring colonial nesting birds in Biscayne National Park.

For the 2022 nesting year, there were 8 species photographed nesting and 18 species visually observed using the colonies. As previously seen, more species were observed than photographed nesting. This suggests colony locations function not only for reproduction but also for roosting and refugia for the additional species.

The monitoring results have yielded valuable nesting data for documenting species-specific nesting patterns and trends. We have chosen to break down survey results by grouping bird species according to their feeding method: diver, stalk and strike, and tactile (**Figures 17** through **19**). Species specific information is presented with a focus on the six focal species.

The 2022 nesting year showed DCCO nesting on all nine colonies (**Figures 20** and **21**). The DCCO remains the most prominent nesting bird species in our survey, comprising 96% of the photographed nests of focal species (**Table 17**) and 93% of the peak nest counts for the last 10 nesting seasons (**Table 18**).

Table 17. Peak nest numbers for all colonies of the last 10 nesting seasons.

Nesting Season	DCCO	GBHE	GREG	GWHE	ROSP	WHIB
2014	1336	11	24	18	4	60
2015	802	13	14	18	0	38
2016	1213	11	12	28	3	24
2017	1245	11	16	40	4	95
2018	1147	16	29	46	9	66
2019	940	13	4	40	3	33
2020	657	11	3	38	2	9
2021	796	19	19	51	12	0
2022	736	12	3	25	3	12
2023	853	10	7	27	1	16

Table 18. Nesting index numbers for all colonies over the last 10 seasons.

Nesting Season	DCCO	GBHE	GREG	GWHE	ROSP	WHIB
2014	6285	27.5	58	80.5	11	82
2015	5525	23	33	72.5	0	61
2016	7113.5	32	52	138.5	12	27
2017	8472.5	46	54	198.5	9	172
2018	5782.5	50	88.5	195	21	137
2019	5908.5	52.5	5	192.5	6	42
2020	2083	22	4	103.5	3	18
2021	3844	43	40.5	182	21	0
2022	4414.5	19	7	69.5	3.5	37.5
2023	5249.5	30.5	20	122.5	34	30

There were no new colonies detected on our census flight and all surveyed colonies maintained some level of nesting. Only Soldier Key and West Arsenicker showed increases in the number of species. Arsenicker Key, Jones Lagoon Ragged Key 4, and Ragged Key 5 showed reductions in species while Kings Bay, Kings Road, and Mangrove Key remained the same. This last year showed the DCCO as the only species we detected nesting on all nine colonies and GBHE nesting on seven colonies (**Figure 20**).

Because of a helicopter problem and an administrative shutdown, we were unable to survey from December 2021 through February 2022. The May 2022 survey also did not take place because of the lack of personnel and helicopter availability. The lack of data makes it difficult to create and compare annual trends.

Five of the six focal species 2022 peak nest values came in lower than their respective 2021 values (**Table 17**). WHIB was the exception to the trend. For the fourth consecutive season, the peak nest numbers for DCCO remain under 1,000 nests (**Table 17**).

Compared to the last nesting season, the number of species nesting by colony, the data show two colonies with increases and four colonies with decreases, and two colonies remained the same (**Figure 21**). There was at least one of the focal species nesting on all nine colonies (**Figure 21**).

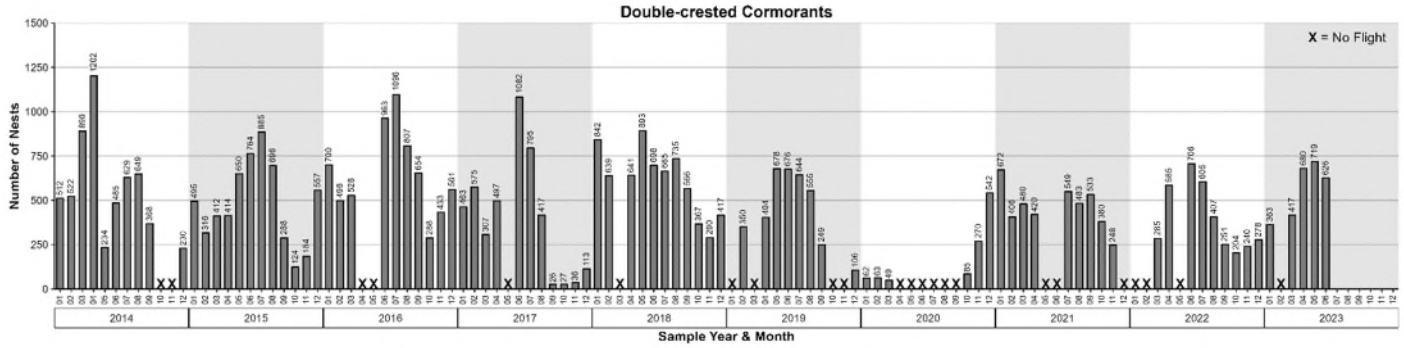

Figure 17. Number of DCCO nests per month.

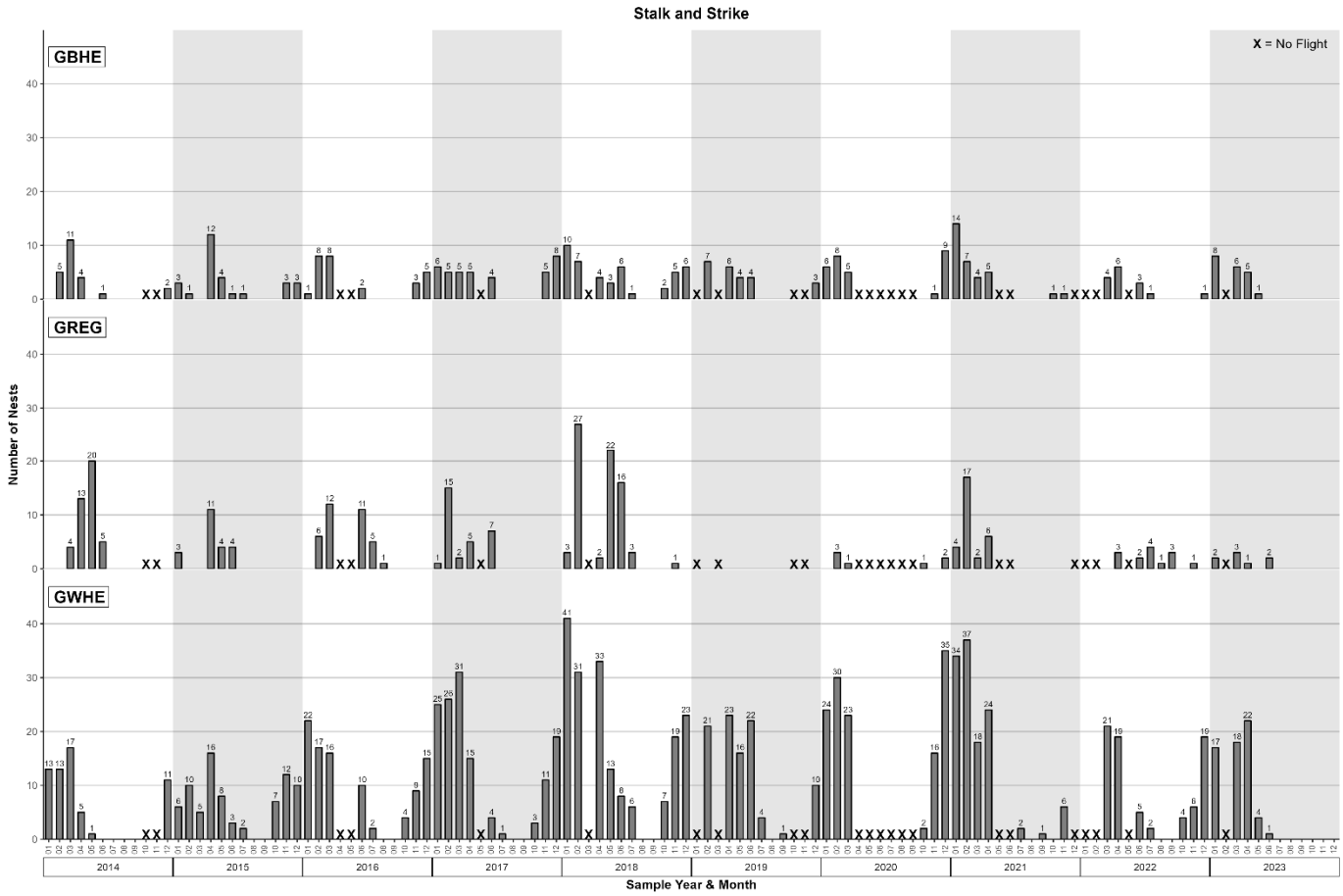

Figure 18. Number of GRBH, GREG, and GRWH, which are stalk and strike foragers, nests per month.

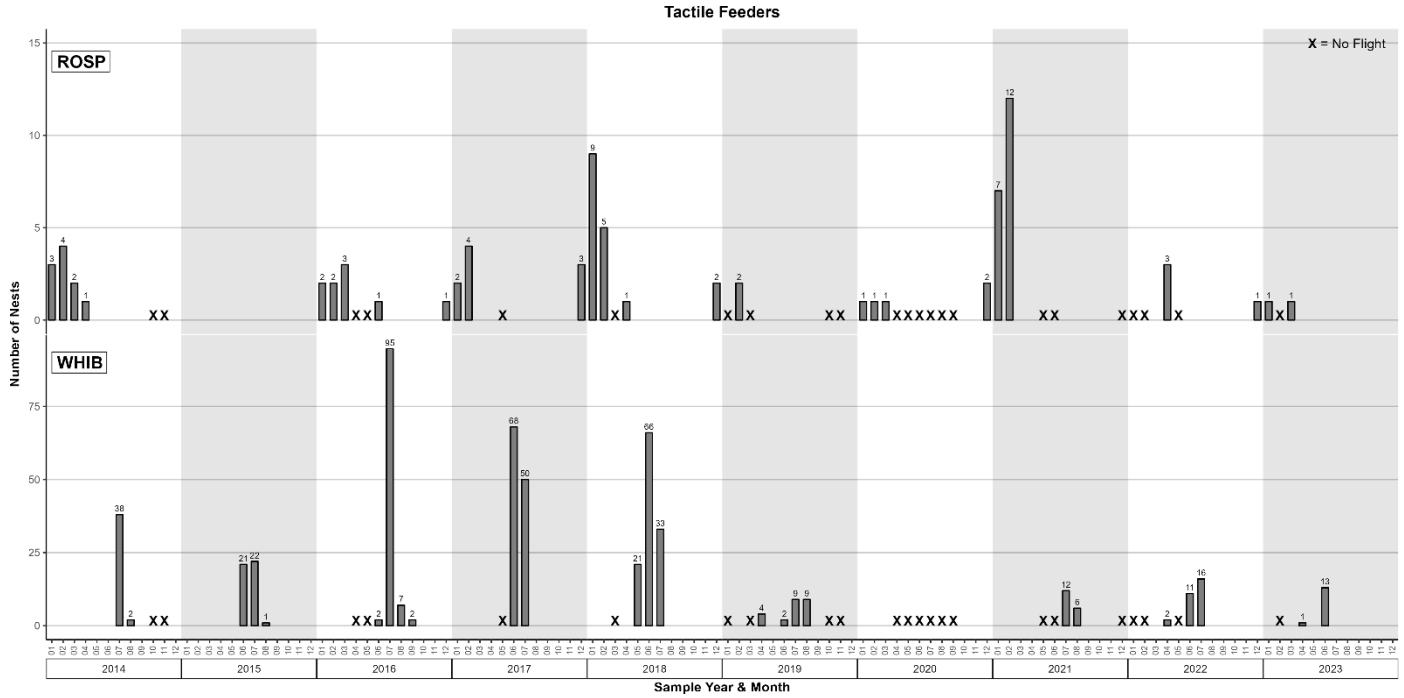

Figure 19. Number of WHIB and ROSP, which are tactile foragers, nests per month.

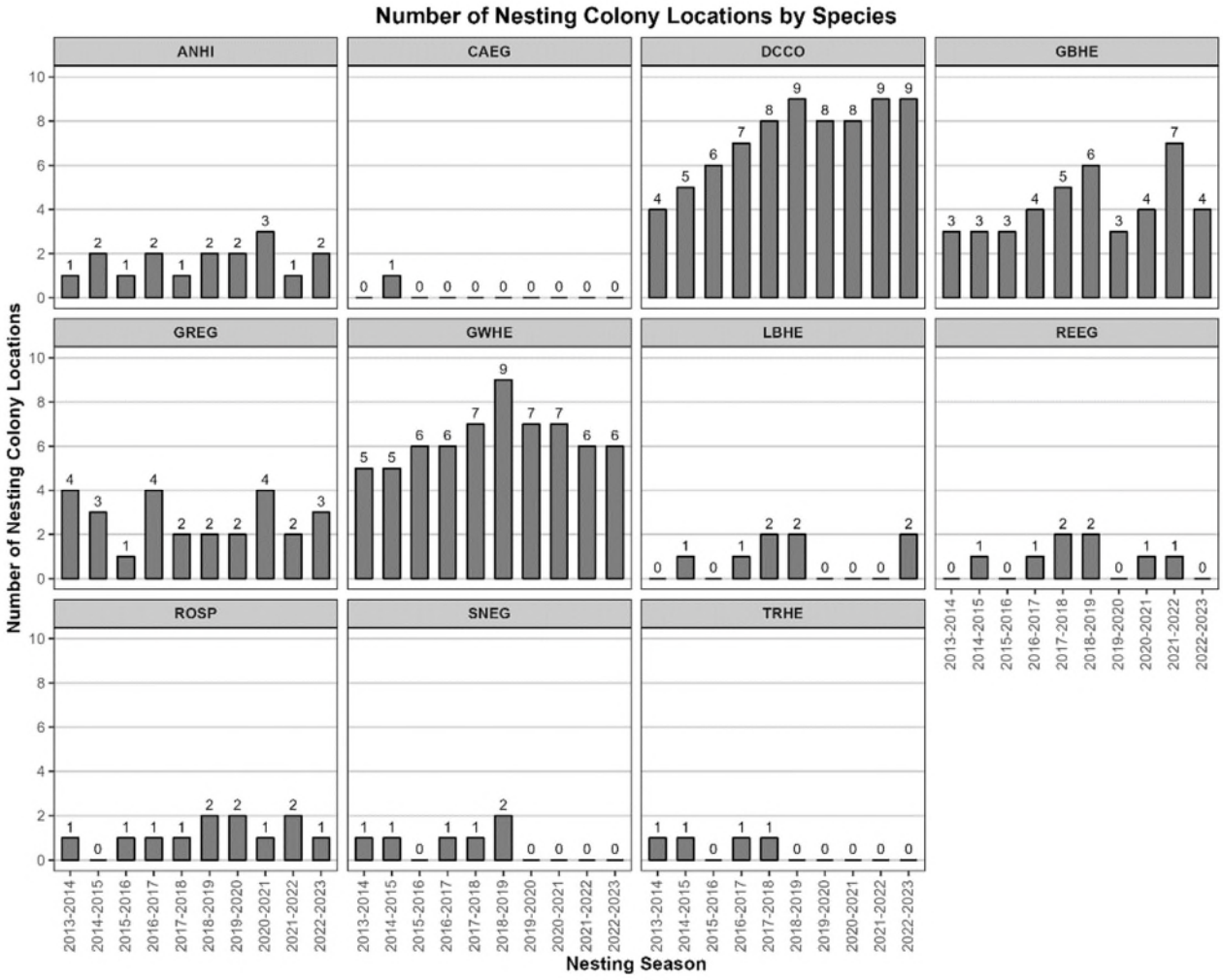

Figure 20. Annual total number of nesting colonies for each species in Biscayne Bay.

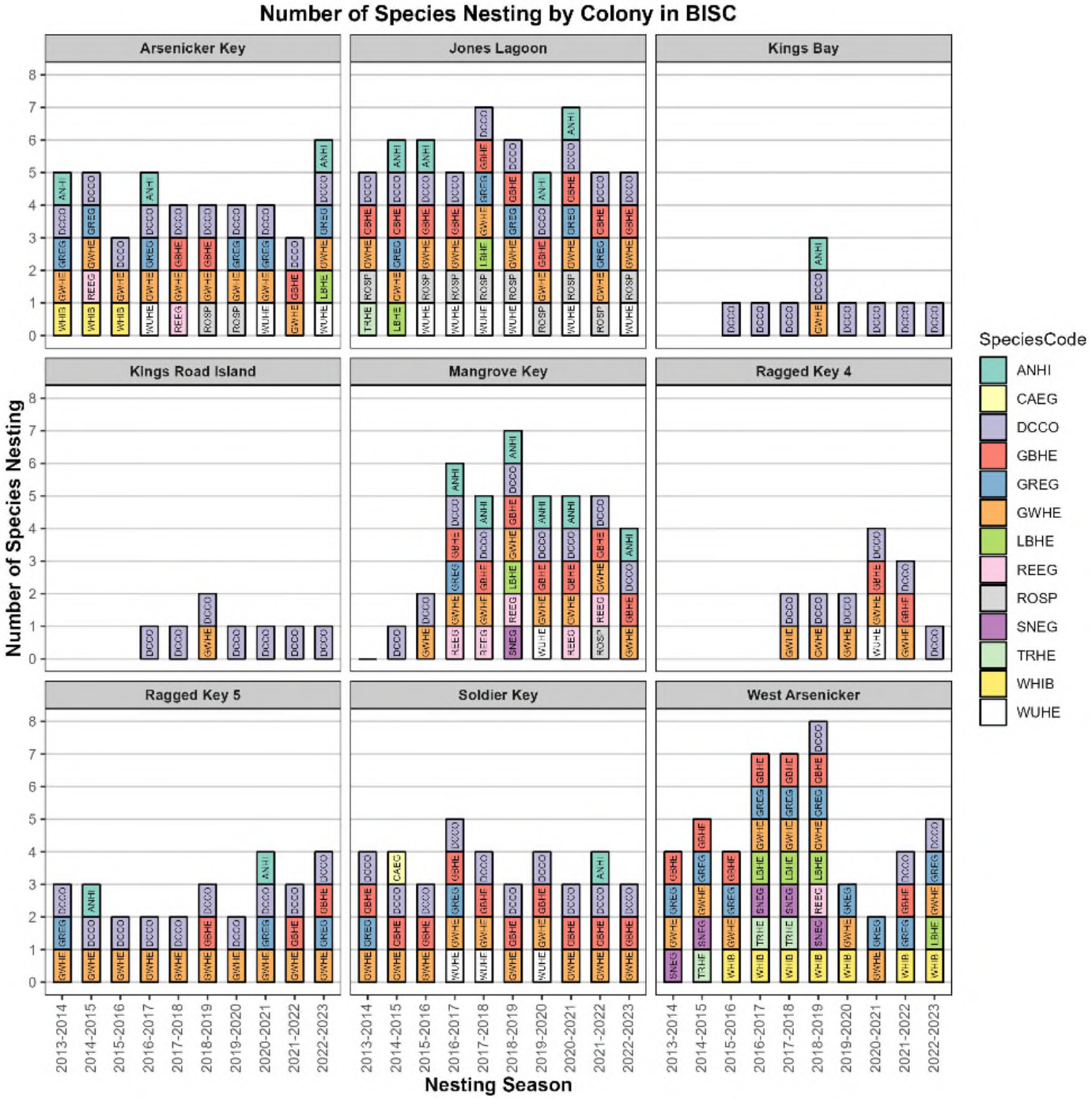

Figure 21. Number of species detected nesting, by colony and year. (Includes all egrets, ibises, spoonbills, and herons.)

2023 Results and Discussion

In the 2023 nesting year, the SFCN completed its thirteenth year of monitoring colonial nesting birds in Biscayne National Park. When interpreting the data for this nesting season, it is important to consider that one survey did not take place.

The monitoring results have yielded valuable nesting data for documenting species-specific nesting patterns and trends. We have chosen to break down survey results by grouping bird species according to their feeding method: diver (DCCO), stalk and strike (GBHE, GREG, and GWHE), and tactile feeders (ROSP and WHIB) shown in **Figures 17** through **19**).

There were no new colonies detected on our census flight and all surveyed colonies maintained some level of nesting. Ragged Key 5, Arsenicker Key, and West Arsenicker showed increases in the number of species when compared to the last season. Jones Lagoon, Kings Bay, and Kings Road showed the same number of species nesting as last season (**Figure 21**). This 2023 nesting season showed the DCCO as the only species detected nesting on all nine colonies. GBHE nested on four colonies and GWHE on six colonies (**Figure 20**). On three colonies, Kings

Bay, Kings Road, and Ragged Key 4, DCCO was the only species detected nesting (**Figure 21**).

Arsenicker Key had the highest species diversity with six species nesting while Jones Lagoon and West Arsenicker both had five species detected nesting. There was at least one of the focal species nesting on all nine colonies, which has been consistent since the start of surveying the nine colonies beginning in the 2018 season (**Figure 21**).

Comparison of peak nest counts and nesting index for the last ten previously monitored years inclusive of the 2023 nesting season, are shown in **Tables 17** and **18**. **Tables 19** and **20** show the mean, maximum, and minimum for the peak nest counts and nesting index values respectively for the last season and prior nine seasons. Peak nest counts in the tables should not be used as true abundance estimates as nests and birds were likely observed during more than one sample period but instead, interpreted more as an estimate of the number of nesting birds the resources are able to support (similar to carrying capacity).

Table 19. Mean, maximum, and minimum peak nest numbers calculated using the last 10 years of data.

Species	Mean	Maximum	Minimum
DCCO	972.5	1336	657
GBHE	12.7	19	10
GREG	13.1	29	3
GWHE	33.1	51	18
ROSP	4.1	12	0
WHIB	35.3	95	0

Table 20. Mean, maximum, and minimum peak nestling index numbers calculated using the last ten years of data.

Species	Mean	Maximum	Minimum
DCCO	5339.6	7623	2083
GBHE	33.2	52.5	17
GREG	35.1	88.5	4
GWHE	128.3	195	67.5
ROSP	11.85	34	0
WHIB	60.65	172	0

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SOUTHWEST FLORIDA

The 2022 nesting season represented 65th consecutive years monitoring the historic Corkscrew WOST colony. This colony was once critical to the success of the species in its South Breeding Region, producing nearly half of this region's WOST every decade from the 1960s through 1990s (**Figure 22**) and serving as the largest WOST colony in the South Breeding Region 80% of years from 1965 to 2006 (S. Clem, unpublished data). The Corkscrew colony has been struggling in recent years concurrent with regional wetland loss and degradation. This degradation includes over drainage of Audubon's Corkscrew Swamp Sanctuary (CSS) due to downstream flood control associated with increased development (Clem and Duever 2019, Clem and Cornell 2021). In the 16 nesting seasons since 2006, the Corkscrew colony has only seen six successful nesting years.

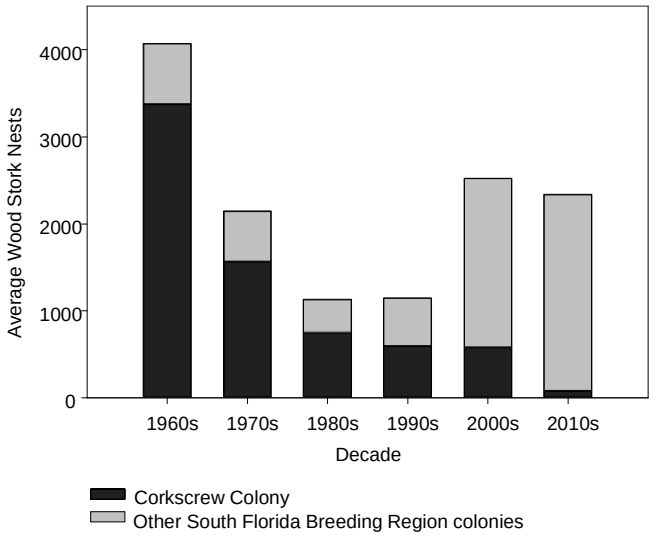

Figure 22. Average contribution of the Corkscrew Colony to WOST nesting in the South Florida breeding region for the 1960s through 2010s.

In addition to CSS, in 2022 Audubon Florida monitored two active WOST colonies in Lee and Collier counties. These new colonies arose following the decline of the Corkscrew colony and have seen WOST nesting nearly every year since 2006. Both sites are islands within permanent water bodies, and each appears to have little capacity for increased nesting beyond what is seen in most years. While these new colonies certainly see more consistent nesting than the Corkscrew colony, this region's total WOST nesting effort is still appreciably lower than it was prior to hydrologic disruption at CSS, particularly during years with ideal hydrologic conditions where WOST would be expected to nest in great numbers. Two other WOST colonies—Caloosahatchee East (26.696583, -81.794950) and Collier-Hendy Line (26.370383, -81.272717)—active in prior years but have not seen WOST nesting in > 10 years were monitored early in the nesting season, but once again, we saw no nest initiation. These colonies have been deemed inactive.

Continued effort is needed to reduce over drainage and restore pre-2006 hydrology to CSS. Reversing over drainage would improve nesting and foraging conditions in CSS and the surrounding Corkscrew Regional Ecosystem Watershed (CREW). Additionally, increased efforts are needed to conserve and restore hydrologic function in wetlands throughout Southwest Florida, particularly as development accelerates within and around the Corkscrew Watershed. These efforts would complement ongoing wetland restoration projects like those in Picayune Strand and Southern CREW, providing opportunities to improve both foraging and nesting habitat for wading birds in the region. Improving wetland quality and increasing foraging conditions in the Western Everglades is vital for WOST recovery in the Greater Everglades, as these wetlands

are available early in the nesting season when other Everglades wetlands have not yet come online for foraging.

In 2023, following a drier-than-typical WY2022, WY2023 had a wetter-than-typical rainy season, topped off by rainfall from Hurricane Ian, which made landfall in this region in September. In the Corkscrew Swamp, water levels following Hurricane Ian were the third highest in Audubon's 66-year daily water level record, just higher than those seen following Hurricane Irma in 2017. Notably, post-hurricane water levels at CSS following Hurricanes Irma and Ian (peak water levels = 4.17 and 4.18 ft, respectively) were not as high as those seen following major rain-making tropical systems recorded prior to CSS' hydrologic alteration: 1960 peak water level = 4.47 ft (Hurricane Donna) and 1995 peak water level = 4.33 (Tropical Storm Jerry and Hurricane Opal).

METHODS

Monthly aerial surveys were conducted from a fixed-wing aircraft between December and June for both the 2022 and 2023 nesting seasons. At each colony location, a series of overlapping photographs were taken of the colony from an altitude of 500 to 1,000 ft. While WOST were the primary target for these surveys, all light-colored wading birds were counted.

HYDROLOGY

In WY2022, rainfall at CSS was average, as CSS received a total of 54 inches. While rainfall was distributed typically between wet and dry seasons, Hurricane Nicole led to an above average November that raised wetland water levels slightly higher than typical late wet season levels through mid-December and likely led to a delay in WOST nest initiation. Water levels began falling quickly in December, with below average rainfall from December to March. Since the 2000s, water levels were below historic averages beginning in early January (**Figure 23**, top panel). An unseasonable rainfall event in late-April/early-May (4.5 inches in one week) prompted an additional monitoring flight in early May, but wading birds did not seem negatively impacted by the resulting short-term pulse in water levels across the region.

In recent years, dry season recession rates at CSS have been notably higher than those seen prior to the mid-2000s, a trend concurrent with the reduced hydroperiods that have been linked to downstream drainage. In WY2022, mid-December to early-February biweekly recession rates were 1.6 to 4.4 times greater than those seen WY2007-WY21 and 2.7 to 4.3 times greater than those seen during the WY1960–WY2006 period (**Figure 23**, bottom panel). Recession rates late-February to mid-March were similar to those seen in recent years, peaking at over 0.6 inches per day just prior to drydown at CSS's B-gage in early April. Water level data from other parts of the region indicate water levels continued to fall through May, with nesting season ending with the onset of the rainy season in early June.

In addition to deleterious impacts on aquatic prey standing stock due to shortened hydroperiods and decreased nest success (due to predation) at overdrained nesting sites, unusually high recession rates shorten the time high density prey patches are available for wading birds. As hydrologic impacts of development on adjacent wetlands become more prevalent in Southwest Florida, more research is needed to better understand impacts of these higher-than-average recession rates on prey communities and higher trophic levels, including wading birds.

Wading Bird Foraging Flock

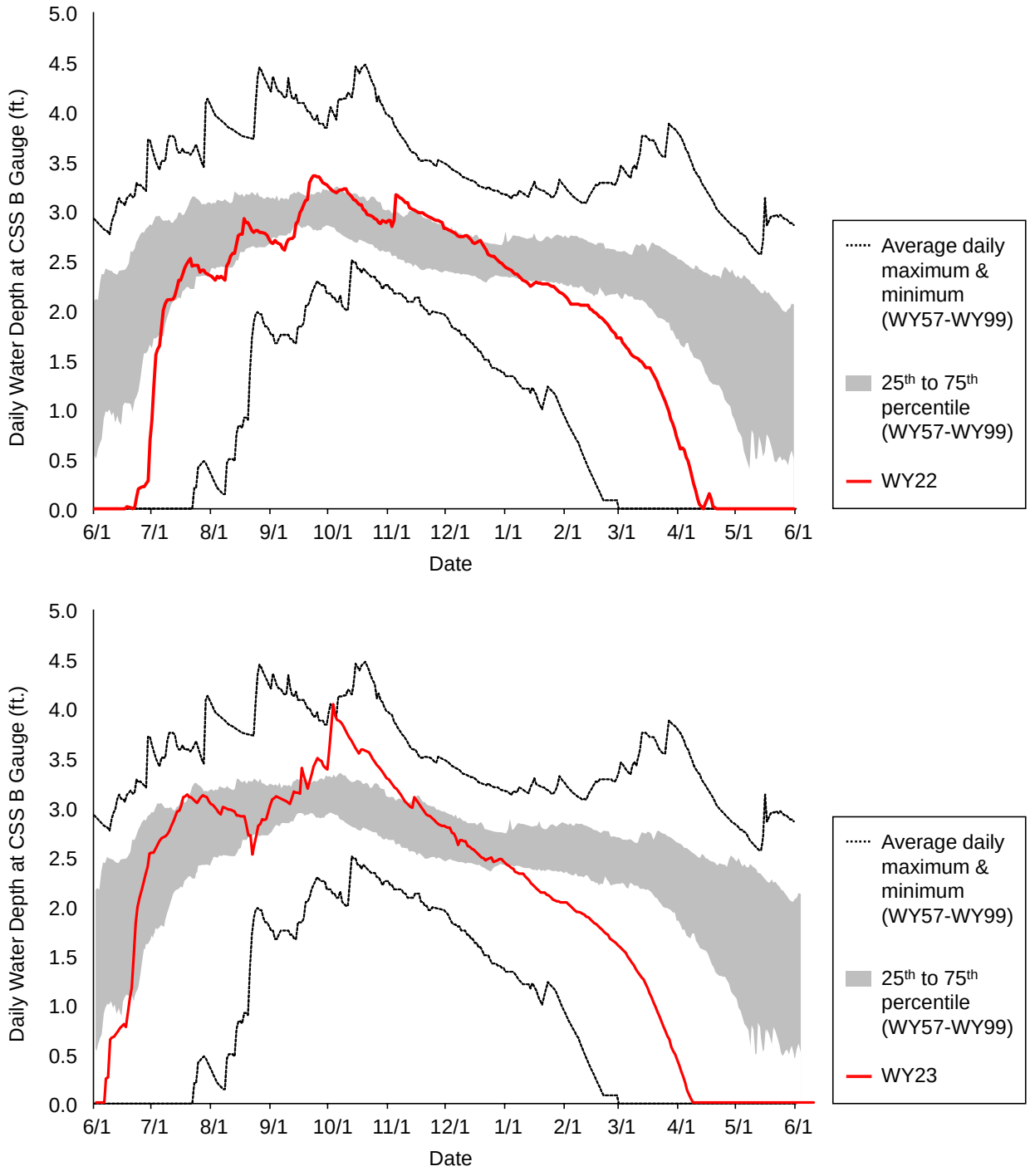

Figure 23. Daily water levels at Corkscrew Swamp Sanctuary's B Gauge prior to hydrologic disruption (WY1957–WY1999) and in WY2022 (top panel) and WY2023 (bottom panel). Zero represents ground level at the B Gauge.

In WY2023, water levels in CSS fell very quickly and steadily following Hurricane Ian (**Figure 24**, left panel), with biweekly recession rates consistently nearing or exceeding 5 millimeters per day (mm/d) throughout the dry season and exceeding 10 mm/d in the last month before the swamp dried completely down (**Figure 24**, right panel).

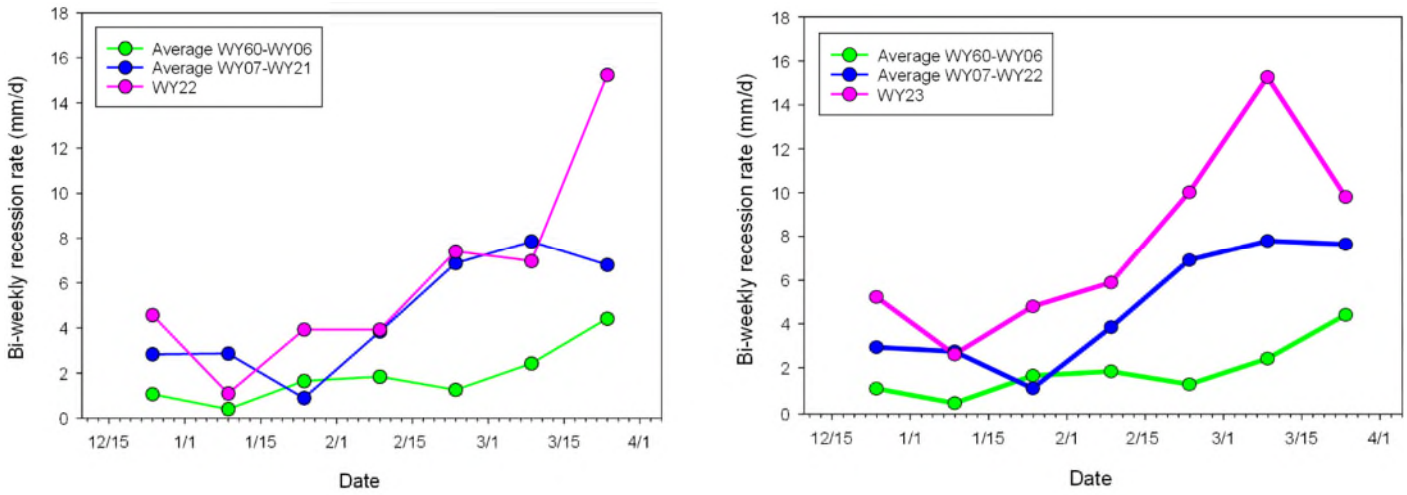

Figure 24. Bi-weekly surface water recession rates in millimeters per day (mm/d) near the Corkscrew colony mid-December through late-March prior to hydrologic disruption (WY1960–WY2006), since hydrologic disruption (WY2007–WY2021), and in the WY2022 (left panel) and WY2023 (right panel) nesting seasons.

2022 Results

Flights were conducted December 8, January 4, February 10, March 8, April 6, May 5, May 10, and June 7. First WOST nesting was observed in February, fledging began by May, and most WOST chicks had fledged by June. Peak nest counts are reported for each colony for the 2022 nesting season in **Table 21**. For the tenth time in 16 years, no WOST nesting was observed at the Corkscrew Colony. At peak, BC-29 had 152 WOST nests, 8% lower than the 5-year average. In addition to WOST, BC-29 saw nesting from GREG, ROSP, and Anhinga (ANHI). The Lenore Colony had a peak of 344 WOST nests, 8% higher than the 5-year average. In addition to WOST, Lenore saw nesting from GREG and GBHE, with SNEG, CAEG, ROSP, and ANHI also present in the colony.

Table 21. Peak nest counts for Southwest Florida WOST colonies in 2022.

Colony	Latitude	Longitude	WOST	GREG	WW	GBHE	ROSP	ANHI	Total
Corkscrew	26.381013	-81.619753	0	0	0	0	0	0	0
BC-29	26.273025	-81.344057	152	86	45	0	3	2	288
Lenore	26.688867	-81.83015	344	94	31	11	0	0	480
Total			**496**	**180**	**76**	**11**	**3**	**2**	**768**

2023 Results

WOST initiated nesting at the Corkscrew colony in mid- to late-December 2022. In early January, 130 adult WOST and 26 WOST nests were observed. By March 10, 34 WOST nests and 18 nestlings were observed at this colony, with most nestlings appearing to be approximately 4 weeks old. By April 4, no evidence of nesting activity was seen in the colony and no WOST were present. Peak nest counts are reported for each colony for the 2022 nesting season in **Table 22**. With no evidence of nest predation or failed nests, we believe at least most of these WOST force fledged due to the rapid fall of water levels and resulting poor foraging conditions.

Table 22. Peak nest counts for Southwest Florida WOST colonies in 2023.

Colony	Latitude	Longitude	WOST	GREG	WW	GBHE	ROSP	ANHI	Total
Corkscrew	26.381013	-81.619753	34	6	6	0	0	0	46
BC-29	26.273025	-81.344057	251	48	35	0	12	0	346
Lenore	26.688867	-81.83015	425	58	15	24	8	3	533
Total			**710**	**112**	**56**	**24**	**20**	**3**	**925**

Two other Southwest Florida WOST colonies were active in 2023, despite one of them (Lenore Island) sustaining a direct hit from Hurricane Ian only three months prior. Like Corkscrew, nesting initiated at Lenore Island and BC-29 in late December, but at these colonies peak nesting effort was seen in early April (the same flight where it was observed that WOST had abandoned the Corkscrew colony). WOST nesting at Lenore Island and BC-29 were 33 and 53% higher, respectively, than the colony's 5-year average, with GREG and ROSP also nesting within each colony.

Annual observations of WOST nesting continue to reflect degraded hydrologic conditions that have been described within the Corkscrew Swamp in recent decades (Clem and Duever 2019, Clem and Cornell 2021). Audubon Florida's science team is optimistic about SFWMD's new Corkscrew Watershed Initiative and the potential for hydrologic restoration of this system that may improve nesting and foraging conditions for WOST and other wading birds, in addition to myriad other

positive implications for wildlife and Southwest Florida residents.

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

For 16 consecutive years, the Florida Department of Environmental Protection (DEP) and U.S. 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 DEP's Office of Resilience and Coastal Protection, and J.N. "Ding" Darling National Wildlife Refuge (NWR) have conducted colonial nesting bird surveys within the J.N. "Ding" Darling NWR Complex, and the Matlacha Pass, Pine Island Sound, Gasparilla Sound-Charlotte Harbor, Cape Haze, and Lemon Bay Aquatic Preserves (**Figure 25**). Colonial wading and diving bird nest monitoring began in 2008 with nine islands and expanded to 34 islands in 2011. This year, 40 islands were monitored and 33 were identified as active wading and diving bird nesting sites. Two new active islands were monitored beginning mid-nesting season 2021, and the peak nest counts were included in the 2022 and 2023 nesting season results. Goals of this continuous study include establishing a long-term data set to assess nesting effort, seasonality, and to monitor activity status of known rookeries and establishment of new rookeries in the greater Charlotte Harbor area. Goals also include enhancing and restoring nesting sites to ensure suitable nesting habitat for wading and diving birds. In 2017, two islands in Pine Island Sound were designated by the Florida Fish and Wildlife Conservation Commission (FWC) as Critical Wildlife Areas (CWAs); Hemp Key and Broken Islands. The islands were posted as CWAs in 2018.

METHODS

The study area was divided between the 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. DEP/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 2023. Peak numbers reflect the highest number of nests per species throughout the survey period. The total number of peak nests was also calculated for each island.

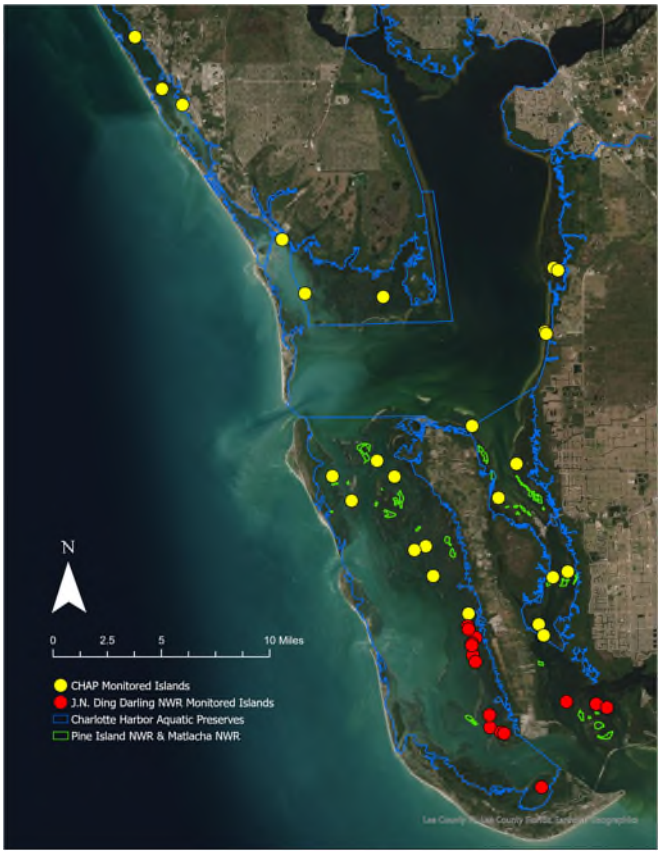

Figure 25. Locations of monitored bird colonies in the Charlotte Harbor Aquatic Preserves and J.N. Ding Darling NWR Complex.

2022 RESULTS

The peak estimate for all colonial nesting birds in the study area was 1,868 nests (**Table 23**). This was approximately a 5.6% increase from the 2021 total peak nesting effort of 1,769. Diving birds constituted approximately 65% of the documented nests while the remaining 35% were wading bird nests. The largest nesting efforts in 2022 occurred on Broken Islands (327), Hemp Key (290), and Skimmer Island (155). In 2022, Skimmer Island supported the greatest species diversity with 13 species nesting. The 2022 nesting season produced record setting peak nesting effort for four species: DCCO, SNEG, TRHE, and the state threatened listed species REEG. The 2022 peak nesting effort was the highest recorded total peak nesting effort in a nine-year period. (**Table 23**).

Table 23. Colonial nesting bird peak counts for Charlotte Harbor aquatic preserves and J.N. "Ding" Darling NWR complex February through July 2022.

Colony (Island)	Latitude	Longitude	GBHE	TRHE	LBHE	SNEG	GREG	REEG	CAEG	YCNH	BCNH	GRHE	WHIB	BRPE	DCCO	ANHI	ROSP	Total
Bird Keys	26.6679	-82.2276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird Rookery Keys	26.6742	-82.0897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bodifer Key	26.49771	-82.11252	0	14	0	0	1	0	0	0	1	0	0	1	12	0	0	16
Broken Islands	26.6777	-82.1940	3	9	0	1	1	1	8	0	1	0	37	138	126	0	2	55
Burnt Store Marina N	26.7625	-82.0669	2	2	1	6	7	0	0	0	0	1	0	9	7	0	0	19
Burnt Store Marina S	26.7611	-82.0660	3	1	0	0	0	0	0	13	0	2	0	0	0	0	0	19
Clam Key	26.5063	-82.1128	2	0	0	1	1	2	0	0	2	0	0	0	25	2	0	8
Cork Island	26.5742	-82.1273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crescent Island	26.5979	-82.0639	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Darling Keys	26.6669	-82.1811	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. of Chadwick Cove	26.9289	-82.3511	15	1	0	14	13	0	0	0	0	0	0	0	3	1	0	43
Fish Hut Island	26.5467	-82.1245	2	10	2	5	7	3	6	0	0	1	0	0	24	4	0	30
Forked Creek Keys	26.9980	-82.3879	0	6	3	6	10	0	9	0	7	0	0	0	5	1	0	32
Gasparilla Marina S	26.8269	-82.2625	3	0	0	2	12	0	0	0	0	0	0	33	24	3	0	17
Givney Key	26.5145	-82.0553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemp Key	26.5999	-82.1532	16	0	0	1	21	5	0	0	0	0	0	99	148	0	0	43
Litte Oyster Creek	26.9203	-82.3363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lumpkin Island	26.6015	-82.0526	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Lower Bird Island	26.5125	-82.0330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Masters Landing	26.5666	-82.0749	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. of Mason Island	26.5581	82.1219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. of York Island	26.4945	82.1043	3	2	0	4	6	1	0	0	0	0	0	46	9	2	0	16
N. Regla	26.5422	82.1227	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
N. of Big Smokehouse	26.0000	-82.1225	5	0	0	0	0	0	0	0	0	0	0	0	13	0	0	5
NE. of York Island	26.4940	-82.1021	2	0	0	0	0	0	0	0	0	0	0	18	0	2	0	2
NW of Mason Island	26.5543	82.125	0	4	0	0	0	0	0	0	1	1	0	0	0	0	0	6
NW. of Pumpkin Key	26.5660	-82.1279	4	0	0	0	0	0	0	0	0	0	0	0	12	0	0	4
Oyster Creek W	26.8181	-82.3359	1	0	0	3	7	0	0	1	0	0	0	36	26	0	7	19
Pirate Harbor N	-82.0597	26.8052	8	0	0	5	23	1	0	0	1	0	0	55	37	1	0	38
Pirate Harbor SE	-82.0565	26.8037	3	22	2	4	0	0	36	0	2	0	0	13	19	3	0	33
Royal Palm Marina W	-82.3708	26.9640	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Skimmer Island	26.5104	-82.0250	2	39	5	19	6	3	1	0	3	1	10	39	26	1	0	88
SW. of Mason Island	26.5534	-82.1250	0	8	0	2	0	0	0	0	0	0	0	0	2	1	0	10
SW. of Pumpkin Key	26.5640	-82.1275	2	2	1	0	2	0	0	0	1	0	0	0	8	1	0	8
Tarpon Bay Keys	26.4577	-82.0744	2	9	0	4	10	1	0	0	1	0	0	17	13	0	0	27
Turtle Bird Island	26.7876	-82.1876	0	8	0	7	0	0	0	0	0	0	0	0	21	0	0	15
Upper Bird Island	26.5592	-82.0714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Useppa Oyster Bar	26.6513	-82.2134	1	0	0	0	0	0	0	0	0	0	0	47	80	1	0	1
White Pelican Island	26.7905	-82.2463	3	0	0	15	2	3	0	0	0	0	0	0	5	0	0	23
Total			**93**	**137**	**14**	**99**	**129**	**20**	**60**	**14**	**20**	**7**	**47**	**551**	**645**	**23**	**9**	**1868**

Species Summaries – Diving Birds

DCCO nesting peaked at 645 nests, which is approximately 34.5% of the total nests in the 2022 season. This was a record setting peak nest count for DCCO and a 14% increase from 566 peak nests documented in 2021. Nesting was documented on 22 islands, with the highest nest count of 148 occurring on Hemp Key in April.

BRPE nesting peaked at 551 nests on 13 islands accounting for approximately 29% of the nesting effort documented this season. This was very similar to the BRPE nest count of 547 in 2021. The highest peak nest count occurred in May at Broken Islands with 138 nests.

ANHI nesting peaked at 23 nests which was down 44% from the 2021 peak count of 41. The highest nest count observed occurred on Fish Hut Island with a peak nest count of 4.

Species Summaries – Wading Birds

GBHE nesting efforts were documented on 22 of the 28 active islands. The peak nest count for GBHE was 93. This was a 13% decrease from last year's peak nesting effort of 107. Hemp Key had the largest number of peak nests (16).

TRHE nests were documented on fifteen islands with a peak nest count of 137. This was a record setting peak nest count for TRHE and an 80% increase from last year's peak nest count of 76. The highest peak nesting effort occurred on Skimmer Island with a peak nest count of 39.

LBHE nesting peaked at 14 in 2022. This was a 22% decrease from the peak nest count of 18 in 2021. Nests were documented on six islands with the highest nest count of 5 on Skimmer Island.

SNEG nesting occurred on 17 islands with a peak nest count of 99. This is a record setting peak nest count for SNEG. The highest nest count of 15 was recorded on White Pelican Island.

GREG nesting peaked at 129. This was a 22% decrease of the peak nest count of 166 in 2021. The greatest GREG nesting effort was documented on Pirate Harbor North with a nest count of 23 nests.

REEG were documented nesting on nine islands with a peak nest count of 20. This was a record setting peak nest count for REEG and approximately a 43% increase from 2021 peak nesting effort. The highest nest count observed occurred on Hemp Key; with a peak nest count of 5.

Reddish Egret with white morphology

Green Heron

Yellow-crowned Night Heron (YCNH) had a peak nest count of 14 in 2022 nesting season. Burnt Store Marina South had the highest peak nest count (13) in April.

BCNH nesting was documented on ten islands and peaked at 20 nests. The highest peak nest count (n = 7) occurred on Forked Creek Keys.

Green Heron (GRHE) nesting peaked at 7 and nesting activity occurred on 6 islands. This was an increase of 2 nests from 2021 peak nesting effort.

WHIB nesting occurred on two islands with a peak count of 47. Broken Islands accounted most documented nests (37).

CAEG nesting peaked at 60 in 2022. This was a 28% increase from the peak nest count of 47 in 2021. The highest peak nest count of 36 was recorded at Pirate Harbor Southeast in June.

ROSP were first documented in the study area in 2018. Since then, ROSP continue to be documented each year. The peak nesting effort (9 nests) occurred on two islands with the highest nest count of 7 on Oyster Creek West.

2023 Results

The peak estimate for all colonial nesting birds in the study area was 2,789 nests (**Table 24**). This was approximately a 49% increase from the 2022 total peak nesting effort of 1,868. Diving birds constituted approximately 53% of the documented nests while the remaining 47% were wading bird nests. The largest nesting efforts in 2023 occurred on Broken Islands (673), Hemp Key (287), and Skimmer Island (249). In 2023, Broken Islands supported the greatest species diversity with 14 species nesting.

Table 24. Colonial nesting bird peak counts for Charlotte Harbor aquatic preserves and J.N Ding Darling NWR complex February through July 2023

Colony (Island)	Latitude	Longitude	GBHE	TRHE	LBHE	SNEG	GREG	REEG	CAEG	YCNH	BCNH	GRHE	WHIB	BRPE	DCCO	ANHI	ROSP	Total
Bird Keys	26.6679	-82.2276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird Rookery Keys	26.6742	-82.0897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bodifer Key	26.49771	-82.11252	1	20	0	5	3	1	1	0	10	1	0	0	55	4	0	101
Broken Islands	26.6777	-82.1940	15	30	4	12	4	3	4	0	4	3	262	159	167	5	1	673
Burnt Store Marina N	26.7625	-82.0669	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3
Burnt Store Marina S	26.7611	-82.0660	5	0	0	5	0	0	0	6	0	2	0	0	10	0	0	28
Clam Key	26.5063	-82.1128	0	2	0	0	0	1	0	0	5	0	0	0	34	1	0	43
Cork Island	26.5742	-82.1273	2	4	0	0	0	0	0	0	0	1	0	0	42	2	0	51
Crescent Island	26.5979	-82.0639	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Darling Keys	26.6669	-82.1811	3	0	0	0	3	0	0	0	0	1	0	0	0	0	0	7
Dog Island	26.8205	-82.2671	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
E. of Chadwick Cove	26.9289	-82.3511	12	0	0	15	24	0	0	0	0	0	0	0	0	0	1	52
Fish Hut Island	26.5467	-82.1245	3	6	0	7	0	1	2	0	2	0	0	0	50	5	0	76
Forked Creek Keys	26.9980	-82.3879	0	4	6	13	44	0	10	0	8	0	0	0	10	4	0	99
Gasparilla Marina S	26.8269	-82.2625	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	15
Givney Key	26.5145	-82.0553	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
Hemp Key	26.5999	-82.1532	16	0	0	17	39	4	0	0	7	0	0	73	131	0	0	287
Litte Oyster Creek	26.9203	-82.3363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lumpkin Island	26.6015	-82.0526	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower Bird Island	26.5125	-82.0330	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Masters Landing	26.5666	-82.0749	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. of Mason Island	26.5581	82.1219	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	4
N. of York Island	26.4945	82.1043	4	4	0	0	0	0	0	0	1	0	0	7	4	3	0	23
N. Regla	26.5422	82.1227	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	3
N. of Big Smokehouse	26.0000	-82.1225	11	0	0	0	0	0	0	0	5	1	0	0	19	0	0	36
NE. of York Island	26.4940	-82.1021	4	3	0	5	6	0	0	0	0	0	0	39	17	3	0	77
NW of Mason Island	26.5543	82.125	0	3	0	0	0	0	0	0	0	1	0	0	6	1	0	11
NW. of Pumpkin Key	26.5660	-82.1279	2	0	0	0	0	0	0	0	3	0	0	0	1	0	0	6
Oyster Creek W	26.9181	-82.3359	2	0	0	3	18	0	0	0	0	0	0	43	43	0	7	116
Pirate Harbor N	-82.0597	26.8052	12	10	0	29	34	1	15	0	1	0	0	30	21	1	1	155
Pirate Harbor SE	-82.0565	26.8037	0	7	2	20	0	0	27	0	4	0	0	39	29	1	0	129
Royal Palm Marina W	-82.3708	26.9640	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Skimmer Island	26.5104	-82.0250	4	43	1	33	34	3	4	0	23	0	0	55	49	0	0	249
SW. of Mason Island	26.5534	-82.1250	2	4	0	0	0	0	0	0	3	0	0	0	21	1	0	31
SW. of Pumpkin Key	26.5640	-82.1275	0	1	0	1	1	0	0	0	3	1	0	0	1	0	0	8
Tarpon Bay Keys	26.4577	-82.0744	3	28	0	24	28	1	0	0	32	0	0	21	36	4	0	177
Turtle Bird Island	26.7876	-82.1876	0	3	0	7	0	0	0	0	2	4	0	4	32	0	0	52
Upper Bird Island	26.5592	-82.0714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Useppa Oyster Bar	26.6513	-82.2134	7	0	0	1	3	0	0	0	2	0	0	70	106	1	0	190
White Pelican Island	26.7905	-82.2463	9	0	0	29	28	3	0	0	0	0	0	0	2	0	0	71
Total			**133**	**172**	**13**	**226**	**271**	**18**	**63**	**6**	**115**	**20**	**262**	**540**	**904**	**36**	**10**	**2,789**

Species Summaries – Diving Birds

DCCO nesting peaked at 904 nests, which is approximately 32% of the total nests in the 2023 season. This was a record setting peak nest count for DCCO and a 40% increase from 645 peak nests documented in 2022. Nesting was documented on 26 islands, with the highest nest count of 167 occurring on Broken Islands in May.

BRPE nesting peaked at 540 nests on 11 islands accounting for approximately 19% of the nesting effort documented this season. This was very similar to the BRPE nest count of 551 in 2022. The highest peak nest count occurred in May on Broken Islands with 159 nests.

ANHI nesting peaked at 36 nests, which was 56% increase from the 2022 peak count of 23. The highest nest count observed occurred on Broken Islands and Fish Hut Island with a peak nest count of 5.

Species Summaries – Wading Birds

GBHE nesting efforts were documented on 24 of the 33 active islands. The peak nest count for GBHE was 133. This was a 43% increase from last year's peak nesting effort of 93. Hemp Key had the largest number of peak nests (16).

TRHE nests were documented on 16 islands with a peak nest count of 172. This was a 25% increase from last year's peak nest count of 137. The highest peak nesting effort occurred on Skimmer Island with a peak nest count of 43.

LBHE nesting peaked at 13 in 2023. This was one less nest from 2022 with a peak nest count of 14. Nests were documented on 4 islands with the highest peak nest count of 6 on Forked Creek Keys.

SNEG nesting occurred on 17 islands with a peak nest count of 226. This is a 128% increase from 2022 peak nest count of 99 and the highest recorded peak nest count documented since surveys began in 2008.

GREG nesting peaked at 271 and were documented nesting on 16 islands. This was a 110% increase from the peak nest count of 129 in 2022. The greatest GREG nesting effort was documented on Forked Creek Keys with a nest count of 44.

REEG were documented nesting on 9 islands with a peak nest count of 18. This was a slight decrease from 2022 with a peak nest count of 20. The highest nest count observed occurred on Hemp Key with a peak nest count of 4.

YCNH had a peak nest count of 6 in 2023 nesting season. This was a 57% decrease from 2022 peak nest count of 14. YCNH were only documented nesting on one island in 2023, Burnt Store Marina South.

BCNH nesting was documented on 17 islands and peaked at 115 nests. This was a 475% increase from the peak nest count of 20 in 2022. The highest peak nest count (n = 32) occurred on Tarpon Bay Keys. This is the highest peak nesting effort ever recorded during the study period.

GRHE nesting peaked at 20 and nesting activity occurred on 11 islands. This was a 186% increase from the peak nest count of 7 in 2023.

WHIB nesting occurred on 1 island (Broken Islands) with a peak count of 262; a 457% increase from the peak nest count of 47 in 2022. This extraordinary WHIB peak nesting effort could be attributed to the loss of foliage on Broken Island due to mangrove impacts from Hurricane Ian.

CAEG nesting peaked at 63 in 2023. This was a slight increase from the peak nest count of 60 in 2022. CAEG were documented nesting on 7 islands. The highest peak nesting effort (27 nests) occurred on Pirate Harbor Southeast.

ROSP were first documented in the study area in 2018. Since then, ROSP continue to be documented each year. The peak nesting effort (n = 10) occurred on four islands with the highest nest count of 7 on Oyster Creek West.

CONCLUSION

The 2023 nesting season produced record setting peak nesting effort for 7 species: TRHE, SNEG, GREG, BCNH, WHIB, GRHE, and DCCO (**Table 25**). The 2023 peak nesting effort was the highest recorded total peak nesting effort in a 10-year period (**Table 3**). For reference, the previous 10-year average peak nesting effort is 1,491 nests.

Part of this record setting year may be attributed to impacts from Hurricane Ian. On September 28, 2022, Hurricane Ian made landfall as a strong Category 4 on Cayo Costa Island. Every island within the survey area was affected by the storm ranging from mild, to severe damages. These damages include mangrove and other vegetation defoliation, uprooting of vegetation, broken limbs, and island erosion. Due to the catastrophic nature of the storm, many of the islands had different levels of impact from the storm. This is reflected in the 2023 nesting data collected. In some cases, nesting effort on certain islands greatly decreased or were abandoned as nesting sites altogether. In other cases, islands that were in recent years inactive were reutilized. Lastly, on some islands a significant increase in nesting activity was documented within the interior sections of an island. Some of this increase can be attributed to the loss of foliage, which lead to an enhanced ability to detect nesting activity of interior species such as WHIB, BCNH,

GRHE, SNEG, and TRHE. Although it should be noted, staff documented large increased nesting numbers for top canopy nesters as well (GREG, GBHE, DCCO, and ANHI).

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Roseate Spoonbill

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 DEP 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 36 islands, 22 of which were active this year.

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

The objectives of this program are as follows:

- 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 Estero Bay.
- Provide recommendations for the management of nesting wading and diving bird colonies in the EBAB.

METHODS

Surveys between 2008 and 2023 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 m away with a third person recording the data for each nest's species and stage (Audubon of Florida 2004). Staff of EBAP, CHAP, and FWC fulfilled the role of primary observer while volunteers filled the secondary observer and data recorder roles. The average of the two observers' counts were reported. Peak nest counts from 2022 and 2023 were compared with mean peak nest counts from 2008 through 2021, which represent a 14-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 Estero Bay.

2022 RESULTS

The peak nesting effort for wading and diving birds was 389 nests (**Table 25**). June marked the high if the EBAB nesting season, with 240 active nests. The Matanzas Pass colony, with an annual peak of 107 nests, supported the greatest number of nests in the bay. Overall, nesting effort decreased 11% from the 14-year average (**Table 26**). All species-specific increases or decreases in nesting effort are in comparison with the 14-year average unless noted otherwise.

DCCO nests were documented on 7 islands. Nesting activity peaked in June (56 nests). The annual peak count (79 nests) was 15% higher than the 14-year average.

BRPE nests were documented on 3 islands. Nesting activity peaked in May (52 nests). The annul peak nest count (53) decreased 56%.

GBHE nests were documented on 15 islands. The annual peak nest count (38) was 25% higher than the 14-year average.

GREG nests were documented on 4 islands. Nesting activity peaked in June (50 nests) and the annual peak was 56 nests, which represented a 1% increase in nesting effort.

SNEG nests were documented on 4 islands, with peak nest counts (18) in July. SNEG had an annual peak nest count of 25, which is a 14% decrease.

LBHE nests were documented on 2 islands, with peak nest counts in April and August (4 nests). The annual peak nest count (5 nests) represented a 59% decrease in nesting effort.

Table 25. Peak nest counts documented in Estero Bay Aquatic Preserve colonies, January through September 2022.[a]

Colony	Latitude	Longitude	DCCO	ANHI	BRPE	GBHE	GREG	SNEG	LBHE	TRHE	REEG	CAEG	BCNH	YCNH	GRHE	ROSP	WHIB	Total
Big Bird Island	26.382857	-81.84995	5			1										1		7
Big Carlos Pass between M-50&52	26.42244	-81.89527				1												1
Big Carlos Pass M-48	26.42771	-81.9005													2			2
Big Carlos Pass W of M-46	26.42926	-81.90137												1				1
Big Carlos Pass W of M-52	26.42469	-81.89359	3		27	4	21	2		8			14					79
Big Hickory E of M-85	26.35315	-81.84164	12		1	4					1		1			3		22
Coconut Point East	26.38411	-81.84905	8	1		2	15	7		5			7			2		47
Coconut Point West	26.38111	-81.84976				1												1
Chain of Islands	26.438025	-81.869374											1		7			8
Denegre Key	26.437716	-81.867283	10			5							2					17
Estero River M-30	26.430292	-81.861127													1			1
Estero River North	26.43653	-81.86091				1							1	1	1			4
Matanzas Pass	26.46092	-81.95717	30		25	14	2	5	4	13	5		7				2	107
New Pass M-21	26.38865	-81.85925				6												6
New Pass M-9	26.40465	-81.86816				3												3
North Coconut E of M-3	26.41131	-81.85486	11			3	18	11	1	14	1		9		4	3		75
North Coconut M-4 Monkey Joe Key	26.40737	-81.85998				1												1
Ruth's Island	26.40783152	-81.85302049				2									1			3
Taryn's Key	26.410692	-81.854117				1												1
Emily's Keys	26.45286	-81.86753													1			1
Flynn Island	26.410942	-81.852265													1			1
Oyster Island	26.415004	-81.855139													1			1
Big Bird Island	26.382857	-81.84995	5			1										1		7
Big Carlos Pass between M-50&52	26.42244	-81.89527				1												1
Big Carlos Pass M-48	26.42771	-81.9005													2			2
Total			**79**	**1**	**53**	**49**	**56**	**25**	**5**	**40**	**7**	**0**	**42**	**2**	**19**	**9**	**2**	**389**

a. Nests were not observed in the following colonies: 619038C, Big Carlos Pass M-43, 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 South, Houge Channel M-78, Hurricane Pass Rebecca's Island, Kelsey's Island, Little Davis Key, North Coconut M-2, and Taylor Island.

Table 26. Mean peak nest counts (2008–2021), standard error, standard deviation, current (2022) peak nest count, and percent mean difference by species.

Species	Mean (2008–2021)	Std Error	Std Dev	Peak (2022)	Percent Change	Percent Change 2021–2022
DCCO	69	5	16.8870	79	15	20
ANHI[a]	1	0	0.9574	1	-20	
BRPE	120	13	49.2763	53	-56	-18
GBHE	65	4	16.5412	49	-25	2
GREG	55	6	23.9372	56	1	8
SNEG	29	3	9.9264	25	-14	4
LBHE	12	2	6.6390	5	-59	150
TRHE	37	5	19.0263	40	8	122
REEG	8	1	2.7784	7	-15	-30
CAEG	1	0	1.6723	0	-100	
BCNH	15	3	9.5126	42	176	425
YCNH	17	2	8.7042	2	-88	
GRHE	7	1	4.4893	19	171	217
ROSP[b]	3	1	2.5100	9	246	29
WHIB[a]	3	1	3.1091	2	-20	100
Total	**438**	**26**	**95.6319**	**389**	**-11**	**27**

a. WHIB and ANHI compared to 2018-2020 data, not the 14-year average.
b. ROSP compared to 2017-2020 data, not the 14-year average.

TRHE nests were documented on 4 islands. Peak nesting effort occurred in August with 32 nests. The annual peak (40 nests) represented an 8% increase in nesting effort.

REEG nests were documented on 3 islands, with peak nesting effort in July (n = 7). The annual peak nest count (7) represents a 15% decrease in nesting effort.

BCNH nests were documented on 8 islands. Nesting activity peaked in September (34 nests). The annual peak (n = 42) shows 176% increase. YCNH nests were documented on 2 of the islands. Peak nesting was in July contributing to their annual peak nest count (2). This represents an 88% decrease in effort.

GRHE nests were documented on 9 islands. Nesting activity peaked in June (13 nests). The annual peak nest count (19) was 171% higher than the 14-year average.

CAEG nesting was not documented in Estero Bay in 2022. A 100% decrease in nesting effort.

ROSP nests were documented on 4 islands with peak nesting in May (6 nests). The annual peak nest count (9) was 246% higher compared to the 5-year average since ROSP nesting activity was first documented in 2017.

ANHI nesting was documented on 1 island, Coconut Point East. Nesting activity decreased 20% compared to the recent years average when ANHI were first observed nesting in 2018.

WHIB nesting activity peaked on Matanzas Pass in September with a peak nest count of 2. This was a 20% decrease compared to the 2018–2021 period.

This year's work was completed with the invaluable assistance from CHAP, FWC, and our Estero Bay volunteers. Staff and volunteers removed 443 ft of fishing line and 19 hooks from nesting islands and nearby locations between January and September. Large-scale island cleanups are conducted after nesting season to minimize disturbance to colonies. Twenty-two bird fatalities (4 BRPE, 2 DCCO, 2 TRHE, 1 GREG, 1 FICR, and 12 unknown) due to fishing line entanglement were documented.

2022 Discussion

Estero Bay nesting activity exhibits annual variation. The annual peak nest counts this season (389 nests) shows an 11% decrease from the 14-year annual peak average (438 nests), but an increase of 27% from 2021 nesting activity (**Figure 26**).

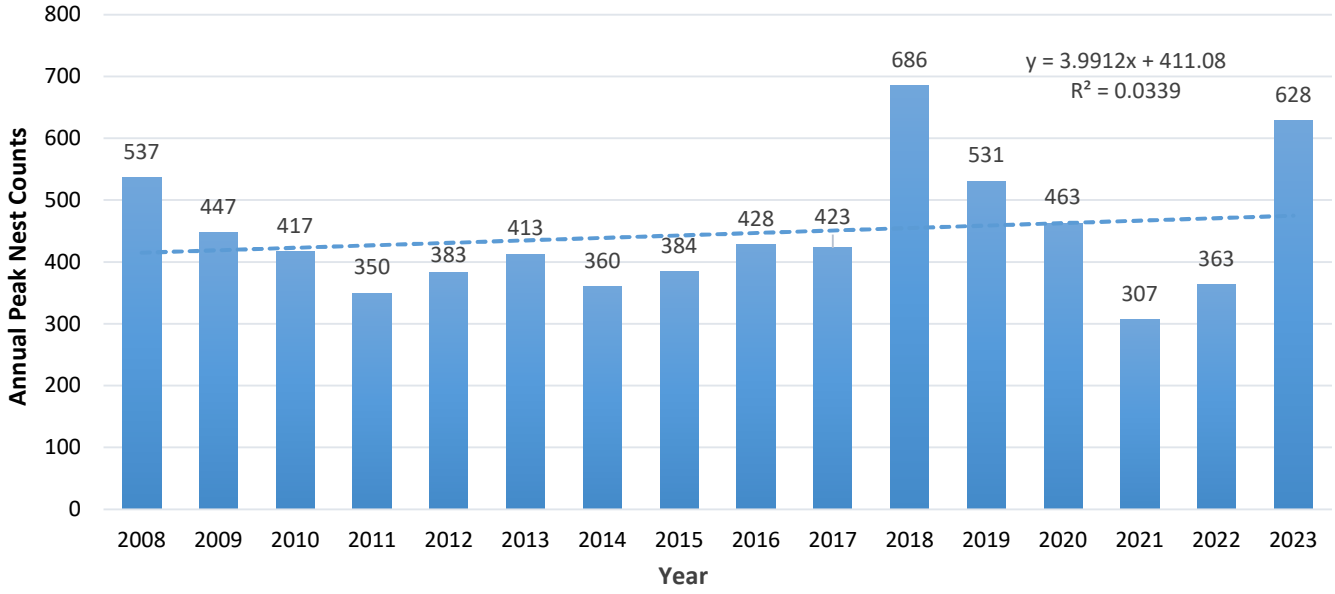

Figure 26. Annual peak nest counts in Estero Bay Aquatic Preserve from 2008 to 2023.

Five species (DCCO, GREG, TRHE, BCNH, and GRHE) showed improvements in nesting activity in 2022 compared to the 14-year average. ROSP nesting (9 nests) showed an increase from its previous years' average (7 nests) and since EBAP first documented nesting in 2017. Seven species (BRPE, GBHE, LBHE, CAEG, YCNH, SNEG, and REEG) showed a decline in nesting activity in 2022 compared to the 14-year average. ANHI and WHIB also showed a decline in nesting effort compared to data from the 2018–2021 period. One island, Coconut Point East, experienced a colony collapse around February, but was able to partially recover. Two new islands were added in June 2022, Oyster Island and Flynn Island, bringing the total number of islands monitored up to 36.

2023 RESULTS

The peak nesting effort for wading and diving birds in the 2023 nesting season was 628 nests (**Table 27** and **Figure 26**). Nesting peaked in May in Estero Bay with an estimated 362 active nests. The Matanzas Pass colony, with an annual peak of 194 nests, had the greatest nesting concentration in the bay. Overall, nesting effort increased 45% from the 15-year average (**Table 28**). All species-specific increases or decreases in nesting effort are in comparison with the 15-year average unless noted otherwise.

DCCO nests were documented on 6 islands; nesting activity peaked in March (79 nests). DCCO's annual peak for 2023 (132 nests) represents a 91% increase in effort.

BRPE nests were documented on 3 islands. Nesting peaked in May (135 nests) with an annual peak of 139 active nests—a 20% increase.

GBHE nests were documented on 12 islands. Nesting effort peaked in March (41 nests) with an annual peak of 50 nests—a 22% decrease.

GREG nests were documented on 6 islands. Nesting peaked in March (91 nests) and the annual peak was 98 nests, which represented a 77% increase in nesting effort.

SNEG nests were documented on 3 islands, with peak nest counts (35) in June. SNEG had an annual peak nest count of 35, which is a 22% increase.

LBHE nests were documented on 3 islands, with peak nest counts (3) in March and May. The annual peak nest count of 5 represented a 58% decrease in nesting effort.

TRHE nests were documented on 4 islands. Peak nesting effort occurred in June with 47 nests, which represented a 28% increase in nesting effort.

Table 27. Peak nest counts documented in Estero Bay Aquatic Preserve colonies, January through August 2023. a

Colony	Latitude	Longitude	DCCO	ANHI	BRPE	GBHE	GREG	SNEG	LBHE	TRHE	REEG	CAEG	BCNH	YCNH	GRHE	ROSP	WHIB	Total
Big Bird Island	26.382857	-81.84995	6				1											7
Big Carlos Pass between M-50&52	26.42244	-81.89527				2				5			6	1				14
Big Carlos Pass M-48	26.42771	-81.9005													1			1
Big Carlos Pass W of M-52	26.42469	-81.89359	7		29	3	16	5		6	1		17					84
Big Hickory E of M-85	26.35315	-81.84164	22			6	1		1		1		2			12		45
Blue Island	26.43589	-81.86483				1									2			3
Chain of Islands	26.438025	-81.869374													4			4
Coconut Point East	26.38411	-81.84905	32	4	52	3	48	19	1	16	2	1	14					192
Denegre Key	26.437716	-81.867283	18			11							10	1				40
Emily's Keys	26.45286	-81.86753													1			1
Estero River M-30	26.430292	-81.861127													2			2
Estero River North	26.43653	-81.86091				1								9	1			11
Estero River South	26.43416	-81.89211												2	1			3
Hurricane Pass/ Rebecca's Island	26.468118	-81.953516												2				2
Kelsey's Island	26.404983	-81.864494													1			1
Matanzas Pass	26.46092	-81.95717	47		58	11	31	11	3	20	6		7					194
New Pass M-21	26.38865	-81.85925				5												5
New Pass M-9	26.40465	-81.86816				3												3
North Coconut E of M-3	26.41131	-81.85486				3	1						5		4			13
North Coconut M-4 Monkey Joe Key	26.40737	-81.85998													1			1
Ruth's Island	26.40783152	-81.85302049													1			1
Taryn's Key	26.410692	-81.854117				1												1
Total					**132**	**4**	**139**	**50**	**98**	**35**	**5**	**47**	**10**	**1**	**61**	**15**	**19**	**12**

a. 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-46 & M-48, Big Hickory M-83 Seagrass Island, Big Hickory Pass M-49 2 NW, Big Hickory Pass M-49 3 NW, Coconut Point West, Flynn Island, Houge Channel M-78, Little Davis Key, North Coconut M-2, Oyster Island and Taylor Island.

Table 28. Mean peak nest counts (2008–2022), standard error, standard deviation, current (2023) peak nest count, and percent mean difference by species.

Species	Mean (2008–2022)	Std Error	Std Dev	Peak (2023)	Percent Change	Percent Change 2022–2023[a]
DCC0	69	4	16.4151	132	91	71
ANHI[b]	0	0	1.0000	4	1100	***
BRPE	116	13	50.5369	139	20	162
GBHE	64	4	16.4708	50	-22	2
GREG	55	6	23.0672	98	77	75
SNEG	29	2	9.6545	35	22	46
LBHE	12	2	7.0326	5	-58	0
TRHE	37	5	18.3506	47	28	38
REEG	8	1	2.6957	10	23	43
CAEG	1	0	1.6417	1	-12	***
BCNH	16	3	9.7429	61	280	118
YCNH	16	2	9.2309	15	-6	650
GRHE	8	1	5.3211	19	144	0
ROSP[c]	1	1	3.4448	12	718	33
WHIB[b]	1	1	2.9155	0	-100	***
Total	**433**	**24**	**94.1621**	**628**	**45**	**73**

a. *** indicates no yearly precent change to show because of 0 nests counted in 2022.
b. WHIB and ANHI compared to 2018–2023 data, not the 15-year average.
c. ROSP compared to 2017–2023 data, not the 14-year average.

REEG nests were documented on 4 islands, with peak nesting effort in June and July (n = 9). The annual peak nest count (10 nests) represents a 23% increase.

BCNH nests were documented on 7 islands, with peak nesting effort in July (n = 43). The annual peak (61 nests) shows a 280% increase.

YCNH nests were documented on 5 islands. Peak nesting was in April and May (n = 10) contributing to their annual peak count (15 nests). This represents a 6% decrease in effort overall but a 650% increase from 2022 nesting numbers.

GRHE nests were documented on 11 islands, with peak nesting effort in April and July (8 nests). The annual peak nest count (19) represents a 144% increase.

CAEG nesting was documented on 1 island with 1 nest. This represents a 12% decrease is nesting effort.

ROSP nests were documented on one island with peak nesting in February and April (12 nests). The annual peak nest count (12) represents a 718% increase in nesting compared to the 5-year average since ROSP nesting activity was first documented in 2017.

ANHI nesting was documented on 1 island, Coconut Point East. This represents a 1,100% increase in nesting efforts compared to the recent years average when Anhinga were first observed nesting in 2018.

WHIB nesting was not observed nesting in the bay. This led to a 100% decrease in nesting efforts compared to the 2018–2021 period nesting activity.

Staff and volunteers removed 188 ft of fishing line and 5 hooks from Estero Bay between January and August. Thirteen bird fatalities (10 BRPE, 1 GREG, and 1 unknown) due to fishing line entanglement were documented. The peak nesting effort for wading and diving birds was 628 nests (**Table 28**). Nesting peaked in May in Estero Bay with an estimated 362 active nests. The Matanzas Pass colony, with an annual peak of 194 nests, had the greatest nesting concentration in the bay. Overall, nesting effort increased 45% from the 15-year average (**Table 28**). All species-specific increases or decreases in nesting effort are in comparison with the 15-year average unless noted otherwise.

2023 Discussion

Estero Bay nesting activity exhibits annual variation. The annual peak nest counts this season (n = 628) shows a 45% increase from the 14-year annual peak average (433 nests) and an increase of 73% from 2022 nesting activity (**Table 28**). This dramatic increase in nesting may be partially a result of of Hurricane Ian passing on September 28, 2022. The large increase of some mid-canopy nesters like YCNH, BCNH, and GREG may be due to the visibility increase inside the depleted mangroves. However, canopy nesting birds DCCO and BRPE, which are easier to identify visually, also increased. The decline in local boating and fishing decreased disturbance overall.

Eight species (DCCO, BRPE, GREG, SNEG, TRHE, REEG, BCNH, and GRHE) showed improvements in nesting activity in 2023 compared to the 15-year average. ROSP nesting (12 nests) showed an increase from its previous years' average (9 nests) and since EBAP first documented nesting in 2017. Four species (GBHE, LBHE, CAEG, and YCNH) showed a decline in nesting activity in 2023 compared to the 15-year average. WHIB also showed a decline in nesting effort compared to data from the 2018–2021 period; however, ANHI showed a large increase in effort from when it was first documented in 2018. One new island was added in March 2023, Blue Island, bringing the total number of islands monitored up to 36.

ACKNOWLEDGEMENTS

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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 CERP Monitoring and Assessment Plan since 2005.

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 SFMWD's DBHYDRO database. The lake stage is calculated as the mean of four gages in the pelagic zone of Lake Okeechobee (L001, L005, L006, and LZ40). All elevation data are presented in NGVD 1929 and locations are in North American Datum of 1983 (NAD 1983). Stage data from 2008 represents the lake levels under the current Lake Okeechobee Regulation Schedule.

2022 RESULTS

See **Tables 29** and **30** for results.

Table 29. Geographic coordinates (NAD 83) and species-specific peak nest abundances in detected colonies during the 2022 breeding season at Lake Okeechobee.

Colony	Peak Month[a,b]	Latitude	Longitude	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	ANHI	Total[a]
Chance Bay	June	27.108117	-80.670867	--	--	--	--	--	--	--	--	--	403	--	**0**
Clewiston Spit	April	26.77573	-80.90938	138	--	194	--	17	2	--	47	2	--	--	**400**
Eagle Bay Island NE	June	27.17064003	-80.8464299	5	101	66	--	--	1	2	2	3	127	--	**180**
Eagle Bay Island S	May	27.179183	-80.837133	--	--	21	--	--	1	5	--	1	240	1	**28**
Gator Farm	May	27.0230043	-81.06110296	49	1	2	40	16	2	10	1	1	138	1	**122**
Gun Range	April	26.893205	-81.124513	32	--	--	--	--	1	--	--	--	70	8	**33**
Lakeport Marina	June	26.9726	-81.1144	107	--	8	--	--	--	--	2	--	442	--	**117**
Little Bear Beach	April	26.72139	-80.84222	51	344	180	--	--	--	1	68.5	1	--	--	**645.5**
Moore Haven NW	April	26.91117	-81.02514	115	442	103	--	5	2	--	8	2	76	4	**677**
Moore Haven East 1	March	26.88641245	-81.09643592	206	--	--	--	--	2	--	--	--	--	6	**208**
Pahokee Airport	May	26.77908	-80.697596	20	4	41	--	--	--	--	1	--	5	--	**66**

a. CAEG and ANHI were excluded from totals since they are not wetland wading birds.
b. Peak month refers to the month during which combined nest effort peaked and does not refer to species-specific peak nest efforts.

Table 30. Timing and nest numbers for species breeding in wading bird colonies at Lake Okeechobee in 2022.[a]

Month	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	AHNI	Peak Nest Effort[b]
March	**565**	106	394	34	14	**7**	4	**124**	--	0	8	1,338
April	451	**786**	453	**40**	**35**	7	--	27	3	338	4	1,802
May	199	246	**536**	30	29	3	**17**	16	4	837	**20**	1,080
June	29	184	157	32	4	--	2	5	5	**1236**	--	418

a. Bold values denote peak nest effort for species.

2023 RESULTS

Hydrology

Water levels during the 2023 nesting season, January 1–June 30, were similar to the 2016 nesting season with mean lake stage 14.99 ft in 2016 and 14.9 ft in 2023. Water conditions in 2023 were characterized by high lake stage, a moderate recession rate, and several 6 reversals (**Figure 27**) during the nesting season.

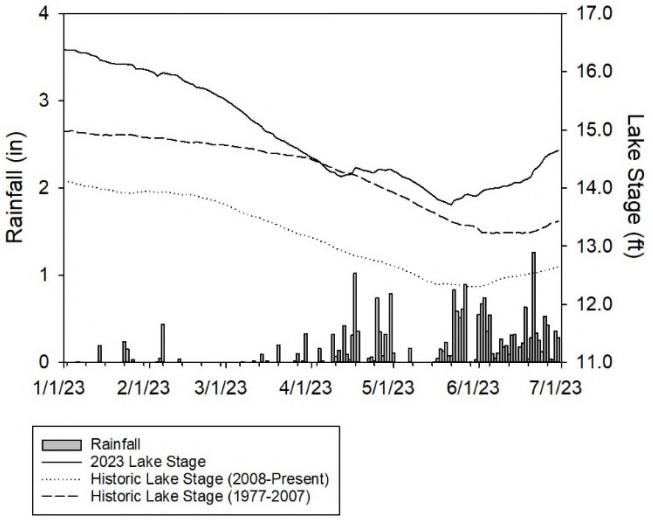

Figure 27. Hydrologic patterns on Lake Okeechobee from January-July 2023 and mean lake stage from the 1977–2007 period and from the 2008–2023 period, since the 2008 Lake Okeechobee Regulation Schedule was implemented.

On January 1, lake stage was at 16.38 ft. The lake receded at a mean rate of 0.01 inches per week (in/wk) from January 1 to February 4 before unseasonal rainfall caused the lake stage to increase from 15.93 ft on February 4 to of 15.98 ft on February 6. The lake receded at a mean rate of 0.03 in/wk from February 7 to April 12 when rainfall caused the lake stage to increase from 14.20 ft on April 12 to 14.35 ft on April 17. The lake receded at a rate of 0.01 in/wk from April 18 to April 23, when rainfall caused the lake stage to increase from 14.27 ft on April 23 to 14.32 ft on April 29. The lake receded at a rate of 0.03 in/wk from April 30 to May 22, when rainfall caused the lake stage to increase from the seasonal low lake stage of 13.72 ft on May 22 to 13.90 ft on May 28. After this, a few days of recession were followed by continuous increase in lake stage from June 1 to June 30, indicating the arrival of the wet season.

Recession were as follows:

- January 1–February 4: 0.01-inch decrease in stage per week
- February 7–April 12: 0.03-inch decrease in stage per week
- April 18–23: 0.01-inch decrease in stage per week
- April 30–May 22: 0.03-inch decrease in stage per week
- May 28–June 1

Reversals were as follows:

- February 5 to 6: 0.03-inch rise in stage per day
- April 13 to 17: 0.03-inch rise in stage per day
- April 24 to 29: 0.01-inch rise in stage per day
- May 23 to 28: 0.03-inch rise in stage per day
- June 1 to 14: 0.02-inch rise in stage per day
- June 17 to 30: 0.04-inch rise in stage per day

Colony Location and Size

Twelve colonies (**Figure 28**) supporting 1,745 GREG, SNEG, and WHIB nests were detected, which is 43.6% lower than the average from the 2008–2023 period, which is 3,096 nests ± 1,901 nests SD. Colonies were detected at 3 created spoil islands (Little Bear Beach, Clewiston Spit, and Pahokee Airport), 7 natural willow islands in the marsh (Eagle Bay Island, Clewiston Marsh, Moore Haven East 1, Moore Haven West 1 Moonshine Bay 1, Moonshine Bay 3, and Moonshine Bay 4), and 3 off-lake, created islands (Lakeport Marina, Gator Farm, and Gun Range). Eagle Bay was the largest colony, supporting 470 GREG, SNEG, and WHIB nests (**Table 31**).

During wet years like 2023, wading birds nest in short hydroperiod colonies more frequently than dry years because colonies are surrounded by water making them inaccessible to mammalian predators and decreasing the travel distance to suitable foraging habitat in the marsh. Willow ridge colonies that are surrounded by long hydroperiod marsh, such as Eagle Bay, are an exception because they remain inundated and are closer to suitable foraging habitat at the western edge of the littoral zone during dry years.

Table 31. Geographic coordinates (NAD 83) and species-specific peak nest abundances in detected colonies during the 2023 breeding season at Lake Okeechobee.

Colony	Peak Month [a]	Latitude	Longitude	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	ANHI	Total[b]
Clewiston Spit	February	26.77573	-80.90938	178	13	105	--	5	3	8	99	26	2	--	437
Eagle Bay Island	March	27.179183	-80.837133	25	204	241	--	--	1	48	144	102	228	10	765
Gator Farm	February	27.022778	-81.060833	109	26	37	58	10	1	10	8	15	292	12	274
Gun Range	March	26.893252	-81.124557	23	--	--	--	--	1	--	--	--	129	29	24
Lakeport Marina	March	26.97336	-81.11562	134	--	78	--	--	--	--	13	--	410	8	225
Little Bear Beach	April	26.721389	-80.842222	99	178	157	--	--	1	18	64	41	13	--	558
Moonshine Bay 1	April	26.91327	-81.02416	2	--	--	--	--	5	--	--	--	--	--	7
Moonshine Bay 3	April	26.92755	-81.03479	2	--	--	--	--	2	--	--	--	--	--	4
Moore Haven NW	March	26.9511	-81.00739	130	2	111	--	2	7	25	99	2	24	8	378
Moore Haven West 1	April	26.898056	-81.088333	22	--	18	--	--	--	--	--	--	--	--	40
Moore Haven East 5	March	26.86221	-81.006862	109	--	12	--	--	2	--	--	--	--	5	123
Pahokee Airport	March	26.77908	-80.6976	18	74	136	--	--	--	58	116	12	111	2	414

a. Peak month refers to the month during which combined nest effort peaked and does not refer to species-specific peak nest efforts.
b. CAEG and ANHI were excluded from totals since they are not wetland wading birds.

Colonies built on created spoil islands and off-lake colonies are typically active every year, likely because high water levels are rarely sustained long enough to destroy nest substrate. Spoil island colonies have supported 27% of on-lake nests in dry years (mean lake stage < 12.9 ft), 29% in moderate years (13.0 to 14.0 ft), and 22% in wet years (> 14.1 ft) since 2008. Variation in nest abundance in 2023 is slightly higher in spoil island colonies (coefficient of variation at spoil island colonies = 79%) than marsh colonies (2008–2023 mean coefficient of variation at natural colonies = 78%), which is abnormal because the small size of created colonies limits total nest numbers, usually resulting in lower annual productivity in spoil island colonies (Chastant et al. 2017). Nevertheless, spoil island colonies continue to be an important contributor to the lake's wading bird numbers, providing the only suitable nesting substrate during some years.

Timing and Success

The median clutch initiation date for GREG (March 15 ± 4.24 days) was the same as the average since 2009 (March 15). Median clutch initiation date for SNEG (March 24 ± 21.7 days) was 3 days later than the average since 2009 (March 21) and median clutch initiation for TRHE (March 13 ± 19.1 days) was 12 days earlier than the average since 2009 (March 25). Median clutch initiation date for WHIB (April 27 ± 24.2 days) was 19 days later than the average since 2009 (April 6). Peak nest numbers were observed in March, April, March, and June for GREG, SNEG, TRHE and WHIB, respectively (**Table 32**).

Nest initiations for SNEG, TRHE, and WHIB peaked between March 9 and April 7, which coincides with the first prolonged water recession (**Figure 28**). Due to the small sample size of GREG nests (n = 4), each with varying estimated clutch initiation dates, a peak nest initiation could not be calculated. There has been no apparent relationship observed between the timing of nest initiations and overall nest survival of focal species, but the temporal pattern of nest initiation by species is consistent with previous years at the lake and in other regions, with GREG initiating nests earlier than SMHE (Ogden 1994, Smith and Collopy 1995, Klassen et al. 2016).

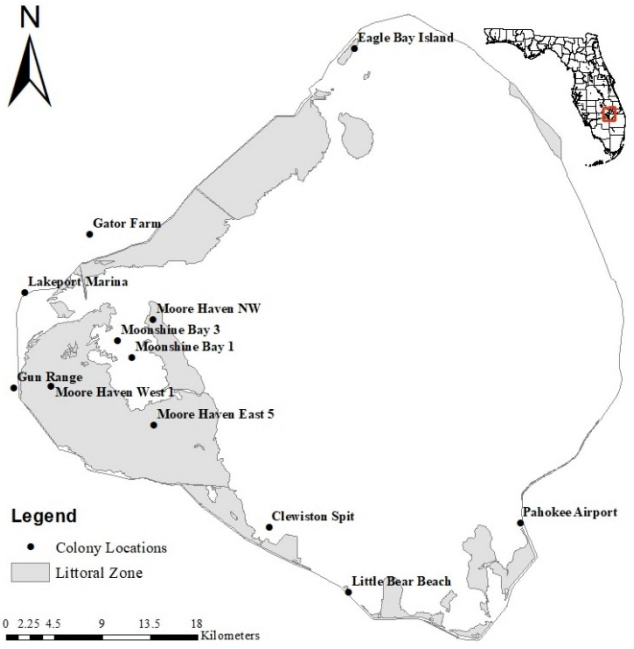

Figure 28. Map of wading bird colonies detected on Lake Okeechobee from February through June 2023.

Table 32. Timing and nest numbers for species breeding in wading bird colonies at Lake Okeechobee in 2023.[a]

Month	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	AHNI	Peak Nest Effort[b]
February	500	6	306	**58**	0	5	0	166	0	0	**12**	1,041
March	**703**	85	576	56	14	**14**	**126**	**525**	47	0	52	2,146
April	266	300	**637**	46	**16**	10	59	256	**144**	516	55	1,734
May	155	350	394	33	4	3	40	250	109	921	32	1,338
June	37	**405**	198	23	0	1	43	183	110	**1433**	10	1,000

a. Bold Values denote peak nest effort for species.

We estimated nest survival (proportion of nests that fledge at least one nestling) using logistic exposure models to account for biases resulting from variation in the initial nest ages at monitored nests (Shaffer 2004). Generalized linear models were fitted with a loglink distribution function. The model estimates daily survival rate (DSR), which can be converted to overall survival rate (DSR interval length). We developed separate models for the incubation and nestling periods because there were clear differences in nest survival rates between the two. Interval lengths were 21 days during the incubation period for SMHE and 26 days for GREG (Parsons and Master 2000, McCrimmon et al. 2011) during the nestling period; interval lengths were 14 days for all species. Nest survival for GREG in 2023 was 1.0 (n = 4), which is 33% higher than the overall survival since 2013 (0.65 ± 0.14; n = 566). Nest survival for SMHE in 2023 was 0.36 (incubating SMHE, n = 226; fledgling TRHE, n = 52; and fledgling SNEG, n = 73, which is 45% lower than the overall survival rate since 2013 (0.66 ± 0.13; n = 3,301). Nest survival for WHIB in 2023 was 0.37 (n = 52), which is 43% lower than the overall nest survival since 2013 (0.65 ± 0.16; n = 581).

Wood Storks and Roseate Spoonbills

Fifty-eight WOST nests and 10 ROSP nests were detected at Gator Farm, an off-lake colony located north of the Fisheating Bay area (**Figure 28**). Five ROSP nests were also detected at Clewiston Spit and 2 ROSP nests were detected at Moonshine Bay. This is the second time since 2015 that ROSP have been observed nesting in on-lake colonies, and nests at Clewiston Spit and Moonshine Bay were successful. From the detected nests, we counted 14 WOST fledglings in photos taken during the aerial survey on June 7 and 11 ROSP fledglings in photos taken during the aerial survey on May 12. WOST have nested at the Gator Farm in 12 of the last 17 years (2007–2010 and 2016–2023) and have successfully fledged chicks every year nesting has occurred. ROSP have nested at natural and anthropogenic colonies since 2009 and every consecutive year since 2015 (**Table 32**).

In 2023, three focal species, GREG, SNEG, and WHIB, initiated an estimated 1,745 nests, which is 43.6% lower than the average since 2008 when the current lake schedule went into effect. GREG nest abundance was estimated to be roughly the same (< 1% higher), while SNEG and WHIB nest abundance were 51 and 63% lower than the average since 2008, respectively. Nesting was observed on marsh, spoil island, and off-lake colonies due to wet conditions in the littoral zone. The Eagle Bay Island (765 nests) and Little Bear Beach (558 nests) colonies, a marsh and a spoil island and off-lake colony respectively, supported the largest number of nests of these species.

ACKNOWLEDGEMENTS

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SAVANNAS PRESERVE STATE PARK

The Savannas Preserve State Park (SVSP) 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 southeastern 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 2022 and 2023, Florida State Park staff surveyed a historic wading bird rookery at SVSP. This rookery, along with two others to the south were originally surveyed between 1995 and 2003 by SFWMD.

SVSP basin marsh hydrological conditions are driven primarily by annual rainfall patterns, but also are influenced by local runoff. In 2022, basin marsh levels remained low throughout the breeding season and in 2023 it remained medium/average.

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 kayak along the island's western and southern edge.

2022 RESULTS

Nest numbers in were lower than numbers observed in 2020 and 2021. Due to vacancies of both observing staff positions, two months are missing from the typical survey timeframe. This site was surveyed February, March, June, and July. The 2022 nest counts for the North Marsh Rookery are provided in **Table 33**.

2023 RESULTS

Nest numbers were the same as numbers observed in 2022 and lower than numbers observed 2021. Due to weather conditions, the months of April and July have no survey data. This site was surveyed February, March, May, and June. The 2023 nest counts for the North Marsh Rookery are provided in **Table 33**.

Table 33. Peak nest counts at Savannas Preserve State Park from 2018 to 2023.

Year	Colony	Latitude	Longitude	GREG	CAEG	SNEG	GBHE	LBHE	BCNH	TRHE	WHIB	GLIB	ANHI	Total
2018	North Marsh Rookery	27.3117	-80.2713	7	0	3	10	5	1	0	1	5	17	**49**
2019	North Marsh Rookery	27.3117	-80.2713	6	8	0	12	3	0	0	0	0	14	**43**
2020	North Marsh Rookery	27.3117	-80.2713	24	13	10	9	6	2	0	26	37	29	**156**
2021	North Marsh Rookery	27.3117	-80.2713	17	11	9	12	7	0	7	3	22	53	**141**
2022	North Marsh Rookery	27.3117	-80.2713	9	5	0	4	0	0	1	18	12	5	**54**
2023	North Marsh Rookery	27.3117	-80.2713	5	2	1	4	0	0	0	22	16	4	**54**
Total				**68**	**39**	**23**	**51**	**21**	**3**	**8**	**70**	**92**	**122**	**497**

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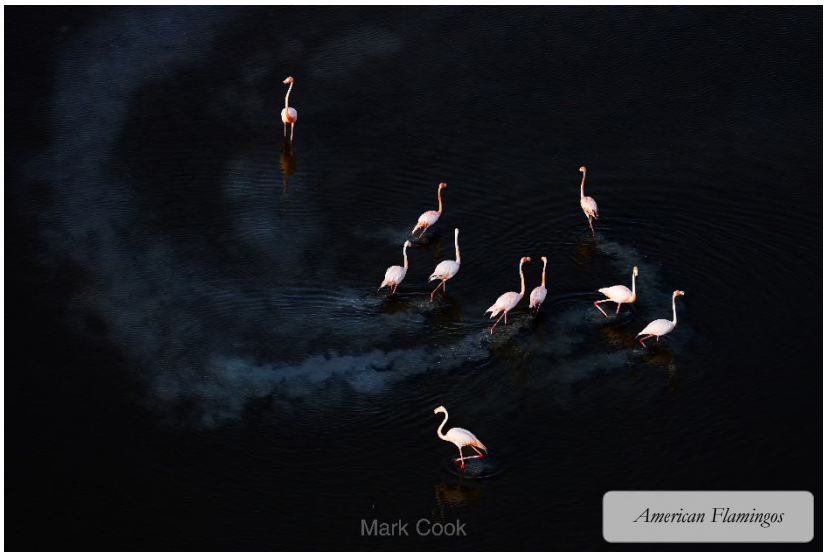


KISSIMMEE BASIN

WADING BIRD NESTING

Birds are integral to the Kissimmee River-floodplain ecosystem and highly valued by the public. 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 supported an abundant and diverse bird assemblage with several recurring breeding colonies of greater than 1,000 nests (National Audubon Society, 1936–1959; FGFWFC, 1957). The Kissimmee River Restoration Project (KRRP) is expected to reproduce the necessary conditions to support such an assemblage once again.

Construction for the KRRP was completed in July 2021, an historic milestone that sets the stage for implementation of the new Headwaters Revitalization Schedule (HRS), which controls operations at the S-65 and S-65A water control structures at the outlets of the Headwaters Lakes and Pool A, respectively (**Figure 29**). With completion of the construction phase of the restoration project, over 24,000 acres of wetland habitat are now receiving partial inundation, and at least 1 of the interim response of foraging wading birds has exceeded the restoration expectation when averaged over the Interim Period (2001–2021) (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 well below historic levels (Williams et. al. 2005a, Cheek 2016).

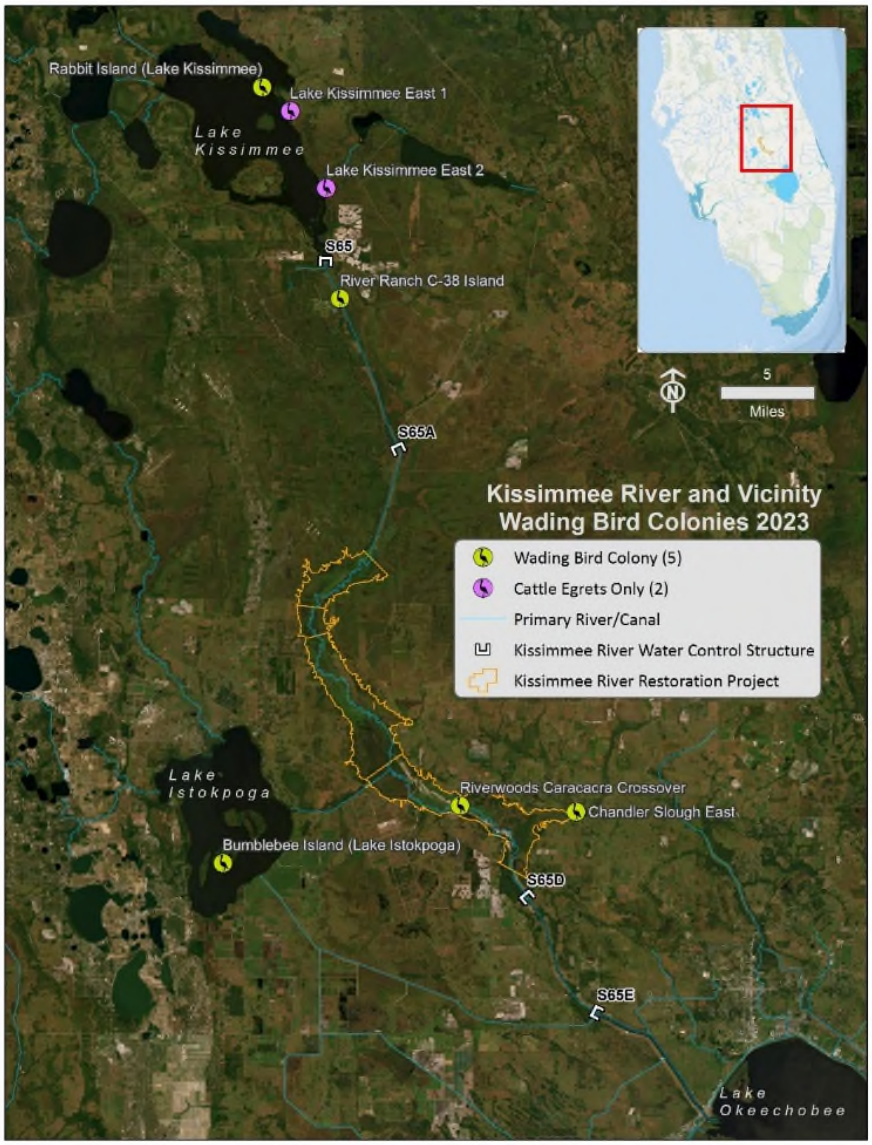


Figure 29. Nesting colony locations in Lake Kissimmee, Lake Istokpoga, and within the Kissimmee River Restoration Project Area during 2023.

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

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).

Methods

As part of the KRREP, SFWMD staff performed aerial surveys during the dry season to survey Lake Kissimmee, Kissimmee River, and Lake Istokpoga for known wading bird colonies and the vicinity for potential new nesting locations. Upon arrival at each colony or potential nesting assemblage, the principal observer recorded nesting species and the number of active nests from a height of approximately 300 ft 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 observed nests for each species. This is particularly pertinent for the small, dark-colored wading birds, such as LBHE, glossy ibis (GLIB), TRHE, YCNH, and BCNH that are not as easily detectable (Frederick et al. 1996). Thus, the colony totals are considered conservative. Nest fate and nesting success were not monitored.

2022 and 2023 Results

SFWMD performed three aerial surveys on March 12, April 21, and May 15, 2023, to visit wetlands, islands, and floodplains within Lake Kissimmee, along the Kissimmee River, and Lake Istokpoga to visit known colonies as well as assess for potential new nesting locations within the vicinity. In additions, the Riverwoods Caracara Crossover Colony was able to be visited by airboat to verify species and activity. The prior 2022-2023 wet season was accentuated with Hurricane Ian in late September and Hurricane Nicole in early November, which produced most of the rainfall (116 and 106% in Upper and Lower Kissimmee basins for the wet season, respectively) and substantial increases in S-65A discharge. This was then followed by below average rainfall during the dry season (69 and 71% in Upper and Lower Kissimmee basins, respectively). These conditions may have helped to improve foraging conditions for wading birds (see the *Wading Bird Foraging and Abundance* section below) as well as allow potential nesting habitat to still be inundated later into the wet season; this may have aided in a new location detected on the Kissimmee River between Riverwoods and Caracara Run. In addition, commonly active sites Rabbit Island (Lake Kissimmee), River Ranch C-38 Island, Chandler Slough East (Kissimmee River), and Bumblebee Island (Lake Istokpoga) had activity (**Table 34** and **Figure 29**). Two locations along the eastern shore of Lake Kissimmee were also discovered, but these only consisted of CAEG.

Nests of aquatic dependent species on Rabbit Island in Lake Kissimmee were comprised of GREG (70), WHIB (100), and GBHE (4). The River Ranch C-38 colony contained 15 GREG nests and one GBHE nest. The Chandler Slough East colony had 15 GREG nests and 2 GRBH nests. Bumblebee Island in Lake Istokpoga contained an exceptionally large number of WHIB nests this season (1,400), along with GREG (120), and small white herons (SMWH; 500). Riverwoods Caracara Crossover peaked at 20 small dark herons (SMDH) and 25 SMWH. These were verified by airboat to be LBHE and SNEG, respectively, with CAEG starting to dominate this colony later into June.

Table 34. Peak (maximum) number of wading bird nests within the Kissimmee River Restoration Project Area, Lake Kissimmee, and Lake Istokpoga surveyed March-May 2023.

2023 Colony Name	Latitude	Longitude	CAEG	GREG	WHIB	GBHE	SMDH	GLIB	BCNH	SMWH	WOST	ROSP	Total Nests	Nests of Aquatic Species
Rabbit Island (Lake Kissimmee)	27.938577	-81.253142	240	70	100	4							414	174
Lake Kissimme East 1	27.920101	-81.228564	600										600	0
Lake Kissimmee East 2	27.860795	-81.197460	150										150	0
River Ranch C-38 Island	27.385082	-81.081226		15		2				35			52	52
Riverwoods Caracara Crossover	27.775581	-81.185435	30				20			25			75	45
Chandler Slough East	27.380323	-80.981183		13									13	13
Bumblebee Island (Lake Istokpoga)	27.340636	-81.285422	400	120	1400					500			2420	2020
Total			**1420**	**218**	**1500**	**6**	**20**			**560**			**3724**	**2304**

Most nesting of aquatic wading bird species and CAEG continues to occur outside of the KRRP area on islands in the Upper Kissimmee Basin and Lake Istokpoga. Previously, only two colonies of aquatic bird species, S-65C Boat Ramp (extant) and Chandler Slough East, have formed within 10 kilometers (km) of the partially restored portion of the Kissimmee River, but it is encouraging to see a new colony formed on an island off the main river channel. However, the continued small numbers of aquatic species nesting along the restored portion of the river suggests that prey availability on the floodplain may not yet sufficiently support the completion of breeding for these wetland-dependent birds. Interestingly, prey availability sampling on the floodplain during the Interim Period does indicate 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–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 for optimal rookery formation will be dependent on operational constraints and other demands on water management. Full HRS implementation by 2026 will allow water managers to better mimic the historical stage and discharge characteristics of the river more closely, presumably leading to increased suitable hydrologic conditions for wading bird nesting colonies. Survey efforts next season will focus primarily within 10 km of the KRRP area and Lakes Kissimmee and Istokpoga.

Mixed Wading Bird flock forging on the Kissimmee River Floodplain

Two colonies, Chandler Slough East and Riverwoods Caracara Crossover, occurred within 10 km 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 (**Figure 29**). The Bumblebee Island colony is approximately15 km away from the KRRP 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 and 23 km, respectively) are too far to the north of the KRRP area for regular foraging by nesting species there. Based on previous 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 KRRP area for foraging this breeding season, although to what extent breeding wading birds utilize the river floodplain is still under investigation.

FUTURE PLANS

Surveys will continue 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 on the South Marsh Rookery between February and June 2024. Habitat improvement efforts, including invasive plant management, prescribed burning, and tussock/floating island management will take place on the basin marsh prior to the 2024 breeding season.

WADING BIRD FORAGING AND ABUNDANCE

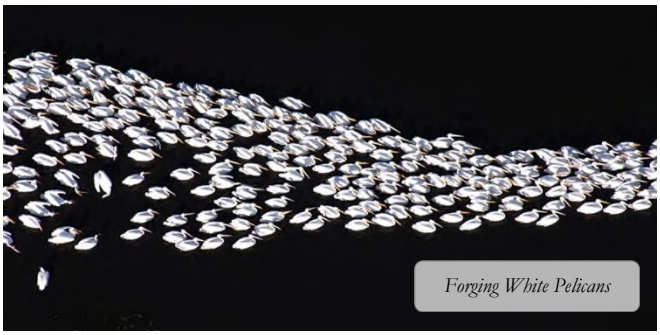
As part of the KRREP, the following restoration expectation was developed for the abundance of foraging wading birds on the floodplain post construction:

[a] Mean annual dry season density of long-legged wading birds (excluding CAEG) on the restored floodplain will be ≥ 30.6 birds per square kilometer or birds/km^2 (3-year running average) and

[b] at least 85% of the monthly surveys will have ≥ 30.6 birds/km^2 (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).

Kissimmee River and Floodplain



Forging White Pelicans

Methods

East-west aerial transects (n = 218) were established at 200-m intervals beginning at the S-65 structure and ending at the S-65D structure (**Figure 29**). 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 per hour. 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" or SMDH. Likewise, SNEG and immature LBHE were classified as "small white herons" or SMWH.

2022 and 2023 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 (± standard error or 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 2002–2021 = 39.0 ± 3.0 birds/km²; (**Figures 30** and **31**). The long-term annual three-year running mean (2002–2023) is 41.4 ± 3.2 birds/km², significantly greater than the restoration expectation of 30.6 birds/km² (t-test, $p < 0.002$, Williams and Melvin 2005). Annual three-year running means have been significantly greater than the restoration expectation of 30.6 birds/km² in only 6 3-year periods during the past 19 years of the 2002–2022 survey period. These were 2002–2004, 2003–2005, 2004–2006, 2005–2007, 2018–2020, and the current period of 2021–2023.

Mean monthly wading bird abundance within the restored portions of the river during the 2022–2023 dry season was 100.3 ± 21.9 birds/km²), bringing the three-year (2021–2023) running average to 54.0 ± 11.5 birds/km², significantly greater than the component (a) restoration expectation of 30.6 birds/km² (t-test, $p = 0.03$, **Figure 31**). Five of six surveys (83%) in the 2022-2023 dry season recorded ≥ 30.6 birds/km², just below the restoration expectation of at least 85%. Unfortunately, no data were collected in November to have 7 total surveys since the flight was not able to be completed.

After an above average wet season, well above average numbers of wading birds were observed during most of the season following a steady recession of water levels on the floodplain after high inundation the previous wet season that led to optimal foraging conditions. Water levels continued to decline through the May survey, by which time wading bird numbers had declined by approximately 90% from their peak in March, with floodplain water depths averaging approximately 0.1 ft (**Figure 32**). During the May survey, only very few ponded pools remained, which likely had already been depleted of prey by this point. However, bird numbers remained above average for most prior dry season surveys, as water levels did not see any ecologically significant reversals (water level increases) of > 0.25 ft on the floodplain (**Figure 32**). Without such reversals during the dry season and a sustained wet season, a steady drydown will typically increase prey availability for wading birds by concentrating prey items into shallower depths within an overall smaller surface area of inundation, although under some circumstances excessive access to prey can result in prey depletion.

As in previous years, WHIB dominated the surveys numerically (7,624, 65.1%), followed in order of abundance by SMWH (SNEG and juvenile LBHE; 1511, 13.5%), GREG (1,357, 11.6%), GLIB (514, 4.4%), GBHE (198, 1.7%), ROSP (144, 1.2%), SMDH (TRHE and adult LBHE; 171, 1.4%), WOST (107, 0.9%), and BCNH and YCNH (21, 0.2%).

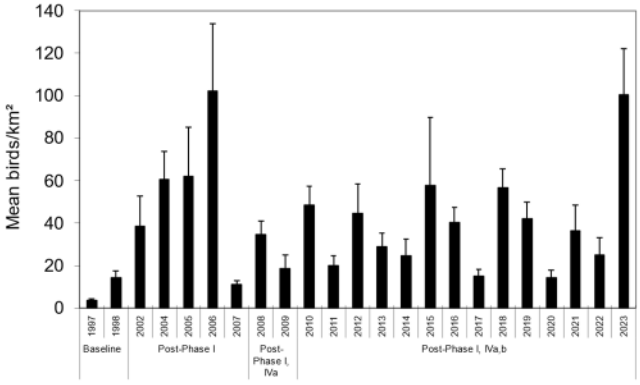


Figure 30. Baseline and post-Phases I, IVA, and IVB mean abundance ± SE of long-legged wading birds/km², excluding cattle egrets, during the dry season (December–May) within the 100-year flood line of the Kissimmee River.

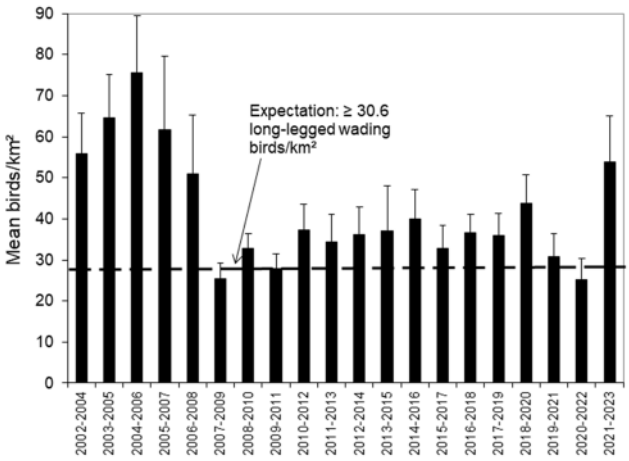


Figure 31. Post-restoration abundance as 3-year running averages ± SE of long-legged wading birds/km², excluding cattle egrets, during the dry season (December–May) within the Phase I, IVA, and IVB restoration areas.

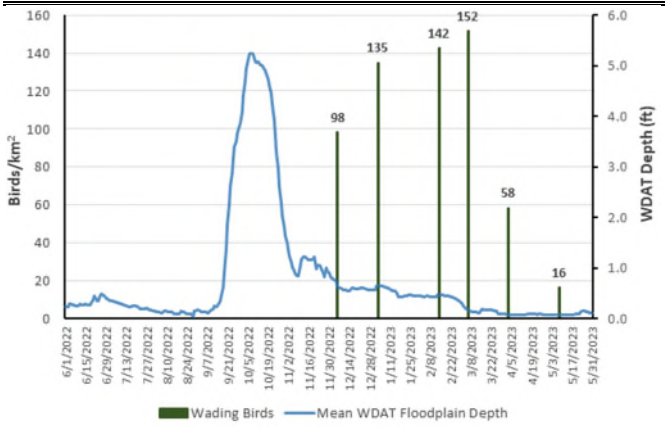


Figure 32. Wading bird abundance versus mean floodplain depth in the KRRP area (Phases I, IVA, and IVB) during the 2022-2023 dry season (December- May, November survey was unable to be completed in PW2023). Floodplain depth is obtained from the South Florida Water Depth Assessment Tool (WDAT; Godin 2012).

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SOUTH FLORIDA VARIOUS LOCATIONS

METHODS

FWC staff and volunteers conducted nest counts at seven wading bird colonies throughout FWC's south region in 2023.

Bird Island CWA (27.190821, -80.187908) is a spoil island next to Sewalls' Point, Martin County 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. Counts are conducted from a boat circling the island, and it is certain that some interior nests are not counted.

BallenIsles (26.830148, -80.109158) is a small island located on a lake within the BallenIsles Country Club golf course in Palm Beach Gardens, Palm Beach County. Counts are conducted on foot from vantage points on the north and south sides of the golf course**.** Counts were conducted every month throughout the breeding season.

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. Counts are done by boat, and it is certain that some interior nests are not counted. In 2022, not all species present were recorded. In 2023, there were 12 different species present during these surveys with nearly 700 WOST adults present in March and over 300 WOST chicks counted in April. Survey efforts were focused on WOST and state listed species.

Wakodahatchee Wetlands (26.479889, -80.142326) is a manmade wetland in Boynton Beach, Palm Beach County, 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, Broward County. The 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.

ABC Islands CWA (25.063633, -80.366492) encompasses three spoil islands on the eastern side of Marco Island, Collier County. 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. Counts were conducted by boat circling each island, and it is certain that some interior nests were not counted.

RESULTS

In 2022, WOST nest numbers were lower than in 2021 at all but one colony and productivity was lower at all colonies where this species was present. There were fewer ROSP nests overall this season than in 2021 although trends differed between colonies. Wakodahatchee Wetlands and the Solid Waste Authority of Palm Beach County were the most diverse colonies surveyed by FWC in this region with fourteen species observed at Wakodahatchee and thirteen species recorded at the Solid Waste Authority throughout the breeding season. Eleven species were confirmed to be nesting at both colonies. The Solid Waste Authority had the highest number of WOST nests with peak chick counts reaching approximately 180 in mid-May. Wakodahatchee had the second highest number of WOST nests of any colony.

Table 35 presents data for the 2022 season. **Table 36** presents data from the 2023 season.

Table 35. Peak numbers of nests at various locations from January to June 2022

Colony	ANHI	BCNH	CAEG	DCCO	GBHE	GLIB	GREG	GRHE	GWHE	LBHE	ROSP	REEG	SNEG	TRHE	WHIB	WOST
Bird Island CWA	*	*	3	8	*	0	30	0	0	*	14	*	3	0	0	57
BallenIsles	5	*	0	28	*	0	7	*	0	0	0	0	*	5	0	24
Solid Waste Authority	+	3	+	0	*	4	35	*	0	1	32	0	10	32	234	194
Wakodahatchee Wetlands	+	*	32 ^	+	14	2	37	1	0	1	*	0	1	15	*	119
Sawgrass Ford	9 ^	*	*	17 ^	0	0	44	*	0	0	0	0	0	5	*	105
Griffin	5 ^	*	0	36 ^	*	0	*	0	0	*	0	0	*	40	+	56
ABC Islands CWA	3	2	*	17	8	0	21	*	*	*	0	2	2	4	*	0
Total	**22**	**5**	**35**	**106**	**22**	**6**	**174**	**1**	**0**	**2**	**46**	**2**	**16**	**101**	**234**	**555**

* Species observed onsite but no nests were recorded. 0 value indicates that species were not observed at this site.
+ Species present but nests were not counted.
^ Nest numbers only counted through March.

Table 36. Peak numbers of nests from January to June 2023

Colony	ANHI	BCNH	CAEG	DCCO	GBHE	GLIB	GREG	GRHE	GWHE	LBHE	ROSP	REEG	SNEG	TRHE	WHIB	WOST
Bird Island CWA	*	*	*	14	*	0	41	0	*	14	3	0	41	115	214	*
BallenIsles	*	*	*	31	1	0	15	0	0	*	4	1	*	31	52	*
Solid Waste Authority	0	1	*	0	*	4	47	0	3	23	13	24	*	245	360	0
Wakodahatchee Wetlands	10	2	*	1	12	13	31	0	4	0	*	15	0	156	233	10
Sawgrass Ford	0	*	*	8	0	*	2	0	*	0	0	2	0	31	35	0
Griffin	0	0	0	32	0	*	0	0	*	0	0	4	*	48	52	0
ABC Islands CWA	4	1	*	21	15	0	38	1	0	0	7	3	*	0	65	4
Total	14	4	0	107	28	17	174	1	7	37	27	49	41	626		14

* Denotes that species were observed onsite but no nest were recorded. A "0" value indicates that species were not observed at this site.

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PALM BEACH COUNTY NATURAL AREAS

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Staff at Palm Beach County's Department of Environmental Resources Management surveyed for evidence of wading bird breeding activity at four previously used colonies within county natural areas. Surveys were mainly focused between January and May in 2022 and 2023. Only the Northeast Loxahatchee Slough and Central Loxahatchee Slough colonies were used during these two breeding seasons.

METHODS

Staff used flight line surveys, food deliveries, and one reconnaissance visit to time their survey with peak nesting efforts. Within each colony, there were some nests at which the chicks were too young to identify, and adults were not observed during the limited survey time. These nests were recorded as *Egretta* sp. (EGSP).

The Northeast Loxahatchee Slough Colony was visited by staff on May 2, 2022, and April 18, 2023. 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 from multiple vantage points encircling the colony to ensure adequate 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 18, 2022, and May 2, 2023, staff counted nests via kayak.

RESULTS

Nest count data (**Table 37**) from each colony for the 2022 and 2023 breeding season is conservative due to nest density and the need to minimize disturbance.

White Ibis in Mangroves on the Loxahatchee River

Table 37. The 2022 and 2023 peak number of wading bird nests by species observed in the Loxahatchee Slough Natural Area.

Colony	Latitude	Longitude	CAEG	LBHE	TRHE	BCNH	YCNH	SNEG	EGSP	Total
2022										
Northeast Loxahatchee Slough	26.89205	-80.17307	0	20	11	2	0	0	2	**35**
Central Loxahatchee Slough	26.86861	-80.1778	2	81	10	0	0	3	36	**132**
2023										
Northeast Loxahatchee Slough	26.89205	-80.17307	0	0	6	0	0	0	26	32
Central Loxahatchee Slough	26.86861	-80.1778	6	3	82	24	1	2	51	169

HOLEY LAND AND ROTENBERGER WILDLIFE MANAGEMENT AREAS

Holey Land and Rotenberger Wildlife Management Areas (HWMA and RMWA, respectively) are located in far southwestern Palm Beach County. Together, they comprise over 65,000 acres of the Everglades Complex of Wildlife Management Areas (WMAs) in conjunction with Everglades and Francis S. Taylor WMAs. These WMAs are managed by FWC as lead areas within the WMA system for a diverse array of wildlife, habitats, and public recreational uses. As part of the Central Everglades ecosystem, HWMA and RWMA are vast freshwater wetlands dominated by sawgrass prairie with interspersed tree islands and willow shrublands. As such, both areas are important foraging, roosting, and nesting areas for a variety of wading bird species.

Hydrologically, HWMA is primarily rainwater fed, while water levels in RWMA are based on both rainwater and SFWMD water control structures. Area staff record weekly water data based on gage readings in both WMAs. This year, RWMA experienced mostly below average water levels through the winter and spring of 2023. However, HWMA experienced consistently higher than average water levels through the same time period.

Since 2018, FWC staff have surveyed several wading bird rookeries occurring across the two areas. HWMA has supported 4 rookeries at various times throughout the last 6 years (Northeast Holey Land: 26.42809, -80.69825; North Holey Land: 26.36931, -80.68499; South Holey Land: 26.36282, -80.68398), while RWMA has supported one inconsistently (West Rotenberger: 26.438883, -80.88243). However, two of the HWMA rookeries (North and South) have supported Little Blue Heron (LBHE) and Tricolored Heron (TRHE) nesting for 6 consecutive years.

METHODS

FWC staff survey the rookeries each breeding season to count peak nest occurrence. Ground surveys are conducted between mid-April and the end of June according to a standardized protocol. These rookeries all occur in willow heads along canals immediately adjacent to levees and are surveyed via truck.

2022 RESULTS

For the fifth consecutive year, HWMA supported 2 small nesting colonies on the eastern boundary of the area (26.392066, -80.687990; 26.364294, -80.685077). The nest numbers generally decreased from last year; approximately 3 TRHE and 13 LBHE nests were observed in the northern colony, and approximately 7 TRHE and 5 LBHE nests were observed in the southern colony (Table 39).

RWMA supported one wading bird nesting colony on the western boundary of the area (26.438883, -80.882432). In April 2022, multiple active nests were observed, including approximately 25 Anhinga (ANHI) nests, 18 Cattle Egret (CAEG) nests, 4 Great Egret (GREG) nests, 1 snowy egret (SNEG) nest, 1 TRHE nest, and 1 LBHE nest (Table 39).

2023 RESULTS

Surveys were conducted in mid-May 2023. Overall nest numbers decreased compared to the 2022 breeding season. TRHE and LBHE were the only species observed nesting at any colony. Only 2 TRHE and 2 LBHE nests were counted in the northern colony, while approximately 4 TRHE and 11 LBHE nests were counted in the southern colony (**Table 38**). No wading bird nesting was observed at the RWMA rookery or the Northeast Holey Land rookery this year. Imperiled species nesting data can be seen in **Figure 33** and overall nest numbers in the recent past can be seen in **Tables 39** and **40.**

Table 38. The 2022 and 2023 peak numbers of wading bird nests by species observed in HWMA and RWMA.

Colony	Latitude	Longitude	LBHE	TRHE	GBHE	GRHE	SNEG	GREG	CAEG	ANHI	BCNH	WHIB	GLIB	WOST	Total
2022															
North Holey Land	26.392066	-80.68799	13	3											16
South Holey Land	26.364294	-80.68507	5	7											12
Northeast Holey Land	26.42809	-80.69825													0
West Rotenberger	26.438883	-80.88243	1	1			1	4	18	25					50
2023															
North Holey Land	26.36931	-80.68499	2	2											4
South Holey Land	26.36282	-80.68398	11	4											15
Northeast Holey Land	26.42809	-80.69825													0
West Rotenberger	26.438883	-80.882432													0

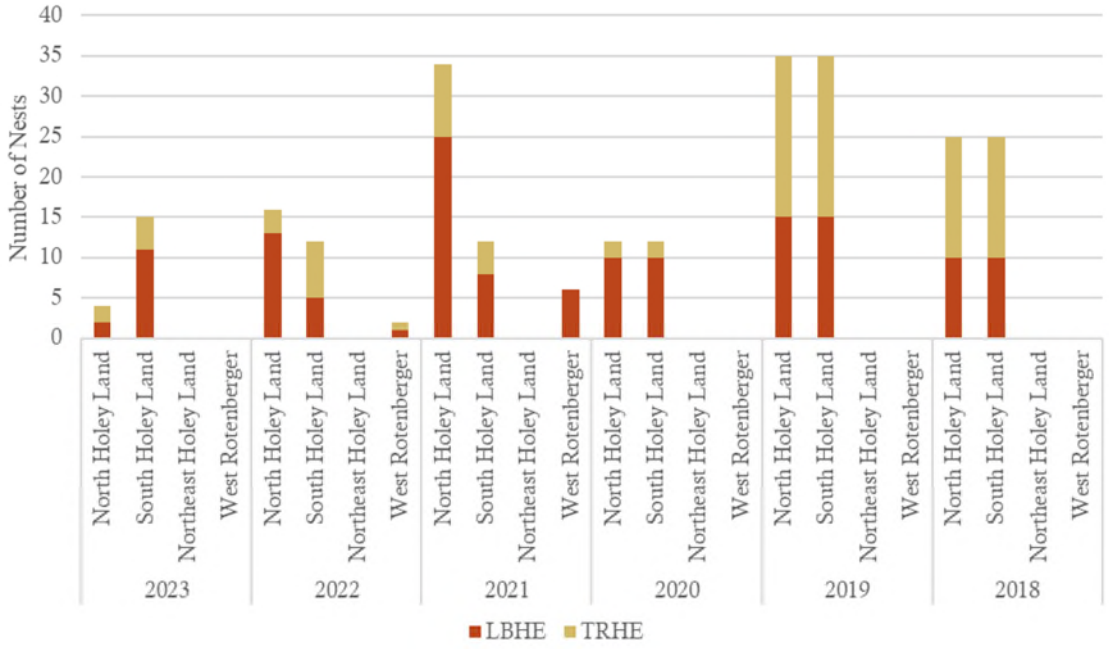

Figure 33. Imperiled wading bird species nesting in HWMA and RWMA by year.

Table 39. Total nests across all wading bird species in HWMA and RWMA by year.

Colony	Latitude	Longitude	2018	2019	2020	2021	2022	2023	Average
North Holey Land	26.36931	-80.68499	25	35	12	34	16	4	21.0
South Holey Land	26.36282	-80.68398	25	35	12	12	12	15	18.5
Northeast Holey Land	26.42809	-80.69825	0	15	3	0	0	0	3.0
West Rotenberger	26.43888	-80.882432	200	0	0	127	50	0	62.8
Total			**250**	**85**	**27**	**173**	**78**	**19**	**105.3**

Table 40. Peak numbers of wading bird nests observed in HWMA and RWMA across all rookeries by year.

Year	LBHE	TRHE	GBHE	GRHE	SNEG	GREG	CAEG	ANHI	BCNH	WHIB	GLIB	WOST	Total
2023	13	6											19
2022	19	11			1	4	18	25					78
2021	39	13				13	102	6					173
2020	20	4						3					27
2019	30	40						15					85
2018	20	30				30	150	20					250
Average	**23.5**	**17.3**	**0.0**	**0.0**	**1.0**	**15.7**	**90.0**	**13.8**	**0.0**	**0.0**	**0.0**	**0.0**	**105.3**

Future Plans

Area staff will continue surveying HWMA and RWMA rookeries to contribute long-term wading bird nesting data. In addition, area staff will continue land management techniques such as prescribed fire, mechanical mulching, and invasive plant treatments to maintain suitable foraging and nesting habitats for a variety of wading bird species.

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STATUS OF WADING BIRD RECOVERY

The sustainability of healthy wading bird populations is a primary goal of 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 RECOVER program established performance measures that include a 3-year running average of the numbers of nesting pairs of key avian species in the mainland Everglades, the timing of 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 South Florida Ecosystem Restoration Task Force's System-Wide Ecological Indicators Reports 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 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). These reports can be found online at https://www.evergladesrestoration.gov/system-wide-ecological-indicators-report-archive.

The main indicator species are GREG, SNEG, WHIB, and WOST. Although the 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 WCAs and mainland ENP for both the 2022 and 2023 nesting seasons.

Nesting Great Egrets at Cuthbert Lake in Coastal Everglades National Park

Great White Heron Nest in Coastal Everglades National Park

RESTORATION METRICS

Numbers of Nesting Pairs

The 3-year running average for nesting pairs in the mainland Everglades for the 2020 to 2022 period are 9,178 GREG pairs; 2,180 SNEG pairs; 39,051 WHIB pairs; and 1,503 WOST pairs. For the 2021 to 2023 period, the three-year running averages are 9,221 pairs of Great Egrets; 2,648 Snowy Egrets; 37,639 White Ibises; and 1,583 Wood Storks (**Figure 34** and **Table 41**).

Great Egret

GREG trends 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 26 consecutive sampling periods since 1996.

Snowy Egret

SNEG trends decreased markedly from 1988 to 1999, increased dramatically from 2000 to 2008, then decreased variably through the 2017 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. A slow increase has occurred since and, generally, big nesting years for flock-foraging species show a big increase in SNEG nesting. Nonetheless, three-year running averages of breeding SNEG have been consistently well below the target restoration goal during the time they have been monitored systematically since 1986.

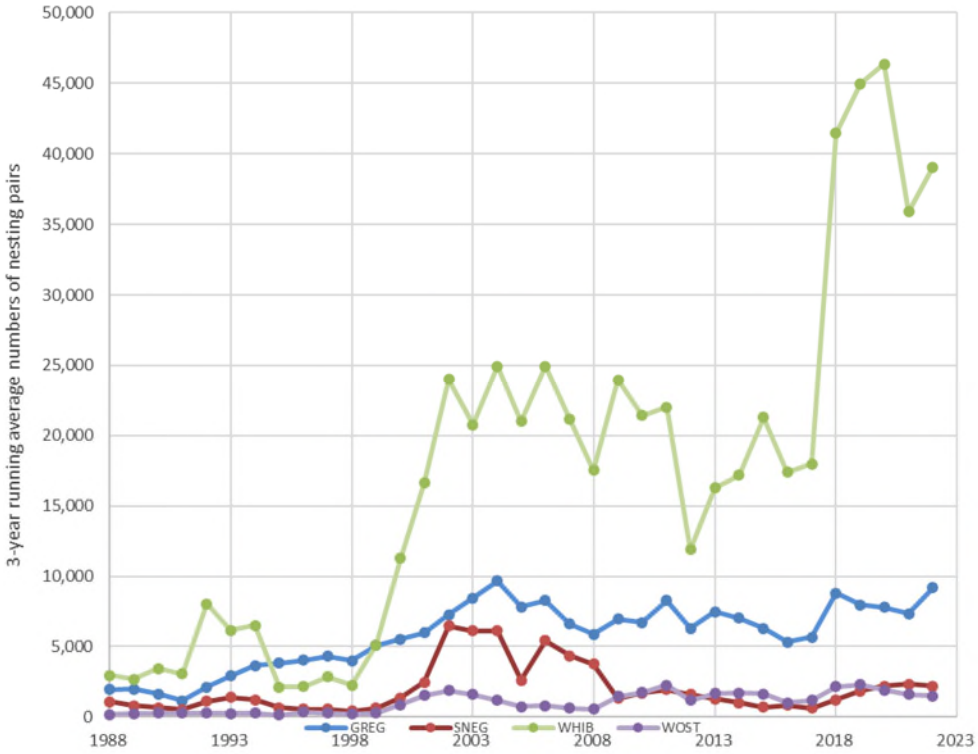


Figure 34. Long-term trends in nesting pair numbers for GREG (blue), SNEG (red), WHIB (green), and WOST (purple).


Cabbage Bay Wood Stork nesting colony in Coastal Everglades National Park

White Ibis

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 (2002–2011). The final period in this record (2012–2023) showed substantial fluctuations in WHIB nesting, with a 50% reduction in 1 year and 3 additional years below the average of the previous decade. In the last 6 years, ibis nesting has doubled from the previous decade. The huge nesting effort in the 2018 and 2021 nesting seasons pulled the running average up markedly, and the running average may remain high for the next three years simply because of the contribution of large numbers of fledged chicks from those two banner years. WHIB nesting populations have met or exceeded the breeding population criterion every year for the past 24 years.

Wood Stork

WOST showed a marked increase from averages in the 200 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 14 of the last 23 years, including in 2023. However, the running average for 2023 was again just above the minimum target of 1,500.

Table 41. Three-year running averages of numbers of nesting pairs of GREG, SNEG, WHIB, and WOST in the mainland Everglades (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**
2020-2022	**9,178**	2,180	**39,051**	**1,503**
2021-2023	**9,221**	2,648	**37,693**	**1,583**
Target Minima	**4000**	**10,000**	**10,000**	**1500**

Overall

Together, these statistics illustrate 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 four 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 SMHE in the genus *Egretta* (TRHE and LBHE) are also declining sharply in the Everglades.

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 35**), and during the last four years has ranged between 25 and 42%. In 2022 and 2023, 16 and 23% of all nests respectively were in the coastal region, which is still high when compared with the average since 1986 but represents a considerable reduction from the last ten years. 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 because 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 2022 and 2023, the ratios were 3.7 and 3.1, respectively (**Figure 36**), which are the lowest scores since 2017. The 5-year running averages were 5.49 in 2022 and 5.36 in 2023, which are still strongly influenced by the high proportions in 2018 and 2019 but remain significantly below the restoration threshold for this metric.

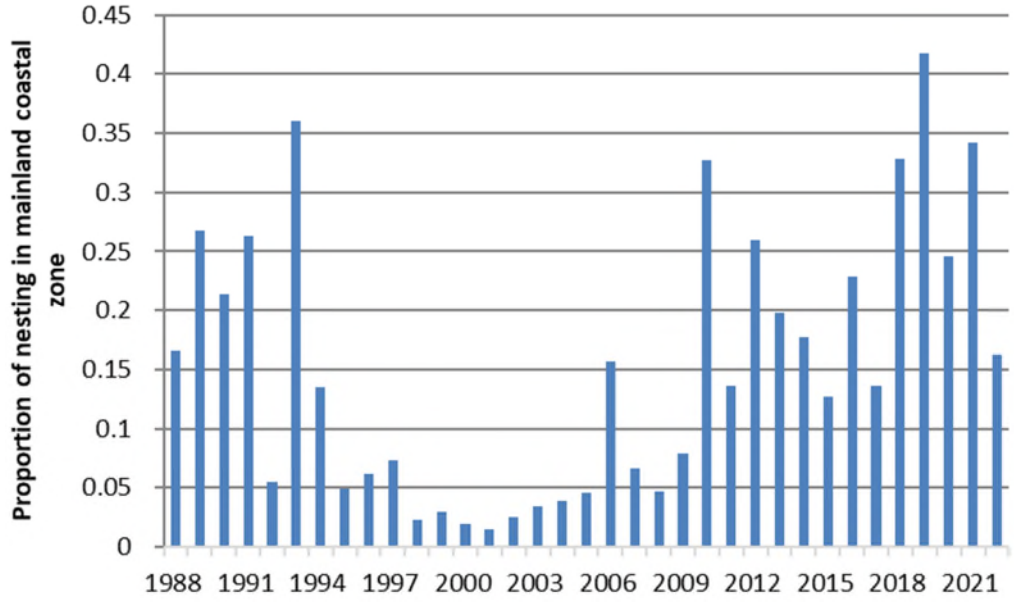


Figure 35 Proportion of all mainland Everglades nests that were located within the coastal estuarine zone, 1986–2022.

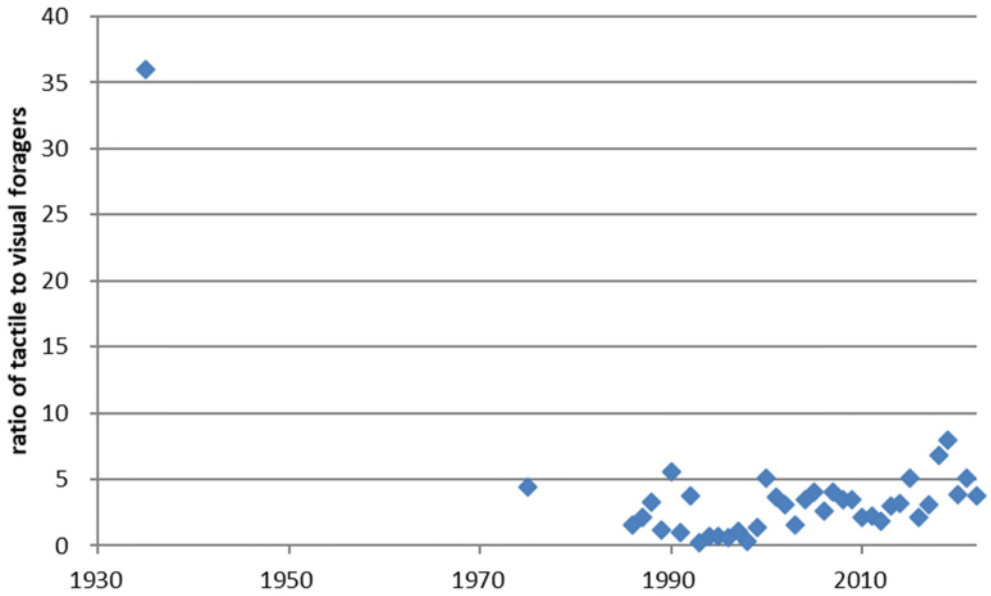


Figure 36 Ratio of tactile feeding species (ibis +stork) nests to sight foraging (GREG) nests in the Everglades, 1930–2022.

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 37**). 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 2022 date was early mid-February, which was late by about one month by comparison with most recent years, while the 2023 date was late January. The four-year running average for 2023 was 2.25, which corresponds to an averaged nest initiation date of late January or early February. This metric has seen slight improvement since 2016, though much of the consistency may be traced to the lagged nature of the metric as a running average, as late nesting has occurred over the last 3 years.

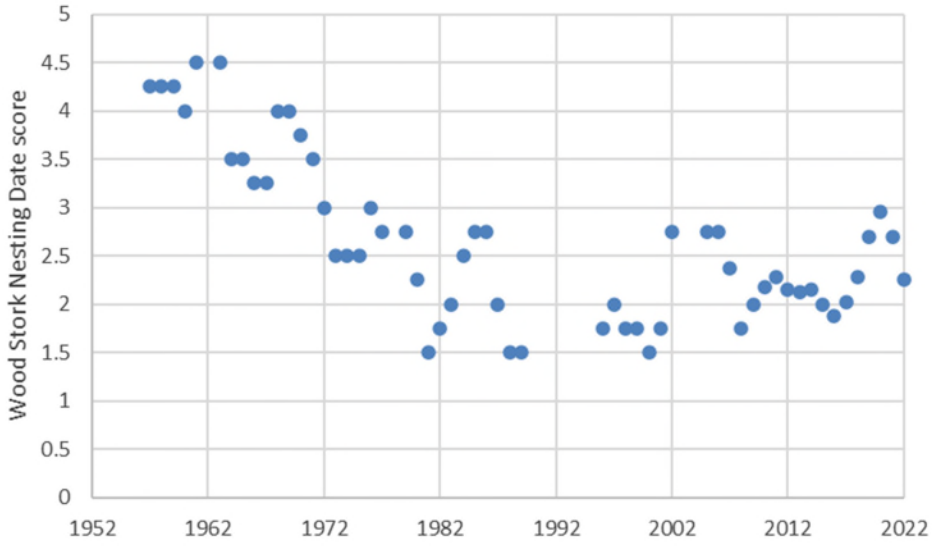
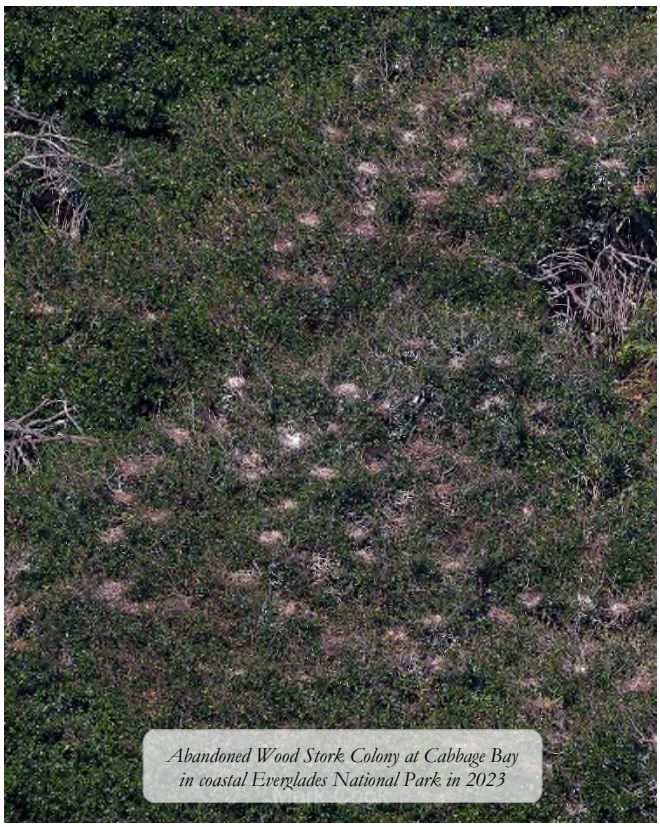


Figure 37 Four year running average of WOST nest initiation date in the Florida Everglades. Initiation in November is a 5, initiation in March is a 1.



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 2023 WHIB nesting reached the restoration criterion of > 16,977 nests, and the interval averaged over the last 5 years is 1.0 years, which meets the restoration guideline.

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 five 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 nesting remains a solid indicator of ecological

conditions. The lack of movement of the other measures suggests 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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