SOUTH FLORIDA WADING BIRD REPORT

Volume 22 Mark I. Cook and Michael Baranski, Editors January 2017

SYSTEMWIDE SUMMARY

NESTING IN SOUTH FLORIDA

An estimated 26,676 wading bird nests (excluding Cattle Egrets, which do not rely on wetlands) were initiated in South Florida during the 2016 nesting season (December 2015 to July 2016). This is a relatively poor nesting effort compared to the 10-year annual average (42,023.9 nests), and the lowest count since 2008 (18,669 nests). This reduced nesting effort continues a trend of relatively poor to moderate nesting since 2010. The average nest count during the current decade (2010 to 2016) is 35,146 nests per year, which is a 27% decline from the period between 2000 and 2009 (47,910 nests per year).

Most wading bird species exhibited reduced nesting effort during 2016. The White Ibis (WHIB), the most numerous wading bird species in South Florida, produced 12,271 nests, approximately 10,000 (45%) fewer nests than the 10-year annual average. Wood Storks (WOST) produced 1,457 nests, down 38% from the 10-year average. Small herons of the *Egretta* genus have exhibited sharp declines in nest numbers over the past decade, and this pattern continued in 2016: nesting efforts by Snowy Egrets (SNEG; 1,987 nests), Little Blue Herons (LBHE; 278 nests), and Tricolored Herons (TRHE; 888 nests) were reduced 51%, 61%, and 16%, respectively, from their 10-year averages. Great Egret (GREG) nesting (7,922 nests) was less impacted than the other species, down 7% from the 10-year average. The only species to exhibit increased nesting during 2016 was the Roseate Spoonbill (ROSP; 566 nests), which produced 20% more nests than the 10-year average.

Wading bird nesting is not evenly distributed in South Florida (**Figure 1**). The most important nesting region in terms of total number of nests is the Everglades Protection Area (hereafter Everglades), which comprises the Water Conservation Areas (WCAs) and Everglades National Park (ENP), and supports between 70% and 95% of all nests annually. Wading birds initiated an estimated 18,487 nests in the WCAs and ENP during 2016, which is 45% fewer than the decadal average (33,781.4 nests) and 44% fewer than last year (33,140 nests). The next largest nesting aggregation, Lake Okeechobee, typically produces approximately 10% of all nests. This year, Lake Okeechobee produced an estimated 2,453 nests, which is 52% fewer than the 10-year average (5,151.4 nests) and 36% fewer than last year (3,852 nests). Other regionally important nesting areas in 2016 were Florida Bay and the Kissimmee Lakes, both of which supported more than 1,000 wading bird nests.

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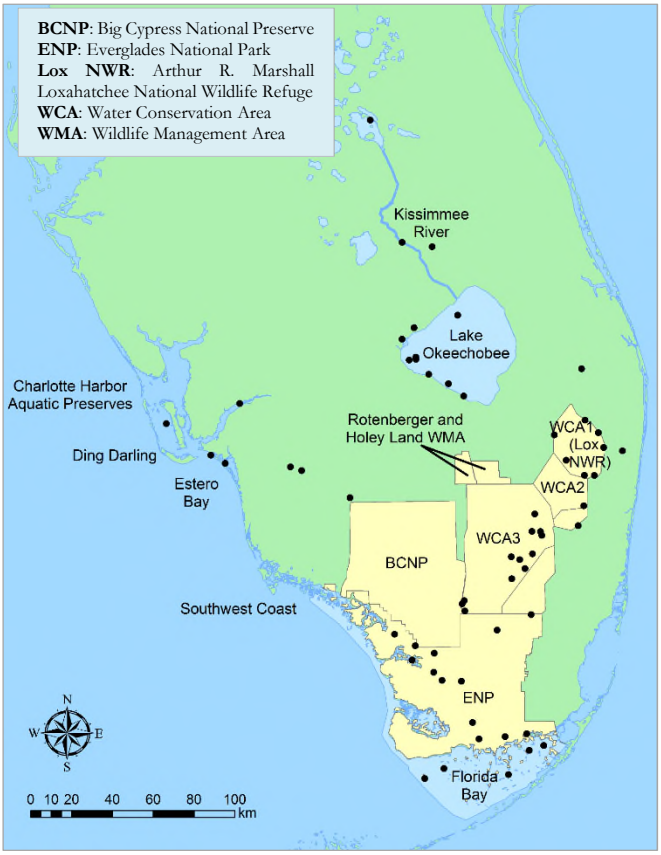

Figure 1. Locations of wading bird colonies with 50 or more nests in South Florida, 2016.

In terms of the distribution of species in South Florida during 2016, the Everglades supported the majority of nesting WHIB and GREG (85% and 67% of their total nests, respectively), but it attracted a relatively smaller proportion of SNEG and WOST (50% and 40% of their nests). Lake Okeechobee supported most of the remaining SNEG nests (42% of nests), while the Caloosahatchee River and other colonies in southwestern Florida were important for WOST (45% of nests). The Everglades attracted only a small proportion of nesting TRHE during 2016 (12% of total nests), with most birds nesting in Florida Bay (63% of nests).

A nesting area of continuing concern is Audubon's Corkscrew Swamp Sanctuary, which has experienced substantially reduced nesting activity in recent years. This historically important nesting area 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. WOST did not nest at Corkscrew Swamp Sanctuary during 2016 and have nested there only twice in the past 10 years. It is possible that loss of critical WOST foraging habitat in southwestern Florida is responsible for the decline (Lauritsen 2011).

Nesting in the Everglades

Nest Numbers

The indicator species for the Comprehensive Everglades Restoration Plan (CERP) are GREG, WHIB, WOST, SNEG, and TRHE. All five species exhibited relatively reduced nesting effort in the Everglades during 2016 (**Figure 2**). Only two of the indicator species (GREG and WHIB) met their CERP numeric restoration targets (3-year running average numbers of nesting pairs) for 2016 (see **Figure 3**; **Table 1**). GREG and WHIB have exceeded target counts every year since 1996 and 2000, respectively, while WOST have exceeded their target during 5 of the last 7 years. SNEG and TRHE have been consistently below target since 1986 (**Figures 2** and **3**; **Table 1**).

The declines of *Egretta* herons have been particularly acute in the Everglades and are cause for concern. Nesting effort in 2016 was reduced 52% for the SNEG relative to the 10-year average, while TRHE nesting was down 67%. These declines in *Egretta* herons do not appear to be due to birds moving to other nesting areas in South Florida; instead, they appear to reflect a general reduction in overall nesting effort in the Everglades. The cause of these sharp declines has yet to be determined.

In Florida Bay, ROSP produced 367 nests, which is almost identical to the count in 2015 (365 nests) and 38% more than the 5-year average (265 nests). However, this effort remains low from a historical perspective, being 22% lower than the 31-year mean (469.5 nests) and far below the mid-20th century nesting effort when more than 1,000 nests per year were common.

Mark Cook

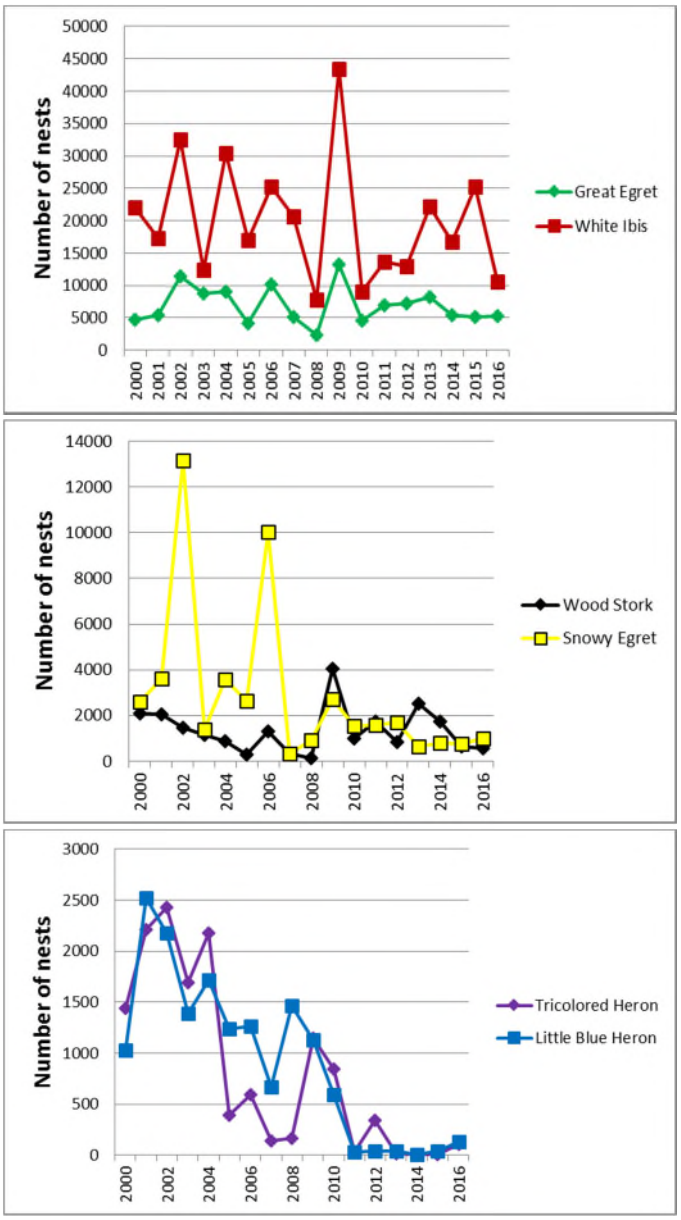

Figure 2. Wading bird nest numbers in the Everglades Protection Area (Water Conservation Areas and Everglades National Park) for individual species since 2000.

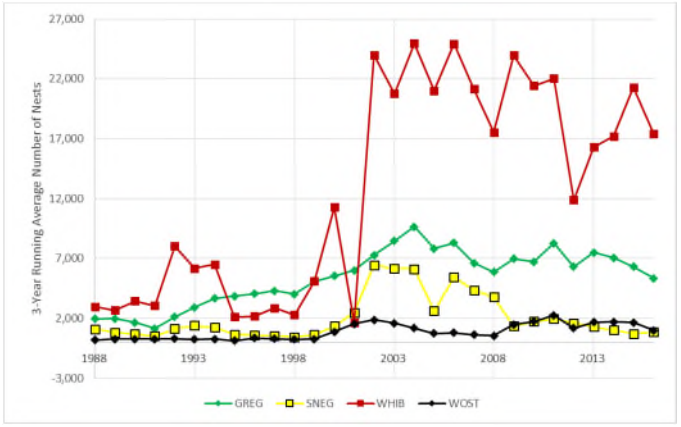

Figure 3. Trends in 3-year running average of nesting pairs of the four target species since 1986.

Table 1. Three-year running averages of the number of nesting pairs for the four indicator species in the Everglades.

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
Target Minima	4,000	10 – 20k	10 – 25k	1.5 – 2.5k

Note: Bold entries are those that meet minimum criteria.

Spatial Distribution of Nests

The estuarine region of ENP historically supported approximately 90% of all nesting wading birds in the Everglades, probably because it was the most productive region of the Everglades ecosystem. During the past 50 years, that productivity has declined due to reduced freshwater flows, and the location of nesting has shifted towards inland colonies in the WCAs and elsewhere in Florida (Frederick et al. 2009). An important goal of CERP is to restore the hydrologic conditions that will re-establish prey availability across the southern Everglades landscape that, in turn, will support the return of large successful wading bird colonies to the traditional estuarine rookeries. In 2016, ENP supported 25.6% of all nests in the Everglades, while WCA-3A and WCA-1 supported 20.5% and 53.9%, respectively. This represents a moderate increase in the proportion of birds nesting in ENP relative to the decadal average (22%) but remains far short of the 50% restoration target.

The location of ROSP nesting colonies within the Florida Bay area has shifted in recent years. Whereas most nesting used to occur on small keys within the bay, many birds have moved during the past 5 years to mainland colonies adjacent to the coast (e.g., Madeira Hammock and Paurotis Pond colonies, which supported 41% of all nests in 2016). The reason for this redistribution of nesting is unclear but might reflect the recent reduction in mammalian predators (i.e., raccoons) on the mainland due to the invasive Burmese python (Dorcasa et al. 2012) or a reduction in the suitability of habitat for nesting on the keys. Some individuals have deserted Florida Bay entirely. For 4 of the past 5 years, approximately 200 ROSP pairs have nested at colonies in the central freshwater Everglades such as northern WCA-3A. This number declined slightly in 2016, with 131 nests found at inland colonies.

Timing of Nesting

WOST have a relatively long reproductive period (approximately 4 months), and it is critical they start nesting early in the dry season to ensure nestlings have time to fledge and gain independence prior to the onset of the rainy season in May or June. WOST prey (i.e., fish) are easy to find and feed upon when concentrated in shallow water during the dry season (winter), but are not available in the wet season (summer) when water levels rise and they re-disperse into deeper marsh waters. Without the dry-season supply of highly concentrated prey, parent birds are unable to feed their offspring. WOST nesting historically started in November or December, but in recent decades, nesting initiation has shifted to January to March (Ogden 1994). The delay is thought to be because of a reduction in the amount and quality of short-hydroperiod wetlands, which provide suitable foraging habitat early in the nesting season. In 2016, WOST nesting was particularly late, with the first eggs noted on March 22. This start time is later than 2015 (late February) and 2014 (late January), and falls far short of the CERP target date of December.

ROSP in Florida Bay also have exhibited a recent shift toward later nesting. For at least 70 years (1936 to 2009), ROSP nest initiations consistently fell between October 1 and December 31. However, as of 2010, nesting has started increasingly later in the season: from 2010 to 2014, nesting started between January 1 and 10; in 2015, it began on January 24; and this year, nesting began on February 5, the latest start date ever recorded. Moreover, the timing of laying appears to be getting considerably more asynchronous within and among colonies. Whereas nest initiations within Florida Bay historically would span a few weeks, lay dates in the past 2 years have extended from January through April. These changes in the phenology and synchrony of nesting might suggest that the timing of optimal foraging conditions for ROSP is changing temporally and spatially within the southern Everglades.

Role of Hydrology and Food Availability on Nesting Patterns

The most important process affecting wading bird nesting in South Florida is the availability of prey (fishes and aquatic invertebrates). Prey availability is a function of the amount of prey animals (prey production) within a wetland and by how vulnerable they are to capture by birds, and both components are strongly affected by hydrologic conditions (Frederick and Ogden 2001; Herring et al. 2011). 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 grow during extended periods (multiple years) of relatively deep, flooded conditions over extensive areas of wetland (Trexler et al. 2005), while some invertebrate species (e.g., crayfish) are most numerous after periodic droughts (Dorn and Cook 2015). Prey vulnerability to capture is determined largely by water depths and whether water levels are rising or falling. Prey become easiest to capture during drying conditions when water levels decline to depths at which the birds can forage effectively (5 to 30 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 prey can disperse within the marsh. Prey availability, therefore, is naturally variable among years depending on prior water conditions and current water depths. Accordingly, wading bird nesting effort and success fluctuates considerably from year to year.

The relatively poor nesting effort of 2016 was due to the unseasonable rainfall and reversed hydrologic conditions of water year 2016 (May 2015 to June 2016). The 2016 breeding season was preceded by a very late and relatively dry 2015 wet season, which meant that water levels remained below ground for extended periods across large areas of the Everglades. Such conditions generally limit the production of small fish, and reduced fish biomass might account for the observed late nesting and decreased nesting effort by most species in 2016. Moreover, the 2015-2016 dry season, the period during which the birds feed and breed in the Everglades, was much wetter than average because of El Niño conditions. The effect of El Niño was that water levels generally were too deep for foraging throughout the Everglades until very late in the dry season (April and May), thereby limiting breeding opportunities (See the Everglades Protection Area Hydrology section for more details).

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 think beyond the noisiness of the annual fluctuations in nesting effort and instead consider the long-term (decadal and longer) trends in nesting responses. The 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 16 years and appear to be regularly meeting restoration targets (**Figure 3**). Moreover, the interval between exceptional WHIB nesting years has met the restoration target (<2.5 years) for 8 of the past 10 years. There have been some recent improvements in the number of birds nesting at historical coastal colonies, but the proportion remains well below the restoration target (5-year running average of 22% compared to the 50% target; **Figure 4**).

Several measures are not improving and are cause for concern. The numbers of SNEG, TRHE, and LBHE are declining sharply (**Figure 2**), and the causes of the declines are unknown. Also, despite improved WOST nesting effort, the late timing of their nesting has remained relatively static and their nesting success is below that necessary to sustain the local population. The ratio of tactile (storks, ibises, and spoonbills) to visual (herons and egrets) foragers has improved since the mid-2000s, but remains an order of magnitude below the restoration target. Also of potential significance is the generally poor overall nesting effort since 2010, which might suggest that overall conditions for nesting in the Everglades are declining. For more information on Everglades restoration performance measures, see the Status of Wading Bird Recovery section at the end of this report. **Figures 3** and **4** were provided by Peter Frederick.

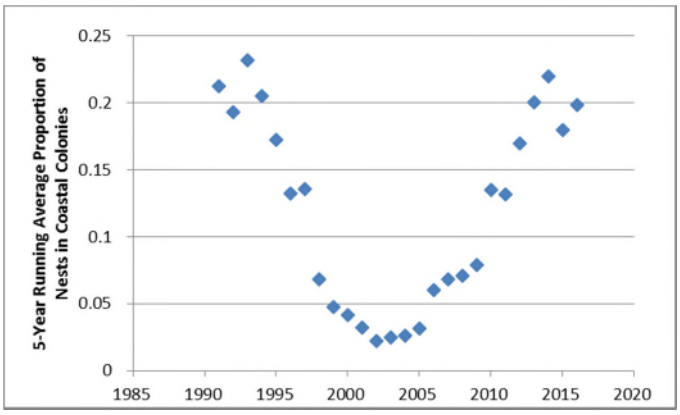

Figure 4. Proportion of all mainland Everglades nesting that is located in the coastal estuarine zone, 1990 to 2016.

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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*), 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, *Ajaja 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*)

Regions, Agencies, and Miscellaneous: Arthur R. Marshall (A.R.M.), Charlotte Harbor Aquatic Preserves (CHAP), Comprehensive Everglades Restoration Plan (CERP), Everglades National Park (ENP), Florida Atlantic University (FAU), Florida Department of Environmental Protection (FDEP), Kissimmee River Restoration Evaluation Program (KRREP), National Geodetic Vertical Datum of 1929 (NGVD29), National Wildlife Refuge (NWR), North American Datum of 1983 (NAD83), Restoration Coordination and Verification (RECOVER), Solid Waste Authority (SWA), South Florida Water Management District (SFWMD), Water Conservation Area (WCA), Water Year (WY)

EVERGLADES PROTECTION AREA HYDROLOGY

The Everglades Protection Area (Everglades) received average rainfall during water year 2016 (WY2016; May 1, 2015 to April 30, 2016). Rainfall was slighter greater than average in Water Conservation Areas (WCAs) 1, 2, and 3 and slightly below average in Everglades National Park (ENP) (**Table 2**). Although the annual total and spatial distribution of rainfall were unexceptional, WY2016 was highly atypical for the skewed timing of its rainfall pattern, with relatively little rain falling during the wet season (May through October) and record-breaking amounts falling during the dry season (November through April). Over the entire District, rainfall was nearly 1 foot above average during the dry season, and in the Everglades this period was the wettest on record since the 1957-1958 dry season.

As a result of the unseasonal rainfall patterns, stages were lower than usual during the wet season and exceptionally high during the dry season for most areas in the Everglades. Wading birds in South Florida typically breed during the dry season when water levels fall to depths at which the birds can forage (between 5 and 30 cm) and when the areal cover of water is reduced such that prey are concentrated at high densities. A slow but steady drying of the marsh is important for producing ephemeral patches of high prey availability and for providing a continuous supply of food across the Everglades landscape to fuel a breeding season that can last 3 to 5 months. During the 2016 breeding season, recession rates generally were too slow and water depths too great for wading bird foraging over large areas of the Everglades. Conditions did become favorable for foraging in the northern Everglades (WCA-1 and WCA-2A) toward the end of the dry season (late April), prompting some nesting; however, a series of rain events and associated water-level reversals in early May brought about the early onset of the wet season and immediate loss of foraging habitat.

Figures 5A to **5G** show the average stage changes in each of the WCAs for the last 3 years in relation to historic averages, flooding tolerances for tree islands, drought tolerances for wetland peat, and recession rates and depths that support foraging and nesting needs of wading birds. These indices are used by the South Florida Water Management District to facilitate weekly operational discussions and decisions. The flooding tolerance of tree islands is exceeded when depths on the islands are greater than 2.0 or 2.5 feet, depending on the elevation of the tree islands, for longer than 120 days (Wu et al. 2002). Drought tolerances are exceeded when water levels are more than 1 foot below ground for more than 30 days (i.e., the criterion for minimum flows and minimum water levels in the Everglades). Wading bird foraging habitat suitability is divided into three categories (red, yellow, and green) based on wading bird foraging ecology research in the Everglades (Beerens et al. 2011, 2015; Cook et al. 2014). A green label indicates good recession rates and depths for wading birds. A yellow label indicates water levels that are too shallow or too deep and/or recession rates that are slightly too rapid or too slow. A red label indicates poor conditions, resulting from poor depths and/or unsuitable recession rates that are rising or falling too rapidly.

WATER CONSERVATION AREA 1

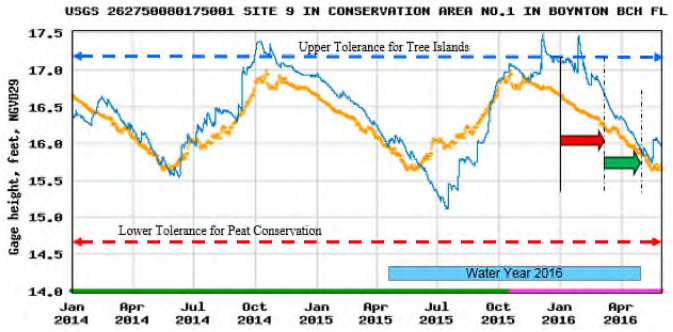
Stages in WCA-1 (Arthur R. Marshall Loxahatchee National Wildlife Refuge) at the start of WY2016 were close to their 21-year average (**Figure 5A**), but the onset of the wet season was delayed such that stages fell approximately 0.75 feet below average and did not rise again until July. Only in October did stages reach their long-term average, and from then through the end of the water year, water levels exceeded the 21-year average. Recession rates during the wading bird breeding season (January through May) generally were poor for the first few months, then improved in March and April with depths becoming suitable for foraging in late March. These conditions triggered the initiation of a large White Ibis (WHIB) colony of approximately 6,500 nests at Colony 99 in southern WCA-1. A series of rain events in early and mid-May then caused a sharp increase in water levels that limited foraging opportunities in the region for the remainder of the nesting season.

Table 2. Average, minimum, and maximum stage (ft NGVD) and total annual rainfall (inches) for WY2016 in comparison to historic stage and rainfall.[1] (Average depths calculated by subtracting elevation from stage.)

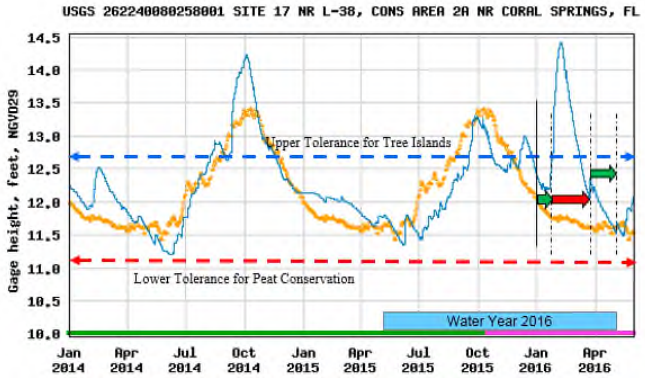
Area	WY2016 Rainfall	Historic Rainfall	WY2016 Stage Mean (min; max)	Historic Stage Mean (min; max)	Elevation
WCA-1	55.56	51.96	16.29 (14.38; 17.58)	15.69 (10.0; 18.16)	15.1
WCA-2	55.56	51.96	12.38 (11.35; 14.40)	12.51 (9.33; 15.64)	11.2
WCA-3	54.79	51.24	9.93 (8.65; 11.50)	9.60 (4.78; 12.79)	8.2
ENP	51.05	54.48	6.42 (5.45; 7.16)	6.02 (2.01; 8.08)	5.1

[1]Rainfall records are calculated based on the periods of record dating from 1953 for WCA-1, 1961 for WCA-2, 1962 for WCA-3, and 1952 for ENP.

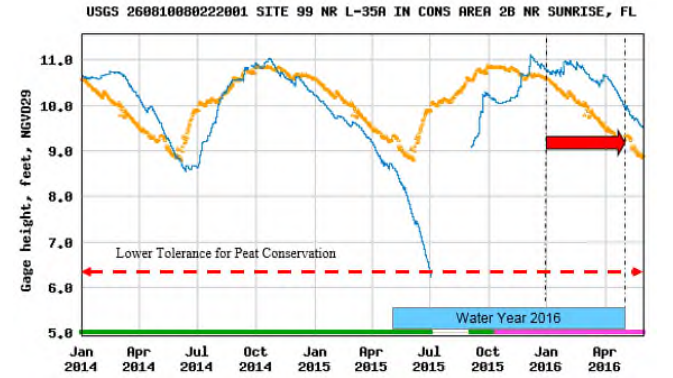
A. WCA-1 – Site 9



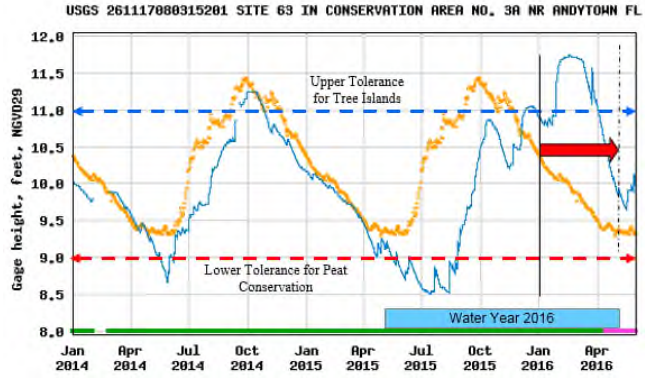
B. WCA-2A – Site 17



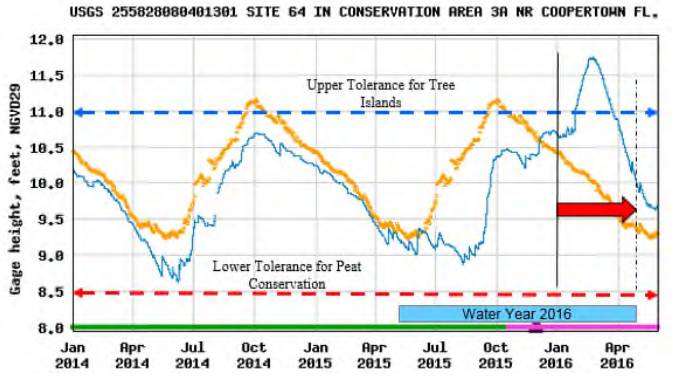
C. WCA-2B – Site 99



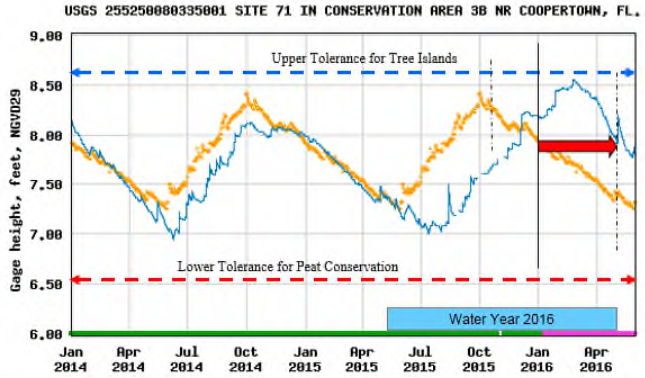
D. WCA-3A – Site 63



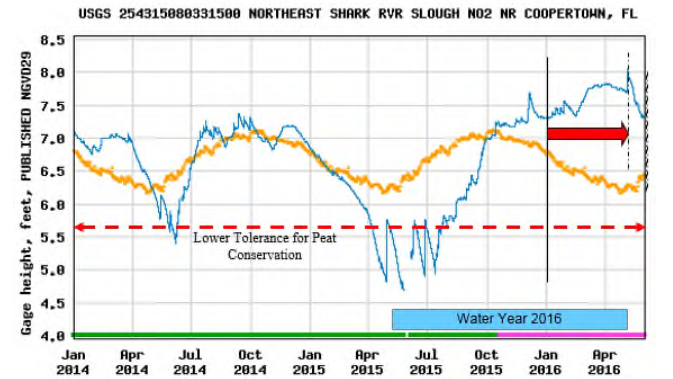
E. WCA-3A – Site 64



F. WCA-3B – Site 71



G. Northeast Shark River Slough



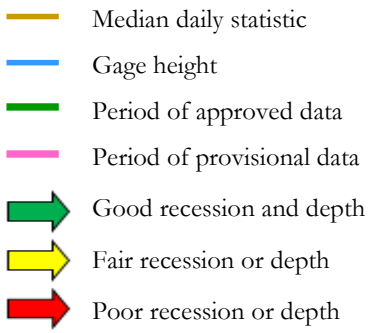


Figure 5. Hydrology in the WCAs and ENP in relation to average water depths (A: 21-year average, B: 21-year average, C: 21-year average, D: 22-year average, E: 22-year average, F: 22-year average, G: 32-year average), and indices for tree island flooding, peat conservation, and wading bird foraging.

WATER CONSERVATION AREAS 2A AND 2B

The hydropattern in WCA-2 was similar to that in WCA-1: stages at the start of WY2016 were close to the long-term average, there was a delayed start to the wet season, depths remained below average until October, and starting in December water levels rose above the 21-year median depth and remained there for the duration of the dry season. Water levels declined almost continuously from February to mid-May, but depths did not become shallow enough for foraging until mid-April. At this time, very large mixed-species flocks of wading birds were foraging in central WCA-2A, and the area became important for supporting the WHIB colonies in WCA-1. As in WCA-1, rising water levels during early May halted foraging.

Unlike the rest of the Everglades, WCA-2B tends to remain too deep year-round for wading bird foraging (**Figure 5C**). However, by early July 2016, water depths at site 99 had fallen to ground level, providing good foraging for late nesting birds during the WY2016 breeding season. Water levels rose thereafter, and from December through the remainder of the water year, depths exceeded the average for the gauge. As a consequence, there was little wading bird foraging in WCA-2B during WY2016 (the red arrow in **Figure 5C** signifies water levels too deep to support wading birds).

WATER CONSERVATION AREA 3A

Water levels in WCA-3A North at site 63 during WY2016 were very different from those of the previous 2 years (**Figure 5D**). Stages were at ground level at the beginning of May, declined below ground until very late August, and then rose rapidly through early October. In December, stages exceeded the median water levels and remained high through the end of the water year. As in several other regions, tree island tolerance levels were exceeded for several months during the dry season, with recession rates and depths not achieving preferred dry season conditions. Despite long periods of rapid recession rates from January to May, the occurrence of multiple extreme water-level reversals meant that depths remained too high for wading bird foraging throughout the nesting season. Gauge 63 is near the Alley North colony, which is often the largest wading bird colony in the Everglades. During favorable nesting conditions this colony can support tens of thousands of nests, but this year only 1,019 nests were counted.

The hydrologic pattern in central WCA-3A (gauge 64) (**Figure 5E**) was similar to that at gauge 63 except that water depths remained above ground at the beginning of the wet season. Water levels in December 2015 exceeded the 22-year median depth, peaking in mid-February at more than 2.6 feet. Despite subsequent rapid recession rates, depths remained too deep for foraging birds throughout the remainder of the dry season.

WATER CONSERVATION AREA 3B

As in other parts of the Everglades, water levels at gauge 71 declined steadily into the wet season until mid-August 2015, when water levels began to rise at a rate parallel to the typical wet season ascension rates (**Figure 5F**). Stages continued to rise through February 2016 and finally began to decline at the end of February. This produced a good recession rate through the end of the water year, but depths remained too high for wading bird foraging. Although water levels were higher than average, they did not exceed depths that are considered stressful for tree islands.

NORTHEAST SHARK RIVER SLOUGH

At the beginning of WY2016 (May 2015) water levels had fallen to approximately 1 foot below ground (**Figure 5G**) where they remained until mid-July. Thereafter, water levels rose relatively rapidly, exceeding the 32-year median stage in early October, and continued rising until late April. The poor recession rates and deep stages were unsuitable for wading bird foraging. These conditions were highly atypical compared to previous years, when conditions usually are very dry at the end of the dry season.

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REGIONAL NESTING REPORTS

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

The University of Florida Wading Bird Project continued its long-term monitoring of wading bird reproduction throughout Water Conservation Areas (WCAs) 2 and 3 and Arthur R. Marshall Loxahatchee National Wildlife Refuge (A.R.M., includes WCA-1) in 2016. Monitoring focused primarily on counts for Great Egret (GREG), White Ibis (WHIB), Snowy Egret (SNEG), and Wood Stork (WOST), the species that serve as bioindicators for the Comprehensive Everglades Restoration Plan (CERP), and are most readily located and identified through aerial searches. Estimates for these and other species were gleaned from aerial and systematic ground surveys as well as visits to nesting colonies and more intensive studies of nest success.

METHODS

Aerial and ground surveys were performed in 2016 to locate and characterize nesting colonies. On or around the 15th of each month from January through June, aerial surveys were performed to find active colonies using observers seated on both sides of a Cessna 182. Surveys were conducted from an altitude of 800 feet 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. The reported numbers of nest starts were derived from a combination of information sources, including peak estimates of nests in any colony, supplemental information from monthly South Florida Water Management District surveys staggered by 2 weeks from this survey, ground visits, and inference from observations across the season.

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 (making up a total of 336 km^2) are approached closely enough to flush nesting birds, and nests were counted directly if visible, or estimated from flushed birds. The totals were added to the numbers derived from aerial estimates. Because ground surveys were conducted on a subset of the total area, the resulting nest estimates should be used mainly for year-to-year comparisons, and reflect minimum estimates for the total number of nesting pairs of Little Blue (LBHE), Tricolored (TRHE), and Great Blue (GBHE) herons.

RESULTS

Nesting Effort

An estimated 14,005 wading bird nests were initiated at colonies within WCA-1, WCA-2, and WCA-3 in 2016 (**Tables 3** and **4**). With the exception of 2010, 2016 was the lowest nesting effort in the last 17 years. The total number of nests were 56% of the 10-year average and 68% of the 5-year average. Nesting effort for WHIB (8,985 nests) accounted for much of this difference, at only 56% of the 10-year average and 62% of the 5-year average. GREG nesting effort was the lowest in the past 6 years, but closer to average compared to other species, at 75% of the 10-year average and 71% of the 5-year average. WOST were not observed nesting in the WCAs in 2016.

Table 3. Number of nesting pairs found in A.R.M. Loxahatchee National Wildlife Refuge (WCA-1) during systematic surveys, February through June 2016.

Colony	Latitude	Longitude	GREG	WHIB	ROSP	SNEG	LBHE	TRHE	BCNH	Unidentified Small White	Colony Total*
LOX 99	26.43822	-80.39053	500	6,800				**			7,300
LOX West	26.55014	-80.44268	200	600	11	200	**		**		1,011
Lox Ramp	26.49511	-80.22533	100	517				20		150	787
Tyger	26.37187	-80.26597	143				**		**	250	393
Canal North	26.55993	-80.24871	60			120		**			180
UTU	26.37197	-80.31035	140								140
6	26.61526	-80.30763				133	**	**			133
Colonies >50 nests			1,143	7,917	11	453	0	20	0	400	9,944
Colonies <50 nests			101	0	0	0	0	0	0	0	101
Total by Species			**1,244**	**7,917**	**11**	**453**	**0**	**20**	**0**	**400**	**10,045**

Note: WOST, GBHE, GLIB, CAEG, unidentified large white birds, unidentified small dark birds, and ANHI were not observed (count = 0).
* Excludes ANHI.
** Present but not counted.

Table 4. Number of nesting pairs found in WCA-2 and WCA-3 during systematic surveys, February through June 2016.

Colony	WCA	Latitude	Longitude	GREG	WHIB	ROSP	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	CAEG	ANHI	Colony Total*
Rhea	2	26.23782	-80.31280	130	300			5	**	**					435
Alley North	3a	26.20132	-80.52873	678	300	41			**	**	**	**			1,019
6th Bridge	3a	26.12428	-80.54148	300	468	20			**	**					788
Jetport South	3a	25.80510	-80.84902	200					30						230
3	3a	26.22918	-80.80352										141		141
Henry	3a	25.81913	-80.83983	134											134
Cypress City	3a	26.12408	-80.50438	120											120
Joule	3a	26.01230	-80.63233	102											102
Horus	3a	25.96052	-80.57207	90											90
Vulture	3a	26.02564	-80.53916	85											85
Jerrod	3a	26.00012	-80.59513	75											75
Vacation	3a	25.91565	-80.63022	62											62
Andytown	3a	26.10715	-80.49802	61											61
Hidden	3a	25.77353	-80.83722	50											50
Colonies >50 nests				2,087	1,068	61	0	5	30	0	0	0	141	0	3,392
Colonies <50 nests***				258	0	0	6	214	69	2	0	18	1	228	568
Total by Species				**2,345**	**1,068**	**61**	**6**	**219**	**99**	**2**	**0**	**18**	**142**	**228**	**3,960**

Note: WOST, unidentified large white birds, unidentified small white birds, and unidentified small dark birds were not observed (count = 0).
* Excludes ANHI.
** Present but not counted.

Roseate Spoonbills (ROSP) nested again at 6th Bridge, Alley North, and LOX West (72 nests total) this season. They also were observed in several other colonies throughout the WCAs but not believed to be nesting. This follows the recent trend of increased nesting effort by ROSP in the WCAs.

There has been a clear trend of fewer TRHE and LBHE nests in the study area over the past decade. This season showed a slight improvement with 2 TRHE and 69 LBHE nests observed during systematic ground surveys. The average number seen between 2008 and 2016 was reduced by 77% for LBHE and 86% for TRHE compared with 1996 to 2007 averages. The *Egretta* herons are not nesting in their former locations within small discrete willow heads in WCA-3. This pattern 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. Competing predictions about the declines are being addressed, with major overlapping explanations about the decline or shifts in composition of the prey base, displacement by Black-crowned Night Herons (BCNH), or movement to coastal colonies.

Reproductive Success

Nest success was monitored at five colonies, including three in ENP (Tamiami West, Paurotis Pond, and Cuthbert) and two in WCA-3 (6th Bridge and Alley North). Individual nests of GREG (n = 143) and *Egretta* herons (n = 52 at all five colonies), WHIB (n = 44 at Alley North, 6th Bridge, and Paurotis) and ROSP (n = 3 at 6th Bridge) were monitored.

Examining nest success (P; probability of fledging at least one young, Mayfield method) systemwide shows overall similar nest success between species (from 47% to 59%). However, nest success between various colonies ranged widely for each species; for example; GREG nest success was 96% (SD = 0.03) at Cuthbert but only 29% (SD = 0.08) at Tamiami West.

Record rainfall in January and February in the WCAs led to exceptionally high water levels throughout the season. High water levels delayed most birds from nest initiation by at least a month. During normal years, GREG start nesting in late January to early February; in 2016, however, they did not begin nesting until late March. A lack of major reversals throughout the season did allow most colonies to successfully fledge chicks. However, some nests were still in the incubation stage as late as mid-June.

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EVERGLADES NATIONAL PARK

MAINLAND

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

Methods

Aerial surveys were conducted of known colony locations monthly from February through July (February 22, March 21, April 11, May 16, June 13, and July 18). Flight altitude was maintained at 600 to 800 feet above ground level. During each flight, visual estimates of nest numbers by species were made and photos were taken of colonies using a digital SLR camera with a 70-200 mm lens. Photos were later compared to visual estimates to assist with determining nest numbers, nesting stage, and species composition.

A systematic colony survey was conducted on May 24 across slough and estuarine habitat within ENP. Two observers, with one observer sitting on each side of a Cessna 206 high-wing float aircraft, searched for colonies along 20 established transects oriented east to west and spaced 1.6 nautical miles apart. Flight altitude was maintained at 800 feet above ground level throughout the survey. Coordinates of colony locations were recorded and photos were taken of colony sites.

Species monitored included Great Egret (GREG), White Ibis (WHIB), Wood Stork (WOST), Snowy Egret (SNEG), Roseate Spoonbill (ROSP), Tricolored Heron (TRHE), and Little Blue Heron (LBHE). Other birds found nesting in colonies such as the Great Blue Heron (GBHE), Anhinga (ANHI), Cattle Egret (CAEG), and Black-Crowned Night Heron (BCNH) were noted as well.

Results

Nesting effort in ENP was down by 21% compared to the 2015 nesting season. The total species nest estimate was 4,774 (**Table 5**). WOST had a peak number of 580 nests, a decrease of 10% compared to the 2015 season. GREG nest counts (n = 1,702) were up by 17%. WHIB (n = 1,560) were down by 57%. SNEG nest counts (n = 550) were up by 75%. Twenty wading bird colonies were monitored (**Figure 6**).

Table 5. Peak numbers of wading bird nests found in Everglades National Park colonies through July 18, 2016.

Colony	Latitude	Longitude	GREG	WOST	WHIB	SNEG	ROSP	TRHE	LBHE	GWHE	ANHI	Total
Alligator Bay	25.67099	-81.14714	75	0	0	75	0	+	+	0	0	150
Broad River	25.50292	-80.97440	150	340	400	150	50	+	+	0	+	1,090
Cabbage Bay	25.62000	-81.05612	150	10	800	125	25	+	+	0	+	1,110
Cuthbert Lake	25.20933	-80.77500	60	0	0	0	0	0	0	0	0	60
East River	25.26860	-80.86785	25	0	0	0	0	0	0	0	0	25
Grossman Ridge West	25.63627	-80.65275	30	0	0	0	0	0	0	0	0	30
Joe Bay	25.23205	-80.56455	70	0	0	0	0	0	0	0	0	70
Lostmans Creek	25.58723	-80.97204	80	0	0	0	10	0	0	0	+	90
Madeira Hammock[1]	25.21932	-80.65945	5	0	60	0	120	87	0	5	12	289
Otter Creek	25.46780	-80.93772	170	0	0	0	25	+	+	0	+	195
Paurotis Pond[2]	25.28150	-80.80300	150	230	300	150	30	0	30	0	+	890
Rodgers River Bay Large Island	25.55667	-81.06984	80	0	0	0	0	0	0	0	0	80
Rookery Branch	25.46356	-80.85256	175	0	0	0	0	0	0	0	+	175
2016 Colony 1	25.74010	-80.91616	20	0	0	0	0	0	0	0	0	20
2016 Colony 2	25.68911	-80.69517	60	0	0	0	0	0	0	0	0	60
2016 Colony 3	25.63213	-80.98903	40	0	0	0	0	0	0	0	0	40
2016 Colony 4	25.52150	-80.80508	2	0	0	0	0	0	0	0	0	2
2016 Colony 5	25.31100	-80.85630	40	0	0	0	0	0	0	0	0	40
2016 Colony 6	25.34570	-80.61298	20	0	0	0	0	0	0	0	0	20
Tamiami West[3]	25.75745	-80.54502	300	0	0	50	0	+	+	0	0	350
Total			**1,702**	**580**	**1,560**	**550**	**260**	**87**	**30**	**5**	**12**	**4,774**

Note: BCNH and GBHE were not observed (count = 0).
+Species present and nesting, but unable to determine number of nests.
[1] Data from Audubon of Florida.
[2] ROSP and LBHE data from Audubon of Florida.
[3] Data from the University of Florida.

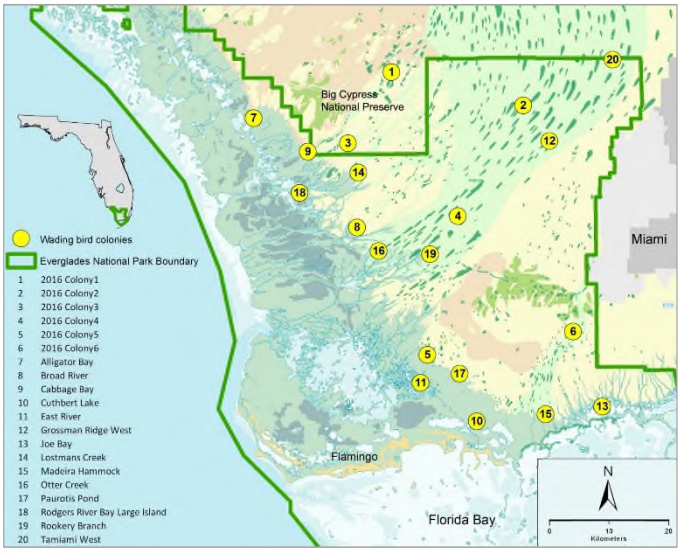

Figure 6. Active wading bird nesting colonies in Everglades National Park and south Big Cypress National Preserve, February to July 2016.

GREG, SNEG, and ROSP were first seen nesting on February 22 at the Broad River, Cabbage Bay, East River, Joe Bay (Diamond Key), Madeira Hammock, Otter Creek, and Paurotis Pond colony sites. Other colonies were empty or had birds roosting only. Although Joe Bay's Diamond Key is located in northern Florida Bay, it is included here as the birds appear to be feeding exclusively on the mainland (flight lines were observed only going to/from the mainland during overflights).

WOST were first seen on March 22 at the Broad River, Cabbage Bay, and Paurotis Pond colony sites. Most adults were paired and standing at new empty nests, though a few were seen incubating. Other colonies were active also; Alligator Bay, Cuthbert Lake, Grossman Ridge West, Lostmans Creek, Rodgers River, Rookery Branch, and Tamiami West had GREG, SNEG, and some ROSP. WHIB were not seen nesting until the April 12 survey.

Peak nest numbers for most species, including WOST but excluding WHIB, were observed during the March 22 survey. Peak numbers for WHIB were observed during the May 16 survey. GREG, SNEG, and ROSP appeared to be successful this season as large young and fledged young were seen in all colonies.

At the Broad River colony, and for reasons unknown, WHIB had mostly abandoned nests when observed on June 13. Approximately 30 fledged birds were seen later in photos, but such small numbers did not correspond to the original estimate of 400 incubating and brooding adults observed during the May 16 flight. WHIB in the other colonies appeared to have better outcomes as many adults and fledged birds were seen on June 13 and July 18.

WOST initiated nesting very late this year (March) and only nested in three colonies (Broad River, Cabbage Bay, and Paurotis Pond). By May 16, adults were tending to one to two medium-sized young per nest. On June 13, some nests were empty and a few contained dead young at Paurotis Pond and Broad River. However, adults were still, standing at nests in the colonies, and most nests still contained one to two medium- to large-sized young. On July 18, all WOST nests were abandoned (most appeared to be empty) and no adults were seen in the colonies.

FLORIDA BAY

Methods

Aerial surveys were conducted in ENP across Florida Bay on January 29, February 22-23, March 4, March 21-22, April 11-12, May 23 and 25, and June 13 using a Quest Kodiak or Cessna 206 high-wing float aircraft. The surveys target nesting Bald Eagles (BAEG) and Ospreys (OSPR); however, nesting Great White Heron (GWHE), GREG, ROSP, SNEG, Reddish Egret (REEG), Brown Pelican (BRPE), Double-crested Cormorant (DCCO), and roosting sites for Magnificent Frigatebird (MAFR) were recorded as well. Nest counts for wading birds and pelicans were recorded by island or island group. The survey area included most islands and island groups within Florida Bay. Islands were checked at least twice during the season and most were checked monthly.

Results

Nesting activity was observed on 44 islands (**Table 6**; **Figure 7**). The large colony that previously nested on Frank Key has not been active in recent years; however, two smaller colonies have been active on nearby Clive Key and Palm Key. WHIB and SNEG were not seen nesting during the survey flights.

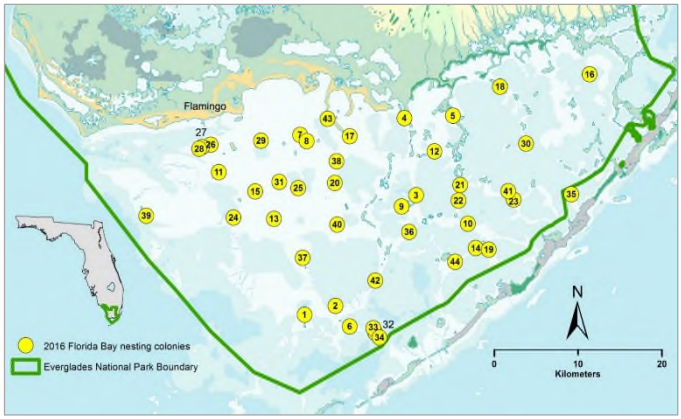

Figure 7. Active nesting colony sites in Florida Bay, January to June 2016.

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Table 6. Nesting activity in Florida Bay, January to June 2016.

Island Name	GWHE	GREG	BRPE	ROSP	GBHE	REEG	DCCO
Arsnicker, Upper	2	0	0	0	0	0	0
Barnes Key, Little	1	0	0	0	0	0	0
Big Key, Middle	3	0	0	0	0	0	0
Black Betsy Key	1	0	0	0	0	0	0
Buchanan Key, East	0	0	47	0	0	0	+
Buoy Key, Big, N	3	0	0	0	1	0	0
Buoy Key, SE	1	0	0	0	0	0	0
Calusa West	3	0	0	0	0	P	0
Big Calusa	3	0	0	0	0	0	0
Captain Key	3	0	0	0	0	0	0
Clive Key	3	24	95	0	2	0	+
Club Key	1	0	0	0	0	0	0
Cluett Key	6	0	0	0	0	0	0
Cotton Key	ND	ND	ND	ND	ND	ND	ND
Cowpens Key	ND	ND	ND	ND	ND	ND	ND
Crane West	8	0	0	0	0	0	0
Dildo Key	2	0	0	0	13	0	0
Duck	1	17	0	3	0	0	+
Dump N	1	0	0	0	0	0	+
Eagle	8	0	0	P	1	P	0
East Key	7	0	0	0	0	0	0
Jim Foot Key	1	0	0	0	0	0	0
Jimmy Channel 1 (N)	3	0	0	0	0	0	0
Jimmy Channel 2 (Big)	1	0	0	0	0	0	0
Low Key	2	0	0	0	0	0	0
Man of War Key	0	0	0	0	0	0	+
Miele Key	1	0	0	0	0	0	0
Murray Key	7	0	0	0	0	0	0
Oyster, East	0	0	0	0	0	0	+
Oyster, West	4	0	49	P	0	P	+
Palm Key	12	0	0	P	5	0	+
Park Key, S	0	0	15	0	0	0	0
Pelican Keys	1	0	0	0	0	0	0
Peterson, Middle	2	0	0	0	0	0	+
Peterson, NW	2	0	0	0	0	0	+
Peterson, SE	3	0	0	0	0	0	0
Pigeon Key	4	0	0	2	0	0	+
Pollock Keys	4	0	0	0	0	0	0
Rabbit, Big	3	0	0	0	0	0	+
Roscoe Key	1	0	0	0	0	0	0
Sandy Key	19	8	35	P	0	0	0
Sid Key	1	0	0	0	0	0	0
Stake Key	3	0	0	0	0	0	0
Twin Keys	3	0	0	0	0	0	+
Umbrella Key	6	0	0	0	0	0	0
West Key	2	0	0	0	0	0	0
Total	**142**	**49**	**241**	**5**	**22**	**P**	**+**

+ DCCO were nesting but estimates from photos were not finalized at the time of publication.

ND = no data; P = adult birds present, status unknown.

Note: The following islands were surveyed but did not have nesting activity: Lower Arsnicker, Big Barnes Key, North Big Key, South Big Key, NW Black Betsy Key, E Bob Allen Key, M Bob Allen Key, W Bob Allen Key (big), W Bob Allen Key (small), Bob Keys, Bottle Keys, Brush Keys, East Buchanan Key (small), West Buchanan Key, Big Butternut W, Little Butternut W, Buttonwood Keys, Calusa South, Calusa Middle, Camp Key, Catfish Key, Coon Key, Corinne Key, Cormorant Key, Crab Keys, Crane East, Curlew Key, Dead Terrapin, Deer Key, Derelict Key, Dump S, East of Big Butternut, End Key, Frank Key, Gopher Keys, Green Mangrove Key, Jimmy Channel 3 (Middle), Jimmy Channel 4 (S), Joe Kemp Key, Johnson, Lake Key, Madeira Key, Madeira Hammock, Manatee Key, North Nest, South Nest, Otter Key, Panhandle Key, N Park Key, Pass Key, Porjoe Key, Little Rabbit, Big Rankin, Little Rankin NE, Russell Key, Samphire Keys, Shell Key, Spy Key, Swash Keys, Tern Keys, Topsy Key, Triplet Key, Whaleback Key, and Whipray Keys.

BISCAYNE NATIONAL PARK

Nesting 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 and incubating eggs, and rearing chicks are energy intensive. If the habitat is insufficient to support these activities, nesting will be affected and may indicate a problem in the ecosystem. The South Florida/Caribbean Inventory and Monitoring Network (SFCN) of the National Park Service (NPS) monitors colonial nesting birds in Biscayne National Park (BNP), and this report summarizes the results for the year July 2015 through June 2016 (hereafter "nesting year").

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

- The number and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants (*Phalacrocorax auritus,* DCCO), Great Egrets (*Ardea alba,* GREG), Great White Herons (*Ardea herodias occidentalis,* GWHE), Great Blue Herons (*Ardea Herodias,* GBHE), White Ibises (*Eudocimus albus,* WHIB), and Roseate Spoonbills (*Platalea ajaja,* ROSP) (referred to as focal species).
- The annual peak active nest counts of colonial nesting birds in BNP for the focal species.
- Changes in an annual nesting index (sum of monthly nest counts) for the focal species.
- Changes in the timing of peak nest counts for the focal species.

METHODS

The monitoring process in 2015-2016 consisted of an annual park-wide survey via helicopter to locate new nesting colonies of wading birds and seabirds within BNP. This was coupled with monthly surveys of the located colonies. Two SFCN technicians, a photographer and an observer, participate in each survey. As the helicopter circles each island colony, the colonies are photographed and the observer records the number of nesting and non-nesting birds. Approximately 350 photographs are taken during each survey. The photographs are downloaded for processing, geotagged, and analyzed to identify active nests by species. Nests are circled on the photographs and then counted from the processed photographs.

Peak nest counts are identified for each colony and then summed across colonies to calculate the peak nesting year total across the park for each species. In addition, an annual nesting index is calculated, which is the sum of monthly nest counts for the entire nesting year. The nesting estimates for months with no sampling are calculated as the average of the months before and after the missing month. The SFCN uses the annual nesting index in addition to peak nest counts because some species, such as 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 feasible at this time. This year's peak nest counts and nesting index are compared to the five previous nesting years mean, maximum, and minimum. Complete methods are described in Muxo et al. (2015).

Colony surveys were conducted during from July to December 2015, from January to March 2016, and in June 2016. The six islands surveyed were: Mangrove Key (25.2340, -80.1857), West Arsenicker (25.40539, -80.30171), Arsenicker Key (25.39706, -80.28644), Jones Lagoon (25.36928, -80.24338), Ragged Key 5 (25.314, -80.105), and Soldier Key (25.5903, -80.1612) (**Figure 8**).

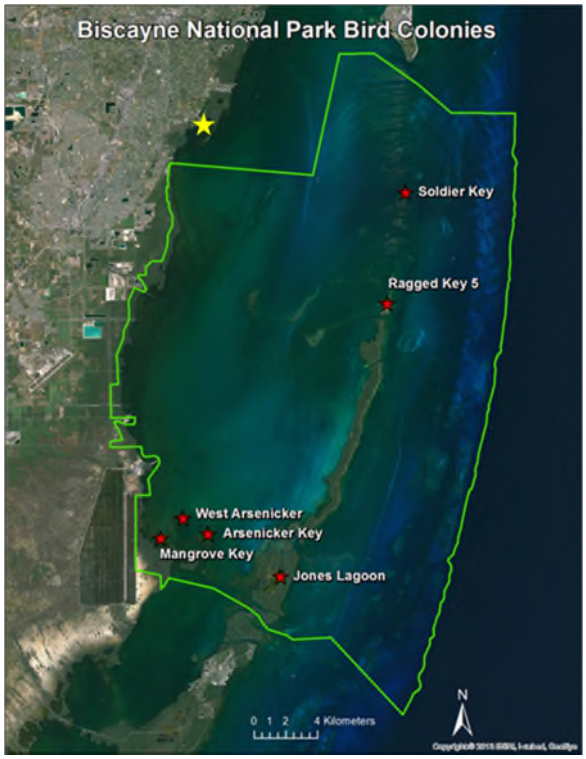

Figure 8. Six island colonies (red stars) monitored within BNP. The yellow star indicates the location of the new Kings Bay Colony.

RESULTS

In the 2015-2016 nesting year, the SFCN completed its sixth year of monitoring colonial nesting birds in BNP. This year, a new colony (Kings Bay) was located approximately 2 km north of BNP. The SFCN began surveying this colony in June 2016, so the 212 DCCO nests observed there were not included in this year's report. The birds likely feed within BNP, and the SFCN will continue to monitor this colony in the future.

This year, the SFCN photographed a mixed GWHE and GBHE nest, labeled a Wurdemann's nest, at Jones Lagoon (**Figure 9**). For the first time, a GWHE nesting on Mangrove Key was photographed in June 2016. Mangrove Key supported a small number of nests (21) for the second year in a row after no nesting was observed during the 2013-2014 nesting season. This was the first year GWHE were seen nesting in all six colonies. ROSP nested on Jones Lagoon this year after failing to nest there last year. **Table 7** shows the peak nest and nesting index for BNP by colony and species for the 2015-2016 nesting year.

Table 7. Peak nest and nesting index for BNP by species and colony for the 2015-2016 nesting year plus the mean, percent change, maximum, and minimum of the five previous nesting years (July through June).

Species	Peak Nest					Nesting Index				
	2015-2016	Mean	% Change	Max.	Min.	2015-2016	Mean	% Change	Max.	Min.
Biscayne National Park										
DCCO	1,001	967.50	3%	1,337	792	5,211	5,276.9	-1%	5,660	4,927
GBHE	11	11.17	-1%	15	6	26	27.3	-5%	44	12
GREG	12	16.00	-25%	24	14	29	44.8	-35%	75.5	22
GWHE	28	22.83	23%	29	18	96	83.8	15%	108	59
ROSP	3	4.83	-38%	12	0	8	10.8	-26%	25	0
WHIB	24	46.17	-48%	78	28	25	66.5	-62%	110	45
Arsenicker Key										
DCCO	158	171.80	-8%	257	107	517	733.5	-30%	983.5	489
GBHE	0	0.40	-100%	2	0	0	1	-100%	5	0
GREG	0	0.80	-100%	2	0	0	1.9	-100%	4.5	0
GWHE	3	3.60	-17%	6	2	12	14.8	-19%	26	11
ROSP	0	0	0	0	0	0	0	0	0	0
WHIB	22	46.00	-52%	60	28	23	70.2	-67%	87	45
Jones Lagoon										
DCCO	110	121.00	-9%	135	100	437	618.8	-29%	905	433
GBHE	8	5.60	43%	10	2	21	15	40%	25.5	6.5
GREG	0	1.00	-100%	2	0	0	1.25	-100%	2	0
GWHE	13	7.60	71%	10	6	48	27.7	73%	34	18
ROSP	3	5.20	-42%	12	0	8	11.4	-30%	25	0
WHIB	0	0.00	0	0	0	0	0	0	0	0
Mangrove Key										
DCCO	21	34.40	-39%	115	0	64	104.70	-39%	309	0
GBHE	0	0	0	0	0	0	0	0	0	0
GREG	0	0	0	0	0	0	0	0	0	0
GWHE	1	0.	0	0	0	1	0	0	0	0
ROSP	0	0	0	0	0	0	0	0	0	0
WHIB	0	0	0	0	0	0	0	0	0	0
Ragged Key 5										
DCCO	492	427.20	15%	706	294	2,900	2,642.00	10%	3,210	2,163
GBHE	0	0.50	-100%	1	0	0	0.50	-100%	1	0
GREG	0	0.40	-100%	1	0	0	0.40	-100%	1	0
GWHE	4	4.20	-5%	7	2	17	14.30	19%	22.5	9
ROSP	0	0	0	0	0	0	0	0	0	0
WHIB	0	0.00	0	0	0	0	0.00	0	0	0
Solider										
DCCO	220	204.00	8%	342	140	1,293	1,187.80	9%	1,397	1,003
GBHE	1	1.20	-17%	2	1	2	3.60	-44%	9	1
GREG	0	0.67	-100%	1	0	0	0.67	-100%	1	0
GWHE	3	3.00	0%	5	2	11	8.30	33%	16	4
ROSP	0	0	0	0	0	0	0	0	0	0
WHIB	0	0.00	0	0	0	0	0.00	0	0	0
West Arsenicker										
DCCO	0	2.40	-100%	10	0	0	3.30	-100%	13	0
GBHE	2	3.60	-44%	5	2	3	7.60	-61%	15	3
GREG	12	14.40	-17%	20	11	29	44.20	-34%	73	19
GWHE	4	3.40	18%	6	1	7	16.20	-57%	29.5	4
ROSP	0	0	0	0	0	0	0	0	0	0
WHIB	2	4.60	-57%	23	0	2	4.60	-57%	23	0

Figure 9. A Great White Heron and Great Blue Heron nest at Jones Lagoon.

The DCCO remains the most common species in this survey, accounting for more than 93% of peak nest counts and 97% of total nests summed across all months in the nesting index (**Table 7**; **Figures 10** and **11**). DCCO were present at all colony sites except West Arsenicker Key; this is the second consecutive year DCCO were not observed nesting at West Arsenicker. There appears be a seasonal pattern with spring and summer peaks for nesting, but clearly DCCO nest year-round. This year's monthly peak nest count occurred in June 2016, with 963 nests compared to the previous year's monthly peak nest count of 885 (**Table 8**). DCCO colonies are variable through time: all the southern colonies (Arsenicker, Jones Lagoon, and Mangrove Key) in BNP showed a decrease in DCCO peak nest counts and nesting indices whereas the northern colonies (Ragged Key and Soldier Key) have stayed stable or increased over the last 5 years. Across the entire park, the DCCO peak nest counts and nesting indices generally are stable (using a linear trendline).

GBHE continued to nest at Soldier Key, Jones Lagoon, and West Arsenicker Key, but did not nest at the other colonies this year. GBHE increased in peak nesting (43%) and in the nesting index (40%) at Jones Lagoon (**Table 7**). GREG were only present at West Arsenicker (**Table 7**). GWHE were present at all colonies, and were most numerous (13 active nests) at Jones Lagoon (**Table 7**). ROSP nested again (only 3 nests) this year at Jones Lagoon. WHIB nested mainly at the Arsenicker Key colony and has consistently occurred at this colony for the last 6 years.

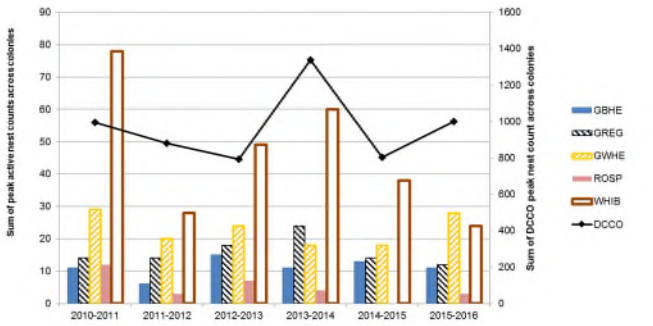

Figure 10. Total of peak active nest counts from all colonies.

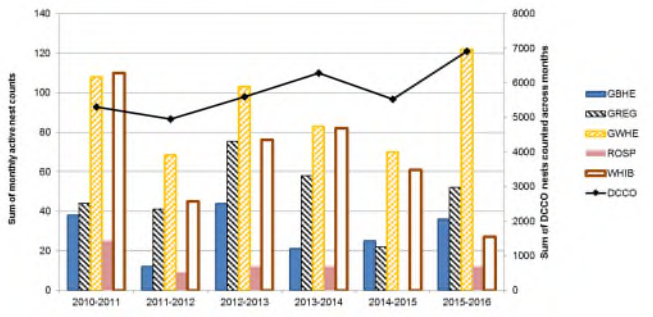

Figure 11. Annual nesting index across colonies by focal species. The number of nests counted at each colony during each month was summed to create an annual nesting index across all colonies for the six focal species. This number exceeds the actual number of nest starts as a single nest could be counted during two or more monthly visits.

Overall, numbers of nests were reflective of the average for the previous 5 years, five of the six focal species peak nest counts and nesting indices fell within the range of variation seen in those years. The exception was WHIB, which had a 48% lower peak nest counts and a 62% lower nesting index than the 5-year mean; while setting new minima, this may in part be due to the June 3 flight being too early to catch their peak nesting in 2016.

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Table 8. Total active nests photographed by species, July 2015 to June 2016.

Species	July	Aug.	Sept.	Oct.	Nov.*	Dec.	Jan.	Feb.*	Mar.	Apr.	May	June
DCCO	885	696	288	124	184	557	700	498	528	NS	NS	**963**
GBHE	1	0	0	0	3	3	1	**8**	**8**	NS	NS	2
GREG	0	0	0	0	0	0	0	6	**12**	NS	NS	11
GWHE	2	0	0	7	12	10	22	**17**	16	NS	NS	10
ROSP	0	0	0	0	0	0	2	2	**3**	NS	NS	1
WHIB	**22**	1	0	0	0	0	0	0	0	NS	NS	2
Total	910	697	288	131	199	570	725	531	567	NS	NS	989

* November 2015 and February 2016 flight dates were actually December 1 and March 4, respectively.
Bold values represent the peak monthly count. NS = no survey.

ROSEATE SPOONBILL NESTING IN FLORIDA BAY

METHODS

Roseate Spoonbills (ROSP) used 61 nesting locations on keys in Florida Bay for nesting colonies and 3 mainland sites adjacent to Florida Bay (**Figure 13**). Note that in the 2014-2015 report, only 44 keys were listed. In this report, nesting sites on small islands adjacent to larger named keys have been included as separate nesting locations, which has not been done in past reports. Colonies were divided into five distinct nesting regions based on the primary foraging locations used by the birds (**Figure 13**; Lorenz et al. 2002). During the 2015-2016 nesting season (November 2015 to May 2016), complete nest counts were performed in all five regions of the bay by entering the colonies on foot and thoroughly searching for nests. Mark and revisit surveys were performed at active colonies within each region to estimate nest success. The surveys entailed marking as many nests as possible shortly after full clutches had been laid, and then revisiting the colonies on a 10- to 21-day cycle. Nests were monitored until failure or until all surviving chicks reached at least 21 days of age, which is when chicks begin branching and can no longer be assigned to a nest. A colony was considered successful if it averaged at least one chick to 21 days per nesting attempt (1 c/n). Mean laying and hatching dates refer to the first egg laid and hatched in each clutch. Results are presented in the context of ROSP nesting activities in Florida Bay since 1984, the year that the South Dade Conveyance System was completed, which has direct water management implications on Florida Bay (Lorenz et al. 2002; Lorenz 2014a).

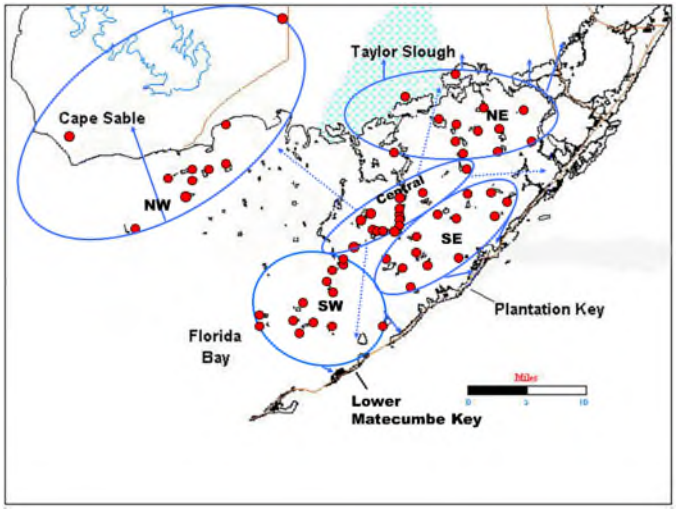

Figure 13. Map of Florida Bay indicating ROSP colony locations (red dots) and nesting regions (blue circles). Arrows indicate the primary foraging area for each region. The dashed lines from the Central region are speculative.

RESULTS

Northwest Region

There were six active colonies in the Northwest, including Paurotis Pond and Cape Sable colonies on the mainland, producing a total of 141 nests. This is comparable to last year's 173 nests, but it is well below the 30-year average of 202 nests (**Table 10**). All of the 131 nests with known fate produced chicks to at least 21 days (100% success rate), with a mean production of 2.18 c/n (**Table 11**). This is above the long-term mean production rate for the Northwest region (**Table 12**) and above what is considered successful. Total production for the Northwest region was estimated at 308 young to 21 days (**Table 11**). The mean lay date was March 14, and the mean hatch date was April 4 (**Table 11**). This is the fourth year in a row that ROSP nested well after the traditional nest initiation period of November-December.

Northeast Region

There were six active colonies in the Northeast this year, including Madeira Hammock, producing 189 nests. This is above the average of 158 nests since 1984-1985 (**Table 10**). Of the 71 nests with known fate, 51 of them were successful (72% success rate); producing 71 chicks to 21 days. The production rate was 1.0 c/n (**Table 11**). This production rate is slightly above the mean production rate of 0.9 c/n for this region since 1984-1985 and is considered successful. The mean lay date was February 29, and the mean hatch date was March 20 (**Table 11**), much later than the traditional nesting period.

Southeast Region

The Southeast region of the bay produced 6 nests this year, well below the mean of 57 nests since 1984-1985 (**Table 10**). Both nests on Pigeon Key were successful, producing 3 chicks, while only 1 nest on Stake Key produced 1 chick. The estimated mean lay date was March 11 (**Table 11**).

Central Region

The Central region yielded 29 nests from 3 colonies, which is lower than the average 44 nests for this region since 1984-1985 (**Table 10**). Estimated total production was 41 chicks fledged for the region. Of the 12 nests with known fate, 75% successfully raised chicks to 21 days (**Table 11**) and was comparable to the mean since 1984 (**Table 12**). The mean lay date was February 16, and the mean hatch date was March 8 (**Table 11**).

Southwest Region

Eight of the 13 potential colonies in the Southwest region were surveyed in 2015-2016; the other 5 were not ground surveyed but were observed and no ROSP were sighted. Only Twin Key was active, producing 2 nests (**Table 10**), one of which produced 2 chicks. The fate of the other nest is unknown. Therefore, Twin Key is estimated to have produced 4 chicks to 21 days, giving the region a success rate of 100% (**Table 10**). The mean lay date was March 14, and the mean hatch date was April 4 (**Table 11**).

Table 10. Number of ROSP nests in Florida Bay, November 2015 through May 2015, with minima, mean, and maxima summary data since 1984-1985.

Region	Colony	Number of Nests	Minimum	Mean	Maximum
Southeast	Stake	4	0	4.66	19
	Pigeon	2	0	7.79	56
	Region Subtotal	**6**	**4**	**57.21**	**117**
Central	Central Bob Allen	18	2	8.60	18
	Jimmie Channel	3	0	15.27	47
	First Mate	1	0	2.60	15
	Brews	7	7	7.00	7
	Region Subtotal	**29**	**3**	**44.04**	**96**
Northeast	N. Nest	2	0	0.58	8
	S. Nest	23	0	15.88	59
	Porjoe	2	0	20.60	118
	Duck	41	0	11.85	100
	Madeira	120	0	26.58	164
	Diamond	1	0	0.50	1
	Region Subtotal	**189**	**3**	**157.88**	**333**
Southwest	Twin	2	0	1.82	8
	Region Subtotal	**2**	**0**	**7.35**	**35**
Northwest	Sandy	6	6	126.90	250
	Clive	4	2	20.13	52
	Palm	100	0	32.38	100
	Paurotis	30	2	42.54	128
	Cape Sable	1	1	4.50	8
	Region Subtotal	**141**	**65**	**202.20**	**325**
Florida Bay Total		**367**	**112**	**469.54**	**880**

Table 11. Breakdown of colonies by region of all monitoring data collected.

Region	Colony	Number of Nests	Number of Chicks to Branchling	Number of Nests with Known Fate	Estimated Production per Nest	Estimated Number of Chicks Fledged	Number of Nests with at Least One Branchling	% Success	Mean Lay Date	Mean Hatch Date
Northwest	Clive	4	3	1	3.00	12.00	1	100	3/6/16	3/27/16
	Palm	100	205	100	2.05	205.00	100	1.00	U/K	U/K
	Sandy	6	U/K	0	U/K	U/K	U/K	U/K	U/K	U/K
	Cape Sable	1	U/K	0	U/K	U/K	U/K	U/K	U/K	U/K
	Paurotis	30	78	30	2.60	78.00	30	100	3/22/16	4/12/16
	Region Subtotal	**141**	**286**	**131**	**2.18**	**307.83**	**131**	**100**	**3/14/16**	**4/4/16**
Northeast	Duck	41	U/K	0	U/K	U/K	U/K	U/K	2/24/16	3/16/16
	North Nest	2	2	2	1.00	2.00	1	50	3/10/16	3/31/16
	Porjoe	2	3	1	3.00	6.00	1	100	2/29/16	3/21/16
	South Nest	23	4	22	0.18	4.18	4	18	2/5/16	2/21/16
	Madeira Hammock	120	62	45	1.38	165.33	45	100	3/22/16	412/16
	Diamond	1	0	1	0.00	0.00	0	0	U/K	U/K
	Region Subtotal	**189**	**71**	**71**	**1.00**	**189.00**	**51**	**72**	**2/29/16**	**3/20/16**
Southeast	Pigeon	2	3	2	1.50	3.00	2	100	3/30/16	4/20/16
	Stake	4	1	2	0.50	2.00	1	50	3/12/16	4/2/16
	Region Subtotal	**6**	**4**	**4**	**1.00**	**6.00**	**3**	**75**	**3/21/16**	**4/11/16**
Central	First Mate	1	U/K	U/K	U/K	U/K	U/K	U/K	3/20/16	4/10/16
	Central Jimmie	3	6	2	3.00	9.00	2	100	3/18/16	4/8/16
	Central Bob Allen	18	8	5	1.60	28.80	5	100	2/26/16	3/18/16
	Brewski	7	3	5	0.60	4.20	2	40	12/6/15	12/27/15
	Region Subtotal	**29**	**17**	**12**	**1.42**	**41.08**	**9**	**75**	**2/16/16**	**3/8/16**
Southwest	S. Twin	2	2	1	2.00	4.00	1	100	3/14/16	4/4/16
	Region Subtotal	**2**	**2**	**1**	**2.00**	**4.00**	**1**	**100**	**3/14/16**	**4/4/16**
Baywide Total		**367**	**380**	**219**	**1.74**	**636.80**	**195**	**84**	**3/7/16**	**3/28/16**

U/K = unknown.

Table 12. Mean number of chicks to 21 days per nesting attempt and the percentage of nests that were successful. Summary data indicate the overall minimum, mean, and maximum production rates (chicks per nest) to 21 days of age as well as the percentage of years that the region has been successful since 1984-1985. Success is defined as a mean of at least 1 chick to 21 days per nesting attempt. Summary figures refer to the focal colony or colonies surveyed in each year.

Region	2015-2016 Nesting Season		Summary Since 1984-1985			
	Mean Production per Nest	% Successful Nests	Minimum	Mean	Maximum	% Years Successful
Northeast	1	72	0	0.93	2.20	53
Northwest	2.18	100	0	1.28	2.50	62
Southeast	1	75	0	0.83	2.09	39
Central	1.42	75	0	0.85	1.86	--
Southwest	2	100	--	--	--	--

-- Nest production was not measured in the Southwest region.

BAYWIDE SYNTHESIS

ROSP nest numbers in 2015-2016 (367 nests) were almost identical to last year and seemed to have stabilized in recent years at approximately 400 nests per year (**Figure 14**; note that counts in 2009-2010 and 2010-2011 were underestimated because ROSP nests observed at Madeira Hammock were not counted). Although this is a positive result given the rapid decline in nesting effort from the early 1990s through 2008-2009, current counts are much lower than historic nesting patterns of the 1970s to 1990s (**Figure 14**) and remain a concern. Similarly, numbers in northeastern Florida Bay are higher than they were in the 2000s, but still much lower than historic numbers (**Figure 14**).

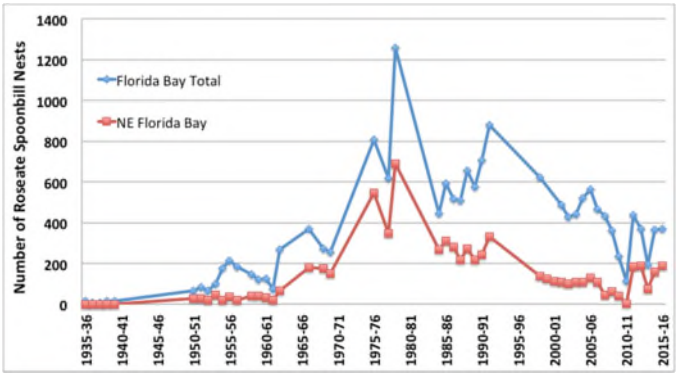

Figure 14. Total ROSP nests in Florida Bay and in the northeastern subregion of Florida Bay since 1935.

Throughout the regions, average nest production was 1.74 c/n with 84% of nests successfully raising at least 1 chick to 21 days (**Table 11**). This means that 2015-2016 was a highly successful year for nesting ROSP. Nesting success in Florida Bay continues the improving trend seen in recent years, but this year's success was not attributed to restoration efforts as it has been in the last few reports. This year, the observed improvement was probably due to the ending of drought conditions during the nesting season. During the wet season from June 2014 through November 2015, South Florida was under the influence of a severe drought. Beginning in November 2015, El Niño conditions resulted in higher than normal rainfall during the 2016 dry season. Frederick and Ogden (2001) indicated that under current management practices, wading birds nesting in the Everglades benefit from droughts and the first year following a drought. As suggested by Frederick and Ogden (2001) and experimentally demonstrated by Dorn and Cook (2015), droughts in the Everglades result in declines in abundance of larger predatory fishes. When the drought ends, the prey species recolonize the previously dried wetlands that are relatively free of piscine predators, thereby making more prey available to nesting birds initially after the drought breaks. This is believed to explain why ROSP performed very well during the 2016 nesting season. Although this appears to be favorable to ROSP in the short term, consequences of severe droughts may be quite harmful in the long term. The recent severe drought resulted in hypersaline conditions and a massive seagrass die off in Florida Bay; very similar events that occurred during the 1987-1990 drought. ROSP and other wading birds had record success rates during the 1987-1990 drought (Lorenz et al. 2002), resulting in population increases during and immediately following the drought (**Figure 14**). However, the damaging effects of that drought and seagrass die-off had long-lasting negative ecological impacts on Florida Bay that lasted for several decades (Lorenz 2014a). These conditions ultimately led to a collapse of the ROSP population following the 1987-1990 drought (**Figure 14**; see Lorenz et al. 2002 for intervening years of 1992-1993 to 1998-1999) as well as the species that this umbrella indicator represent (e.g., other wading birds, game fish, marine mammals, crocodilians) (Lorenz 2014a). Thus, in the short term, it appears that ROSP are performing well, but declines post-drought are anticipated.

Alvear-Rodriguez (2001) estimated ROSP nest initiation dates (first egg laid) in northeastern Florida Bay for 51 years (1936 to 2000) from field notes collected by various researchers. Nest initiation occurred between November 1 and December 31 in all years except two (one in October and one in January). As part of the South Florida Annual Wading Bird Report, nest initiation dates have been reported since 2003. From 2003-2004 to 2009-2010, all initiation dates fell within the range reported by Alvear-Rodriguez (2001). From 2010-2011 to 2013-2014, all nest initiation dates were between January 1 and January 10. Last year, the date was January 24, and this year it was February 5, the latest ever recorded. Consistently later nest initiation dates have occurred in all other regions of the bay as well. Moreover, lay dates within and among colonies were highly asynchronous, spanning January through April. These results suggest that the important environmental cues that promote breeding were either lacking or weaker than normal. Water levels were abnormally high until very late in the year and rarely dropped to the critical level (13 cm) at which prey begin to concentrate (Lorenz 2014b). The delay in nesting and the fact that the majority of nesting occurred in two mainland colonies (Madeira Hammock and Paurotis Pond) suggest that conditions have deteriorated for nesting ROSP within Florida Bay.

Mean sea level in the Gulf of Mexico has a profound impact on water levels in ROSP foraging habitats north of Florida Bay (Lorenz 2014b). In recent years, the steadily increasing sea surface elevation of the Gulf appears to be accelerating (**Figure 15**) and has resulted in higher water levels on the foraging grounds, likely causing reduced prey availability (Lorenz 2014b) and thus delayed nesting in Florida Bay's ROSP population. This also likely explains the low nesting effort, asynchronous nest initiation, and changes in nesting location of ROSP in Florida Bay since 2010. This may ultimately change the way ROSP will be used as an indicator for Everglades restoration in the future. ROSP nesting is one of many environmental indicators revealing that the health of Florida Bay is declining and is exhibiting dramatic and rapid changes in its ecology. Everglades restoration efforts that benefit Florida Bay cannot come soon enough.

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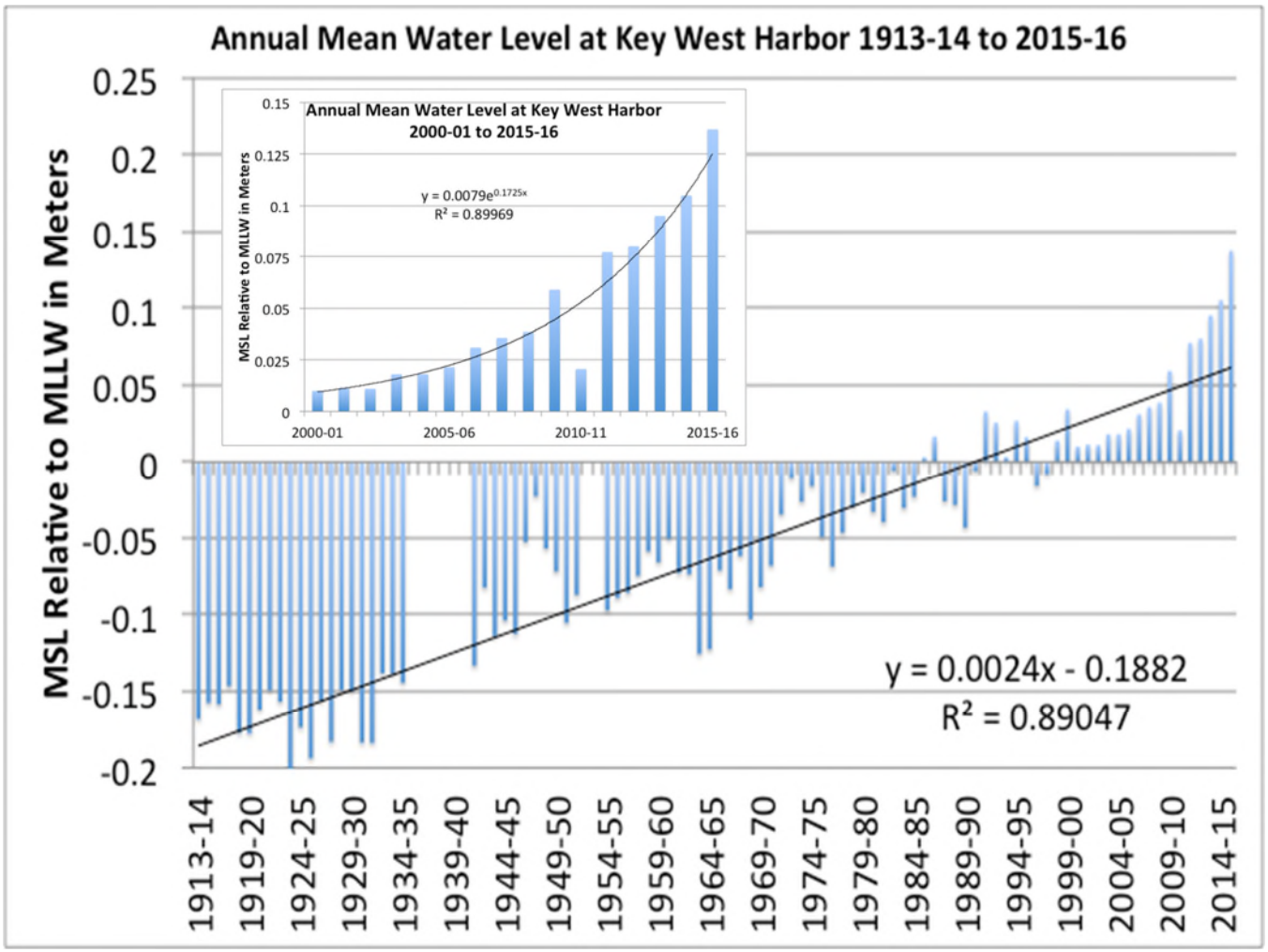

Figure 15. Mean sea level rise relative to mean low low water in Key West Harbor from 1913 to 2015. Inset shows the same data since 2000, indicating the exponential rise in sea level in recent years.

NESTING ACTIVITY OF WATER BIRDS ON ROSEATE SPOONBILL COLONY KEYS IN FLORIDA BAY

While surveying known Roseate Spoonbill (ROSP) colonies throughout Florida Bay, other water bird nesting activity on the keys was investigated. Nineteen species of water birds, 15 of which were nesting on these islands, were encountered and enumerated to the extent possible (**Table 13**). These findings should not be treated as a thorough or exhaustive survey of water birds in Florida Bay. Many keys were not surveyed at all because ROSP did not nest on them. Also, searches did not extend beyond areas where ROSP nested on a given key.

That stated, great efforts were taken to thoroughly find all Reddish Egret (REEG) nests. REEG have become a species of interest at the state and local level in recent years, and are now being treated the same as ROSP (i.e., attempts are made to find all nests and document productivity). REEG estimates likely are an accurate representation of effort for this species in Florida Bay.

Table 13. Number of water bird nests in Florida Bay, November 2015 through May 2016.

Region	Colony*	OSPR	GBHE	GWHE	GREG	LBHE	GRHE	BRPE	DCCO	SNEG	TRHE	BAEA	WHIB	ANHI	WOST	REEG
Northwest	Sandy	3		42	25				125	15	150		40			9
	Clive		50	50	30			60	100	20	100					
	Palm								150							12
	Paurotis					30				150	150		70	5	30	
	Murray	1														
Northeast	Tern										55					
	South Nest	1		1			1									
	Porjoe										1					1
	Duck				15				50	10	90		60			17
	Madeira Hammock			5	5						87		60	12		
	Diamond				90						50					
	Eagle			4												3
	North Nest										1					
	Lil Betsy						2		2							
	Lake	1										1				
Southeast	Low	1														
	Stake	1		2							4					
	East	1														
	Pigeon			2					200							
	Dowitcher Key	1														
	Cowpens			3					40							
Central	East Bob Allen			1												
	West Bob Allen	2														
	Central Bob Allen	1									4					1
	Central Jimmie	6		2							100					7
	Calusa	1														
	South Park							10								
	First Mate	1							21		1					3
	Captain	2							15							
	Ogden #12	1														
	North Jimmie	1														
	Brewski	2		6	4											19
Southwest	South Twin			1					30							
	Buchanons				6				85							
Nest Total		**27**	**50**	**119**	**175**	**30**	**3**	**70**	**818**	**195**	**793**	**1**	**230**	**17**	**30**	**77**

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

* The following colonies (by region) had no recorded nests: Northwest Region – Han Van, Frank, Oyster, Cape Sable, Catfish, and Dildo; Northeast Region – Deer, N. Park, and Pass; Southeast Region – M. Nut, B. Nut, Crane, Bottle, Cotton, West, and Crab; Central Region – Manatee, Polluck, Lil Jim, and Russell; Southwest Region – Arsnickers, Barnes, N. Twin, Peterson, Shell, and Green Mangrove.

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SOUTHWEST FLORIDA

In 2016, Audubon Florida monitored five wading bird colonies in Lee and Collier counties. In addition to the colony at Corkscrew Swamp Sanctuary, each of the sites has been used as a Wood Stork (WOST) colony site at some point in the past decade. These colonies are targeted due to the marked decline of WOST in Southwest Florida, including and most importantly, the historic Corkscrew colony. The decline in WOST in this region is concurrent with wetland loss and reduced hydroperiod of many remaining wetlands. While the primary focus of this investigation was WOST, all wading birds using colony sites were reported.

METHODS

Monthly aerial surveys were conducted from a fixed-wing aircraft (February 23, March 25, April 19, May 23, and June 28). At each colony location, a digital SLR camera with a 70-300 mm lens was used to take a series of overlapping photos of the colony at an altitude of 500 to 1,000 feet above ground level. Photos were processed by two independent observers using Cell Counter in ImageJ (Schneider et al. 2012); observer counts were averaged. For each species, counts included number of birds (adults, hatchlings, and branchlings for WOST) and number of nests. WOST hatchlings/nest and branchlings/nest were counted when such counts could be made with certainty (a subset of total nests). Counts of branchlings also include any fledglings present in the colony, as precisely determining maturity from aerial photographs was not possible.

HYDROLOGY

Corkscrew Swamp Sanctuary recorded 117.0 cm of wet season rainfall (June to September 2015) and 88.4 cm of dry season rainfall (October 2015 to May 2016). Compared to the period of record (1969 to present), rainfall totals were above average in both the wet (86th percentile) and dry seasons (95th percentile). Most notable of the dry season rainfall was 32.7 cm received in January, with 18.6 cm received in a 3-day period (January 26-28). Swamp water levels rose 34.4 cm in the month of January and daily water levels set all-time high records January 28 through February 12.

Despite record high water levels recorded in WY2016, analyses of long-term data have revealed a notable decrease in dry season water levels and consequential reduction in wetland hydroperiod in the Corkscrew watershed since 1999-2000 (Clem and Duever, in prep.). Reduced hydroperiod is particularly pronounced in freshwater marsh/pond cypress, bald cypress, and pond habitats that provide critical foraging habitat for WOST and other waders throughout the nesting season. For this reason, WY2016 water levels are presented in context to historic water levels (WY1957 to WY1999) and water levels seen in recent decades (WY2000 to WY2016) (**Figure 16**).

RESULTS

The 2016 nesting season represented the 59th consecutive year monitoring the historic Corkscrew WOST colony and the 11th consecutive year monitoring four additional WOST colony sites in Lee and Collier counties. Wading birds in Southwest Florida formed colonies and initiated nesting late this year. While nesting effort prior to the January rainfall events is unknown, anecdotal observations suggest there was little to no apparent nesting in early January. Colonies began to form in February with nesting/incubating apparent by late March. Colonies were at peak in late May and the two large colonies (Barron Collier 29 and Lenore Island) were still active during the last flight in late June (fate of remaining young is unknown). Colony summaries are presented in the following subsections and in **Table 14**.

Barron Collier 29

In 2016, Barron Collier 29 recorded the highest nesting effort for all species in the 8 years this site has been monitored. The colony was dominated by WOST and Great Egrets (GREG) with peak nests counts 6 and 3 times higher, respectively, than the average of the previous 7 years (monitoring at this site began 2009). This was the first year Cattle Egrets (CAEG) were observed nesting at this site. At peak (May 2016), 287 WOST branchlings (2.9 branchlings/nest) and 191 nestlings (3.0 nestlings/nest) were observed.

Caloosahatchee East

The 2016 colony at Caloosahatchee East consisted primarily of GREG, and peak nesting effort was 17% higher than the 10-year average for GREG at this site.

Collier/Hendry County Line

No wading bird nesting was observed at this site. Nesting has only been recorded at this site in 2 of the last 8 years (2006 and 2012).

Corkscrew Swamp Sanctuary

No wading bird nesting was observed in the old-growth bald cypress surrounding and north of the sanctuary's Horseshoe Marsh, site of the historic colony. Corkscrew Swamp Sanctuary has reported no WOST nesting in 8 of the last 10 years, with the last notable nesting effort in 2009 (1,120 nests).

Lenore Island

The 2016 colony at Lenore Island was dominated by WOST, with the second highest WOST nesting effort in the 11-year period of record (highest was 2009). WOST nesting effort was 2 times the 10-year average, with 455 WOST branchlings (2.9 branchlings/nest) and 127 nestlings (2.4 nestlings/nest) at peak (May 2016). GREG and Great Blue Heron (GBHE) nesting efforts were 48% and 36% lower than the 10-year average, respectively.

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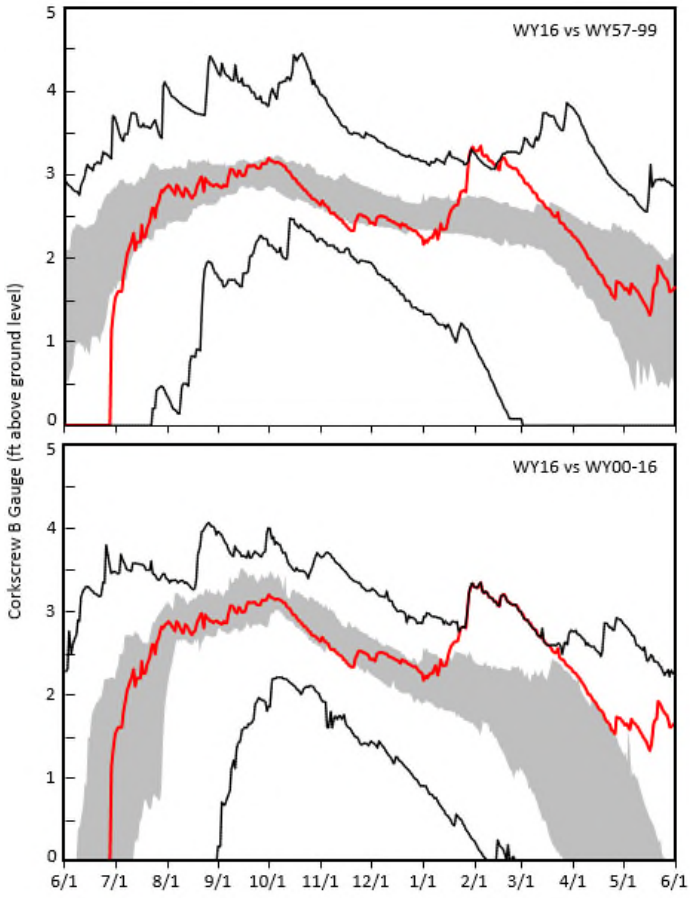

Figure 16. Daily water level (feet above ground level) at the 'B' staff gauge at Corkscrew Swamp Sanctuary (red) in WY2016 (June 1, 2015 to May 29, 2016) relative to two time periods: WY1957-WY1999 (top) and WY2000-2016 (bottom). For each time period, dashed lines represent the daily maximum and minimum and the shaded area represents the 25th to 75th percentile of daily values.

Table 14. Peak nest counts, February through June 2016.

Colony	Latitude	Longitude	WOST	GREG	WW	CAEG	SNEG	ANHI	GBHE	ROSP	BRPE	Total
Barron Collier 29	26.273050	-81.343883	344	84	26	64*	2	0*	0	1	0	**521**
Caloosahatchee East	26.696583	-81.794950	0	15	4	1	0	1	3	0	0	**24**
Lenore Island	26.688867	-81.830150	307	27	20	1	0	1*	9	1	6	**372**
Total			**651**	**126**	**50**	**66**	**2**	**2**	**12**	**2**	**6**	**917**

Note: Nests were not observed (count = 0) at Collier/Hendry County Line and Corkscrew Swamp Sanctuary. Also, WHIB, LBHE, TRHE, and SMDA nests were not observed (count = 0) at any location.
*Nest counts probably underestimated based on observations of adult and juvenile birds.

CORKSCREW REGIONAL ECOSYSTEM WATERSHED MANAGEMENT AREA

The Florida Fish and Wildlife Conservation Commission (FWC) monitored five wading bird nesting colonies in and around Corkscrew Regional Ecosystem Watershed Management Area (CREW) and National Audubon Society's Corkscrew Swamp Sanctuary (CSS). Foraging and roosting aggregations were identified also with the goal of monitoring long-term trends in activity.

METHODS

Monthly systematic aerial surveys of CREW and CSS were performed in a Cessna 182 covering 170 km² (41,910 acres) from November 2015 through July 2016. To locate active colonies, transects were spaced 1.48 km (0.8 nautical miles) apart, oriented northeast to southwest (**Figure 17**) and flown at an altitude of 244 m (800 ft). Once a colony was located, altitude was reduced to 152 m (500 ft), the GPS coordinates were recorded, and digital photos were taken using a Canon EOS 7D with a 70-300 mm lens with image stabilization. Nests were counted from the photos by digitally marking them using Adobe® Photoshop Elements 9. Peak nest numbers (PNN) (the highest nest count for the season) were reported for each species within each colony.

Due to the strong El Niño conditions in 2016, southwest Florida experienced the wettest January on record and an uncharacteristic bimodal pattern of wetland water levels. Stage data indicated that water levels peaked toward the end of the wet season on September 30, 2015 and fell thereafter during the early winter dry season, as is typical. However, heavy rainfall in January 2016 resulted in an unusual and larger (0.15 ft higher) second increase in water level that peaked on February 4, 2016 (CSS Lettuce Lake staff gauge; 26.375582, -81.603836). Water levels declined again after February 4.

RESULTS AND DISCUSSION

A total of 483 nests were counted from 5 active wading bird colonies. This is a 5% decrease from 2014-2015 when only three nesting colonies were observed. Three of the five nesting colonies have been active for the last 4 years (Orange Grove, Sod Farms, and Cypress East) (**Table 15**). No Wood Stork (WOST) nesting was observed in CREW or CSS.

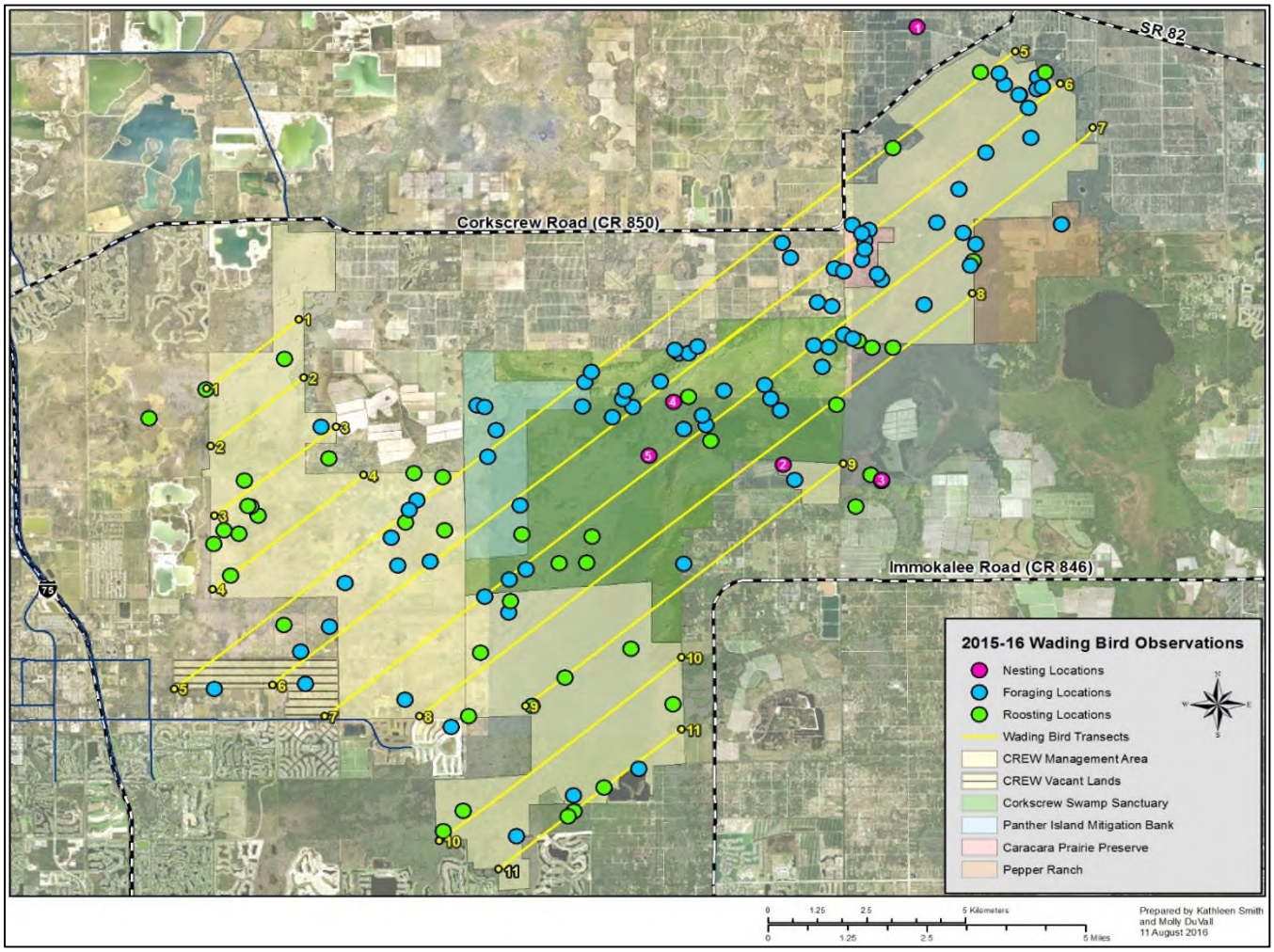

Figure 17. Locations of nesting, foraging, and roosting wading birds in and around CREW Management Area and Corkscrew Swamp Sanctuary, November 2015 through July 2016. Colony 1 is Orange Grove, Colony 2 is Sod Farms, Colony 3 is Cypress East, Colony 4 is Corkscrew Swamp Sanctuary GREG, and Colony 5 is Corkscrew Swamp Sanctuary Small White.

Table 15. Peak number of wading bird nests at the CREW Management Area and Corkscrew Swamp Sanctuary, 2013 to 2016.

Colony	Latitude	Longitude	Year	GREG	SNEG	CAEG	ROSP	BCNH	GRHE	TRHE	LBHE	ANHI	LGWH	LGDA	SMWH	SMDA	Total
1	26.50040	-81.54440	2013	56	1	12	0	0	0	0	0	2	0	0	7	0	**78**
			2014	49	1	1	0	0	1	0	0	6	0	0	5	0	**63**
			2015	18	4	2	0	0	0	2	2	5	2	0	1	0	**36**
			2016	39	2	9	0	0	0	3	1	5	2	1	2	0	**64**
2	26.39442	-81.57841	2013	0	0	198	0	0	0	3	10	1	0	0	116	2	**330**
			2014	0	1	251	0	0	0	1	18	0	0	0	33	0	**304**
			2015	2	16	319	0	0	0	7	66	2	0	0	1	1	**414**
			2016	0	2	70	0	0	0	3	22	0	0	0	7	0	**104**
3	26.39290	-81.55680	2013	8	0	0	0	0	0	0	0	0	0	0	0	0	**8**
			2014	90	0	0	7	0	0	0	0	0	0	0	0	0	**97**
			2015	53	1	0	0	0	0	0	0	2	1	0	0	0	**57**
			2016	77	0	0	0	0	0	0	0	3	0	0	0	0	**80**
4*	26.40473	-81.59860	2014	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
			2016	61	0	0	0	0	0	0	0	1	0	0	0	0	**62**
5	26.3897	-81.6123	2014	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
			2016	1	4	126	1	13	4	2	12	8	0	0	2	0	**173**

Colony 1 = Orange Grove, owned by Alico; Colony 2 = Sod Farms, owned by CREW; Colony 3 = Cypress East, privately owned; Colony 4 = CSS GREG, owned by CSS; Colony 5 = CSS SMWH, owned by CSS.
* The 2016 CSS GREG colony nested approximately 0.86 km (0.54 mi) northwest of the 2014 location.

Orange Grove

The peak count for the Orange Grove colony was 64 nests, a 44% increase compared to 2015 (**Table 15**). The increase was largely due to increased Great Egrets (GREG) nesting at this colony during 2016. GREG were the first species to begin nesting (March). Six species nested in the colony: GREG, Anhinga (ANHI), Snowy Egrets (SNEG), Tri-colored Herons (TRHE), Little Blue Herons (LBHE), and Cattle Egrets (CAEG).

The Orange Grove colony is located on a vegetated island in a retention pond at the Alico-owned orange grove. Power lines (15 m high) pass over the island. Birds nested in Brazilian pepper surrounded by Peruvian primrose willow.

Sod Farms

The peak count for the Sod Farms colony was 104 nests. Nesting decreased 75% from 2015 due to a significant reduction in the number of nesting CAEG. SNEG and TRHE also declined from 2015 (**Table 15**). Five species were observed in this colony, and four of the five species nested (SNEG, LBHE, TRHE, and CAEG). Nesting at this colony was first observed in May.

Birds nested in Carolina willow surrounded by Brazilian pepper. The willow was located in a shallow marsh bordered by bald cypress.

Cypress East

The peak count for the Cypress East colony was 80 nests. This colony consisted primarily of nesting GREG with a few nesting ANHI. The peak count for GREG increased 31% relative to 2015, but was below that of 2014 (**Table 15**). Nesting was first observed in March.

This colony was found in 12 m (40 ft) high bald cypress trees surrounded by an alligator flag depressional marsh.

Corkscrew Swamp Sanctuary GREG

The peak count for the CSS GREG colony was 62 nests and included nesting GREG and ANHI (**Table 15**). Nesting was first observed in April. This colony was initially observed in 2014 with two nesting GREG. In 2016, the colony location moved 0.86 km (0.54 mi) northwest from its 2014 location, and substantially increased the number of nesting birds. The birds in this colony nested on the perimeter of a cypress dome in bald cypress trees.

Corkscrew Swamp Sanctuary Small White

The peak count for the CSS Small White colony was 173 nests. It consisted of seven nesting wading bird species, including Black-crowned Night Herons (BCNH) and a single Roseate Spoonbill (ROSP) nest (**Table 15**). Birds began nesting in April. The primary nesting substrate is Carolina willow interspersed with Brazilian pepper and red maple.

Foraging and Roosting Effort

In addition to nesting colonies, a total of 90 foraging aggregations and 46 roosting colonies were located (**Figure 17**). White Ibis (WHIB) (n = 4,533), GREG (n = 1,097), SNEG (n = 472), CAEG (n = 185), ROSP (n = 146), and WOST (n = 128) were the most abundant species observed in foraging aggregations, with WHIB and GREG being present in 91% and 76% of the foraging aggregations, respectively. WHIB and GREG also were the most common species in roosting colonies with 70% and 39% presence, respectively. Other species of interest either foraging or roosting on CREW included LBHE, TRHE, BCNH, and Yellow-crowned Night Herons (YCNH).

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

INTRODUCTION/BACKGROUND

For nine consecutive years, the Florida Department of Environmental Protection (FDEP) and U.S. Fish and Wildlife Service have been collaborating to collect wading and diving bird nesting data. Staff at Charlotte Harbor Aquatic Preserves (CHAP), a field site of the Florida Coastal Office of the FDEP, and J.N. "Ding" Darling National Wildlife Refuge (NWR) have conducted colonial nesting bird surveys within the Ding Darling NWR Complex, and the Matlacha Pass, Pine Island Sound, Gasparilla Sound-Charlotte Harbor, Cape Haze, and Lemon Bay Aquatic Preserves (**Figure 18**). Colonial wading and diving bird nest monitoring began in 2008 with 9 islands and expanded to 34 islands in 2011. This year, 32 islands were monitored, and 27 were identified as active wading and diving bird nesting sites within the study area. Goals of this continuous study include documenting population trends to better understand avian biodiversity on the islands, and producing a long-term dataset for better analysis of nesting efforts by species throughout the greater Charlotte Harbor estuarine system.

Figure 18. Locations of monitored bird colonies in the Charlotte Harbor Aquatic Preserves and J.N. "Ding" Darling NWR Complex.

METHODS

The study area was divided between the two agencies based on location. J.N. "Ding" Darling staff monitored islands in South Matlacha Pass, San Carlos Bay, and South Pine Island Sound. FDEP/CHAP staff monitored islands in North Matlacha Pass, North Pine Island Sound, Gasparilla Sound, Lemon Bay, and Cape Haze. Both agencies employ a direct count method with a primary observer, secondary observer, boat captain, and data recorder. Islands were circled by boat and individual nests were recorded according to species. Nests were recorded as *incubating*, *chicks*, or *unknown* if the nesting stage could not be determined. Nests were documented as *incubating* when an adult was sitting on the nest in a crouched position, shading the nest. The *chicks* category 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 was not used as a measure of productivity. Data collected from February through July 2016 were analyzed for this report. Peak numbers reflect the highest number per species throughout the survey period. The total number of peak nests were calculated for each island as well.

RESULTS

The peak estimate for 14 species of colonial nesting birds from all islands combined was 1,412 nests (**Table 16**). Approximately 29% (409) of the nests were wading bird species while the remaining 71% (1,003 nests) were diving birds. This was a decrease of 119 nests from last year (peak nesting in 2015 was 1,531 nests). The largest nesting effort in 2016 occurred on Hemp Key (284 nests), Broken Islands (234 nests), and Useppa Oyster Bar (136 nests). The islands supporting nests with the most species biodiversity were Pirate Harbor SE (11 nests), Pirate Harbor N (10 nests), and Broken Islands (10 nests).

Species Summaries

Double-crested Cormorant (DCCO)

DCCO nesting peaked at 554 nests, making up approximately 40% of nests in the 2016 season. Nesting was documented on 16 islands, with the highest nest count (167) occurring on Hemp Key.

Table 16. Colonial nesting bird peak counts for the Charlotte Harbor Aquatic Preserves and J.N. Ding Darling NWR Complex, March through July 2016.

Colony (Island)	Lat.	Long.	GBHE	TRHE	LBHE	SNEG	GREG	REEG	CAEG	YCNH	BCNH	GRHE	WHIB	BRPE	DCCO	ANHI	Total
Broken Islands	26.6777	-82.1940	4	17	2	5	1	8	0	0	0	1	13	100	83	0	234
Burnt Store Marina N	26.7625	-82.0669	7	0	0	0	3	0	0	1	0	0	0	1	1	0	13
Burnt Store Marina S	26.7611	-82.0660	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Clam Key	26.5063	-82.1128	1	0	0	1	1	0	0	1	0	0	0	28	29	1	62
Cork Island	26.5742	-82.1273	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Darling Keys	26.6669	-82.1811	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E of Chadwick Cove	26.9289	-82.3511	9	0	1	5	15	0	0	0	0	0	0	0	4	0	34
Fish Hut Island	26.5467	-82.1245	1	1	1	1	2	2	0	0	0	2	0	0	21	1	32
Gasparilla Marina S	26.8269	-82.2625	5	8	0	11	1	0	0	1	1	2	0	20	33	0	82
Hemp Key	26.5999	-82.1532	18	0	0	0	39	0	0	0	1	0	0	59	167	0	284
Masters Landing	26.5666	-82.0749	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N of Mason Island	26.5581	82.1219	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N of York Island	26.4945	82.1043	2	1	0	0	2	0	0	0	1	2	0	60	14	2	84
N of Big Smokehouse	26.0000	-82.1225	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
NE of York Island	26.4940	-82.1021	0	0	0	0	0	0	0	0	0	2	0	14	0	0	16
NW of Mason Island	26.5543	82.125	0	0	0	0	0	0	0	0	0	0	0	1	22	1	24
NW of Pumpkin Key	26.5660	-82.1279	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Pirate Harbor N	26.8052	-82.0597	5	1	0	7	14	1	5	0	1	0	0	20	5	2	61
Pirate Harbor SE	26.8037	-82.0565	4	12	1	7	0	1	17	1	1	0	0	17	41	4	106
Royal Palm Marina	26.9640	-82.3708	13	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Skimmer Island	26.5104	-82.0250	3	0	0	0	2	0	0	0	0	0	25	24	17	0	71
SW of Mason Island	26.5534	-82.1250	2	0	0	0	0	0	0	0	0	0	0	0	1	1	4
SW of Pumpkin Key	26.5640	-82.1275	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Tarpon Bay Keys	26.4577	-82.0744	7	5	0	4	18	0	0	0	1	0	0	21	16	1	73
Upper Bird Island	26.5592	-82.0714	4	0	0	0	0	0	0	0	0	0	0	23	7	0	34
Useppa Oyster Bar	26.6513	-82.2134	5	0	0	0	1	0	0	0	1	0	0	48	81	0	136
White Pelican Island	26.7905	-82.2463	7	0	0	8	3	5	0	1	0	0	0	0	12	0	36
Total			**104**	**45**	**5**	**49**	**102**	**17**	**22**	**5**	**7**	**15**	**38**	**436**	**554**	**13**	**1,412**

Note: Nesting birds were not observed at the following colonies (islands): Bird Rookery Keys, Crescent Island, Givney Key, Lumpkin Island, Lower Bird Island, and N Regla.

Brown Pelican (BRPE)

BRPE nesting peaked at 436 nests and was documented on 13 islands. This accounted for approximately 30% of the nesting effort documented this season. The highest peak nest count occurred at Broken Islands, with a nest count of 100 occurring in May.

Anhinga (ANHI)

ANHI nesting occurred on 8 islands with a peak nest count of 13. The highest nest count was 4 and occurred on Pirate Harbor SE.

Great Blue Heron (GBHE)

GBHE nesting was documented on 23 islands, 81% of the islands monitored this year. The peak nest count for GBHE was 104. Hemp Key had the largest number of peak nests with a count of 18. A white morph GBHE was documented nesting on Hemp Key.

Tricolored Heron (TRHE)

TRHE nests were documented on 10 islands with a peak nest count of 45. Approximately 65% of the nesting effort occurred on Broken Islands and Pirate Harbor SE, with a combined peak nest count of 29. Both peak nest counts occurred in June.

Little Blue Heron (LBHE)

LBHE nesting peaked at five nests. Nests were documented on 4 of the 32 islands monitored. The highest nest count (2) occurred on Broken Islands.

Snowy Egret (SNEG)

SNEG nesting occurred on 9 islands with a peak nest count of 49. Gasparilla Marina S had the highest peak nest count (11) followed by White Pelican Island (8).

Great Egret (GREG)

GREG nesting peaked at 102. Approximately 38% of nesting effort (39) was documented on Hemp Key, peaking in May. GREG nested on 12 islands.

Reddish Egret (REEG)

REEG were documented nesting on 5 islands with a peak nest count of 17. Broken Islands had the highest nest count of eight, which occurred in June.

Yellow-crowned Night Heron (YCNH)

Five nests were recorded during the 2016 survey period on five separate islands.

Black-crowned Night Heron (BCNH)

BCNH nesting was documented on seven islands and peaked at seven nests.

Green Heron (GRHE)

GRHE nesting peaked at 15 with the highest count occurring at N of Big Smokehouse (4).

White Ibis (WHIB)

WHIB nesting occurred on 2 islands with a peak count of 38. Skimmer Island accounted for approximately 66% of the nesting effort (25).

Cattle Egret (CAEG)

CAEG nesting peaked at 22 with approximately 77% (17) documented on Pirate Harbor SE. This species was also found nesting on Pirate Harbor N with a nest count of five.

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

Estero Bay Aquatic Preserve was designated in 1966 as Florida's first aquatic preserve. Established by law, aquatic preserves are submerged lands of exceptional beauty, biological, aesthetic, and scientific value that are to be maintained in their natural or existing conditions for the benefit of future generations. Estero Bay Aquatic Preserve covers 11,000 acres in Lee County, bordered on the east by Fort Myers, Estero, and Bonita Springs, and on the west by Estero Island, Long Key, Lovers Key, Black Island, Big Hickory Island, and Little Hickory Island. Estero Bay is a shallow estuary fed by five minor tributaries that support extensive seagrass beds, oyster reefs, and hundreds of islands dominated by mangroves. The islands provide roosting and nesting habitat for wading and diving birds; nesting has been documented on 25 islands.

METHODS

Surveys between 2008 and 2016 were conducted once a month throughout the nesting season. Each year, surveys were initiated when birds were observed carrying nesting materials and concluded when all chicks had fledged. Since 2012, surveys were conducted year-round due to the extended period of nesting. Surveys were conducted by boat using a direct count method as described by Audubon of Florida (2004). Islands were surveyed at a distance of 30 to 45 m by two observers; nests were documented by species and nesting stage. The primary observer, an aquatic preserve staff member, was consistent throughout the study period. Trained volunteers conducted secondary observer counts. The average of the two observers' counts was reported. Monthly counts from 2016 are compared with monthly counts from 2008 through 2015. Mean peak nest counts for surveys conducted 2008 to 2015 represent the eight-year average for Estero Bay.

In 2016, surveys were conducted on January 5, 7, and 12; February 15 and 16; March 9 and 15; April 13 and 18; May 11, 17, and 18; June 15 and 16; and July 12, 13, and 18.

RESULTS

In January, 12 islands were active with Double-crested Cormorants (DCCO; n = 27), Brown Pelicans (BRPE; n = 10), Great Blue Herons (GBHE; n = 40), Great Egrets (GREG; n = 2), and a Green Heron (GRHE; n = 1). Between January (n = 90) and July 2016 (n = 167), 18 of the 25 islands monitored were active with an annual peak nest count of 422 (**Table 17**). Nest counts peaked in June (n = 303). The Matanzas Pass colony had the most nests in Estero Bay, with an annual peak count of 130 active nests. Overall, nesting colonies saw a 3% increase in nesting effort from the 9-year average; however, DCCO, GBHE, GREG, Little Blue Herons (LBHE), and Yellow-crowned Night Herons (YCNH) showed a decrease in nesting effort (**Table 18**).

DCCO nests were documented on seven islands, with nesting activity recorded from January (n = 24) through July (n = 38); nesting activity peaked in May (n = 51). DCCO peak nesting numbers for 2016 (n = 67) were 4% below the 9-year average.

BRPE nests were documented from January (n = 18) through July (n = 60) on three islands. Peak nest counts were recorded in June (n = 125), with a season peak of 127 active nests. BRPE peak nesting was 18% above the 9-year average.

GBHE nests were documented from January (n = 44) through July (n = 7) on 12 islands. Nesting effort peaked in March (n = 53) with a peak of 65 nests, 7% below the 9-year average. White morphs were documented on four nests at four separate nesting colonies.

GREG nests were documented from January (n = 2) through July (n = 11) on five islands. Nesting peaked in April (n = 30), and the annual peak was 37 nests, a 29% decrease in nesting compared to the 9-year average.

SNEG nests were documented from March (n = 1) through July (n = 2), with peak nest counts in June (n = 28). SNEG nests were documented on four islands, with an annual peak nest count of 33, a 35% increase over the 9-year average.

LBHE nests were documented on three islands March (n = 1) through July (n = 3); nesting activity peaked in April (n = 8). LBHE peak nest counts for 2016 (n = 9) represented a 39% decrease in nesting effort compared to the 9-year average.

Tricolored Heron (TRHE) nests were documented on four islands between April (n = 2) and July (n = 9), with peak nesting effort in June (n = 32). The annual peak (n = 34) represented a 35% increase in nesting effort compared to the 9-year average.

Reddish Egret (REEG) nests were documented from February (n = 1) through July (n = 6) on four islands. The annual peak nest count (n = 11) represented a 54% increase compared to the 9-year average.

Black-crowned Night Heron (BCNH) nests were documented on 6 islands with an annual peak of 16 nests, a 16% increase compared to the 9-year average. Nesting was documented from March (n = 1) through July (n = 10).

YCNH nesting was documented on six islands from April (n = 5) through July (n = 3). The annual peak nest count was 13 nests, which represented a 37% decrease in nesting effort compared to the 9-year average.

GRHE nests were documented on five islands in January and from April (n = 1) through July (n = 9). Peak nesting effort occurred in July (10 nests), a 78% increase in nesting effort over the 9-year average.

Anhinga (ANHI), White Ibis (WHIB), and Cattle Egret (CAEG) nests were not observed during 2016 surveys.

Between January and July 2016, volunteers contributed 98 hours of service to monitoring and protecting wading and diving bird colonies in Estero Bay. Staff and volunteers removed 264 feet of fishing line and 15 hooks from nesting islands during this time period. Fifteen bird fatalities were documented due to fishing line entanglement.

Table 17. Peak nest counts documented in Estero Bay Aquatic Preserve colonies, January through July 2016.

Colony	Latitude	Longitude	DCCO	BRPE	GBHE	GREG	SNEG	LBHE	TRHE	REEG	BCNH	YCNH	GRHE	Total
619038c	26.36737	-81.84357	0	0	0	0	0	0	0	0	0	1	0	1
Big Bird Island	26.38286	-81.84995	0	0	4	0	0	0	0	0	0	0	0	4
Big Carlos Pass M-43	26.43155	-81.90066	0	0	0	0	0	0	0	0	0	3	0	3
Big Carlos Pass M-48	26.42771	-81.90050	0	0	0	0	0	0	0	0	0	0	1	1
Big Carlos Pass M-50 and 52	26.42244	-81.89527	8	0	4	0	0	0	0	0	1	1	1	15
Big Carlos Pass W of M-52	26.42469	-81.89359	7	26	6	20	12	2	11	3	6	0	0	93
Big Hickory E of M-85	26.35315	-81.84164	6	0	10	2	0	0	0	3	0	0	0	21
Coconut Point East	26.38411	-81.84905	23	54	6	7	7	1	0	1	4	0	0	103
Coconut Point West	26.38111	-81.84976	0	0	4	0	0	0	0	0	0	0	0	4
Denegre Key	26.43772	-81.86728	0	0	6	0	0	0	1	0	1	3	6	17
Estero River M-30	26.43029	-81.86113	0	0	0	0	0	0	0	0	0	0	1	1
Estero River North	26.43653	-81.86091	0	0	0	0	0	0	0	0	0	0	1	1
Hogue Channel M-78	26.34988	-81.84644	1	0	0	0	0	0	0	0	0	4	0	5
Matanzas Pass	26.46092	-81.95717	21	47	13	6	11	6	20	4	1	1	0	130
New Pass M-21	26.38865	-81.85925	0	0	1	0	0	0	0	0	0	0	0	1
New Pass M-9	26.40465	-81.86816	1	0	7	0	0	0	0	0	0	0	0	8
North Coconut E of M-3	26.41131	-81.85486	0	0	3	2	3	0	2	0	3	0	0	13
Ruth's Island	26.40783	-81.85302	0	0	1	0	0	0	0	0	0	0	0	1
Total			**67**	**127**	**65**	**37**	**33**	**9**	**34**	**11**	**16**	**13**	**10**	**422**

Note: Nests were not observed (count = 0) in the following colonies: Big Carlos Pass S of M-48, Big Carlos Pass W of M-46, Big Hickory M-83, Big Hickory M-49 2NW, Big Hickory M-49 3NW, Estero River South, and North Coconut M-4.
ANHI were not observed (count = 0).

Discussion

Estero Bay nesting activity exhibits annual variation. However, the annual peak nest count this season was above the 9-year average and overall show an increasing trend in the bay (**Table 18**). This trend is not consistent across species. While three out of the four canopy-nesting species (DCCO, GBHE, GREG) showed a decline in nesting activity in 2016 compared to the 8-year average, BRPE showed an increase in nesting activity. Out of the eight interior-nesting species, LBHE, CAEG, and YCNH showed a decline in nesting activity for 2016.

The highest concentration of BRPE, GREG, SNEG, and LBHE nesting activity has been concentrated on three islands: Matanzas, Coconut Point East, and Big Carlos West of 52. These islands also represented the highest concentration of fishing line fatalities and human disturbance concerns. Estero Bay Aquatic Preserve staff, in conjunction with stakeholders and the Florida Fish and Wildlife Conservation Commission, completed the Estero Bay Wading and Diving Bird Management Strategy in June 2015. The Management Strategy outlines management efforts and needs based on scientific data and stakeholder input.

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Table 18. Mean nest count, standard error, standard deviation, and percent mean differences by species for mean peak nest counts (2008 to 2015) and current (2016).

Species	Mean (2008-2015)	Std. Error	Std. Dev.	Peak (2016)	% Change
DCCO	70	211	559	67	-4
BRPE	108	326	862	127	18
GBHE	70	212	562	65	-7
GREG	52	158	417	37	-29
SNEG	24	74	195	33	35
LBHE	15	45	119	9	-39
TRHE	25	76	201	34	35
REEG	7	22	57	11	54
CAEG	1	3	9	0	-100
BCNH	12	36	96	16	33
YCNH	21	63	166	13	-37
GRHE	6	17	45	10	78
Total	**411**	**1,243**	**3,289**	**422**	**3**

WADING BIRD NESTING AT LAKE OKEECHOBEE

Since 2005, Florida Atlantic University (FAU) has conducted systematic wading bird nesting surveys at Lake Okeechobee as part of the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan. The estimated number of Great Egret (GREG), Great Blue Heron (GBHE), White Ibis (WHIB), Snowy Egret (SNEG), Little Blue Heron (LBHE), Tricolored Heron (TRHE), Wood Stork (WOST), Glossy Ibis (GLIB), and Roseate Spoonbill (ROSP) nest initiations in 2016 was 2,453 nests, which is 53% below the 10-year average and 50% below the 5-year average. Water levels were highest on February 8, 2016, reaching 16.33 ft. Even after a rapid water-level recession, the lowest water levels were 13.63 ft on May 17, 2016. High water levels delayed nesting, and nests were active through June. However, heavy rainfall and a strong reversal during the recession resulted in high rates of nest failures at the end of the nesting season.

METHODS

From February through June 2016, FAU personnel assessed the location, timing, and nesting effort of wading bird nesting colonies. At several locations, estimates of nest initiations obtained during aerial surveys were validated during separate ground surveys. Only GREG, GBHE, WHIB, and SNEG were included in comparisons of historical nest numbers because they are relatively easy to detect and nest regularly on Lake Okeechobee. Detailed methods are described in previous editions of the *South Florida Wading Bird Report*.

Rainfall and lake stage data were obtained from South Florida Water Management District's DBHYDRO database. The lake stage is calculated as the mean of four gauges in the pelagic zone of Lake Okeechobee (L001, L005, L006, and LZ40). All elevation data are presented in National Geodetic Vertical Datum 1929 (NGVD29), and locations are in North American Datum 1983 (NAD83). Historical stage data are from 1977 to present, which corresponds to the time period of systematic aerial wading bird nesting surveys.

RESULTS

Hydrology

The 2016 nesting season was characterized by the highest dry season water levels since 1998. Unseasonal rainfall from January 15 to February 9, mostly due to a major rainfall event in late January, caused lake stage to increase to a season high of 16.33 ft. A steady recession of water levels from February 10 to May 16 was disrupted by only a few minor rainfall events in early April. The average 2-week recession rate from March 1 to May 17 was 0.29 inches/day. The remainder of the season was characterized by heavy rainfall, particularly from May 17 to 28 (**Figure 19**).

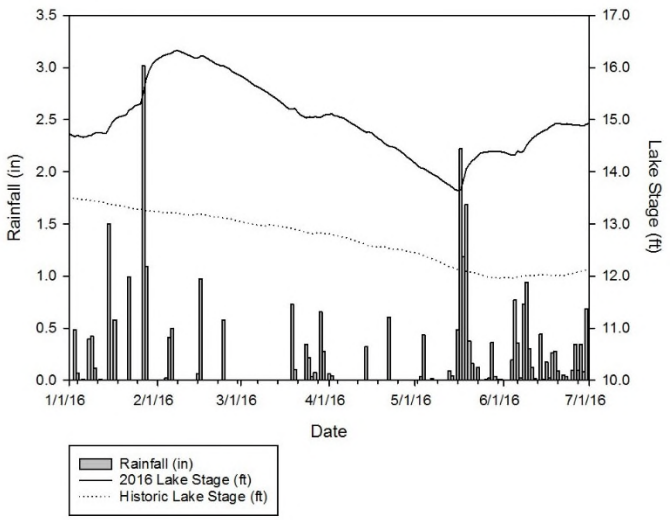

Figure 19. Hydrograph of Lake Okeechobee from January 1 to June 20, 2016, including historic lake stage (1977 to present) and rainfall (inches).

Colony Location and Size

Twelve colonies were detected on-lake and two colonies were detected off-lake (**Table 19**; **Figure 20**). Liberty Point 2 was the largest colony and had a total of 624 nests during the breeding season. The most prevalent species on Lake Okeechobee were GREG (1,114 nests), SNEG (829 nests), and WHIB (270 nests). The total number of wading bird nests (excluding CAEG and ANHI) was 2,453 (**Table 20**), which was 53% below the 10-year average (5,222 ± 3,641 nests) and 50% below the 5-year average (4,888 ± 2,235 nests). The number of GREG nests increased compared to the 5- and 10-year averages, while all small heron and ibis species decreased. Declines in nest numbers were observed throughout South Florida, with the exception of GREG on Lake Okeechobee and SNEG in the Water Conservation Areas.

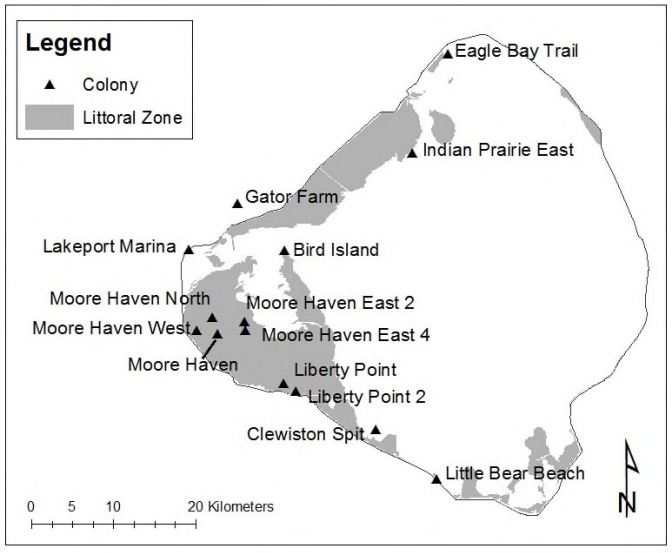

Figure 20. Map of wading bird colonies observed at Lake Okeechobee from February to June 2016.

Table 19. Timing and nesting effort for species breeding in wading bird colonies during 2016 at Lake Okeechobee.

Month	GREG	GBHE	WHIB	SNEG	LBHE	TRHE	WOST	GLIB	ROSP	CAEG	ANHI	Peak Nest Effort[1]
January	--	--	--	--	--	--	--	--	--	--	--	--
February	223	--	--	--	--	--	--	--	--	--	--	223
March	**1,042**	1	33	33	--	6	**63**	--	--	--	--	1,115
April	853	**2**	60	**656**	**41**	76	25	**22**	--	440	5	**1,708**
May	--	--	**225**	125	10	**104**	12	12	**6**	**892**	**35**	482
June	--	--	200	--	--	3	--	--	--	800	--	203

[1] Does not include CAEG or ANHI.
Note: Bold values denote peak nest effort for species.

Table 20. Geographic coordinates (NAD 83) and species-specific peak nest efforts in detected colonies during the 2016 breeding season at Lake Okeechobee.

Colony	Peak Month[1,2]	Latitude	Longitude	GREG	GBHE	WHIB	SNEG	LBHE	TRHE	WOST	GLIB	ROSP	CAEG	ANHI	Total[1]
Bird Island	April	26.97199	-81.00917	--	1	--	22	--	4	--	--	--	--	--	27
Clewiston Spit	April	26.77573	-80.90938	56	--	--	93	--	30	--	12	--	--	--	191
Eagle Bay Trail	April	27.18791	-80.83170	13	--	--	25	5	5	--	--	--	425	--	48
Gator Farm	April	27.02278	-81.06084	165	--	--	60	--	3	63	--	4	150	--	295
Indian Prairie East	April	27.07852	-80.86883	190	--	--	133	--	--	--	--	--	290	6	323
Lakeport Marina	March	26.97260	-81.11440	86	--	--	13	--	3	--	--	--	140	--	102
Liberty Point	April	26.82565	-81.01067	20	--	--	--	--	--	--	--	--	--	--	20
Liberty Point 2	April	26.81752	-80.99675	253	1	225	125	10	10	--	--	--	--	15	624
Little Bear Beach	April	26.72139	-80.84222	70	--	--	90	3	30	--	--	--	--	--	193
Moore Haven	April	26.88058	-81.08236	150	--	12	218	--	20	--	10	--	66	--	410
Moore Haven East 4	April	26.89336	-81.05337	46	--	23	20	23	3	--	--	--	--	--	115
Moore Haven East 2	March	26.88409	-81.05237	37	--	10	30	--	--	--	--	--	--	--	77
Moore Haven North	March	26.89829	-81.08854	25	--	--	--	--	--	--	--	--	--	--	25
Moore Haven West	March	26.88423	-81.10539	3	--	--	--	--	--	--	--	--	--	--	3

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

Timing

GREG and small numbers of SNEG initiated nests by the first aerial survey on March 1, and there was evidence of TRHE and LBHE nesting on the lake before March 24. Median nest initiation dates were March 17, April 7 and April 13 for GREG, SNEG, and TRHE, respectively. WHIB began initiating nests at Liberty Point 2 synchronously during the last week of April and first week of May. Peak nest numbers were observed in March, April, and May for GREG, small ardeids, and WHIB, respectively (**Table 19**).

Wood Storks and Roseate Spoonbills

Sixty-three WOST and 4 ROSP nests were detected at the Gator Farm, an off-lake colony located north of the Moonshine Bay area. Peak nesting for WOST occurred in March with 63 nests detected; however, the number dropped to only 25 nests in April and 12 nests in May. ROSP nests were first discovered during the May 23 aerial survey. At least 13 WOST chicks fledged, but none of the ROSP nests survived. WOST have not been detected nesting on Lake Okeechobee since 2010, and there have been only three records of ROSP nesting on-lake since 1874 (2009, 2013, and 2015)

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LAKE OKEECHOBEE WADING BIRD FORAGING SURVEYS

Lake Okeechobee historically supported large numbers of nesting wading birds. Wading bird reproduction is energetically expensive and requires a continuous supply of easily accessible prey resources to initiate nesting and successfully fledge offspring. Wading bird foraging on the lake mainly occurs in the shallow littoral zone when receding waters fall below 15.5 ft NGVD, with peak usage occurring between 14.5 and 11.5 ft NGVD. This dry-down provides marsh depths that are suitable for foraging and concentrates prey so they become available to birds. In 1978, the Lake Okeechobee Regulation Schedule was altered such that lake stage was increased (as high as 17.5 ft NGVD). Higher average lake levels reduced the availability of prey to wading birds and limited their access to critical foraging habitat (David 1994a). Wading birds responded to this change with a severe decline in nesting effort over the following decades.

In 2000, the regulation schedule was changed to try and account for climatologic conditions and to take more account of the lake's ecological needs. In 2008, as a result of concerns for the integrity of the Herbert Hoover Dike, the Lake Okeechobee regulation schedule was changed again to maintain the lake approximately 1 ft lower than the preceding schedule. This schedule is more conducive to wading bird breeding success. In 2010, the South Florida Water Management District initiated a wading bird foraging monitoring program in Lake Okeechobee's littoral zone to assess whether ecological conditions on the lake were adequate to support wading bird reproduction. This monitoring effort provides water managers with baseline information on wading bird use of the lake in relation to hydrology and other environmental drivers of nesting.

The resulting foraging data are used to help understand the role of hydrology on birds and other trophic levels. This knowledge can be used to develop indicators of habitat quality and predict habitat suitability and utilization based on climatic change, water management decisions, and competing restoration scenarios, and allows for a general overall assessment of ecological conditions within the lake. It also provides important supporting data for the annual Lake Okeechobee wading bird nesting surveys performed by Florida Atlantic University (FAU).

METHODS

Wading bird surveys were conducted biweekly via helicopter from December through June along east-west transects established at 2-km intervals throughout the entire littoral zone of Lake Okeechobee. Surveys were flown at an elevation of 300 ft (91 m) and a speed of 80 to 90 knots. Two observers, one on each side of the helicopter, each surveyed 1 km of the 2-km strip transect so that the entire littoral zone was surveyed. When a group of foraging wading birds (≥50 birds) was detected, the helicopter would circle the location, and the number of birds foraging within the flock and the species composition of the flock were determined. Birds were identified by species or grouped by color, which includes small white waders (Snowy Egret and juvenile Little Blue Heron) and small dark wader (Tri-colored Heron and adult Little Blue Heron). Additionally, a GPS coordinate of the foraging flock location was recorded in order to correlate foraging and water depth conditions. Photographs of each flock were taken to compare with estimates made during the flight to increase the accuracy of the results.

2016 RESULTS

In December 2015, lake levels were at 14.49 ft NGVD, slightly above the 10-year average for this time of year (**Figure 21**). For the remainder of the dry season (January to May) a "super" El Niño climatic pattern led to higher than normal rainfall throughout the watershed, resulting in unusually high lake levels (maximum of 16.4 ft NGVD in mid-February 2016) and a much reduced area of suitable foraging habitat for wading birds. As expected, wading bird abundance increased when water levels receded and lake stage fell below 15.5 ft, and decreased with high lake stage (>16 ft) and/or when reversals occurred (**Figure 21**). The season was driven by two major reversals in water level, which occurred at the beginning (January) and near the end (May) of the nesting season. An almost continuous reversal, starting on January 5 and lasting approximately 54 days, pushed lake levels to 16.4 ft, the highest level during the nesting season since 1998. The length and magnitude of this reversal, which raised water levels by 1.92 ft, left most of the littoral zone inaccessible to wading birds for an extended period of time. Two surveys conducted during this period coincided with near peak lake stage and resulted, respectively, in 80 and 0 birds foraging on the lake. These were the lowest numbers recorded since surveys were initiated in 2010. Thereafter, the lake experienced a steady recession for the next 100 days, dropping to a seasonal stage low of 13.88 ft, with foraging birds steadily increasing to a high of 2,184 on May 12th. Heavy rainfall and increased inputs from the northern watershed led to a second major reversal, starting on May 18 and lasting through June, when the amount of suitable foraging habitat was again dramatically reduced. The negative response by foraging birds during this second reversal was coupled with near complete abandonment (90%) of White Ibis nests (n = 270). Wading bird use of the lake has varied considerably in relation to fluctuating water conditions over the years, with 2016 having the lowest number of foraging birds since regular surveys were re-initiated in 2010 (**Figure 22**). This serves as an example of wading bird tolerance limits to high water levels and extended periods of rising water levels in Lake Okeechobee.

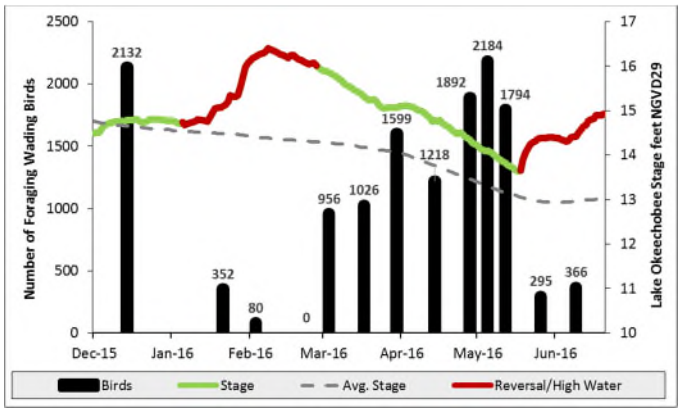

Figure 21. The number of foraging wading birds per survey in relation to lake stage during the 2016 nesting season. The red segments represent high water or reversal periods. The gray dashed line represents the 10-year averaged lake stage.

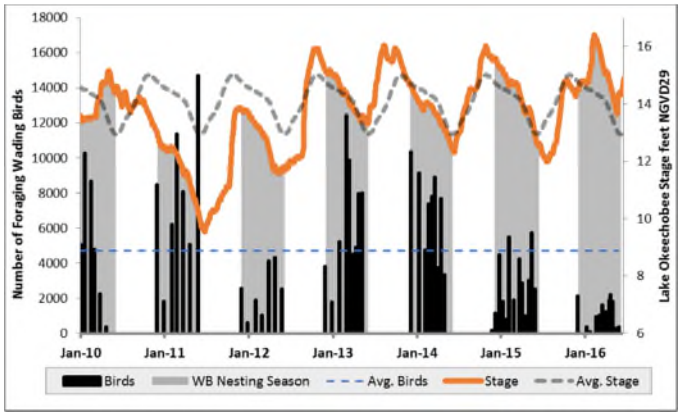

Figure 22. A comparison of the total number of foraging birds surveyed each month from 2010 to 2016 in relation to lake stage (NGVD). The shaded regions represent the survey periods that coincide with the dry season. The blue dashed line represents the average number of foraging wading birds found from 2010 to 2016. The red line is the stage hydrograph, and the gray dashed line represents the 10-year averaged lake stage.

FORAGING AS A PREDICTOR FOR NESTING EFFORT

How the number of foraging birds relate to nesting effort on Lake Okeechobee is often brought up during application of foraging survey results. Often if birds are nesting on the lake, it is assumed they are utilizing the lake as a prey source to sustain nesting activities.

This assumption was examined by correlating peak nesting effort for each of the past 6 years with the number of foraging birds recorded approximately 1 month prior to peak nesting, during peak nesting, and approximately 1 month after peak nesting. Results show that during and after peak nesting foraging, counts are significant and highly correlated (R^2 = 0.6969, 0.893, respectively) to nesting effort (**Figures 23** and **24**). A similar comparison was made in Everglades National Park using foraging data from systematic reconnaissance survey flights and available nesting data to show the nesting effort of certain species is correlated to foraging numbers at the beginning of May (Russel et al. 2002). This may be used as supporting evidence for the importance of accessible foraging habitat during peak and post-nesting (fledgling) for wading birds on the lake.

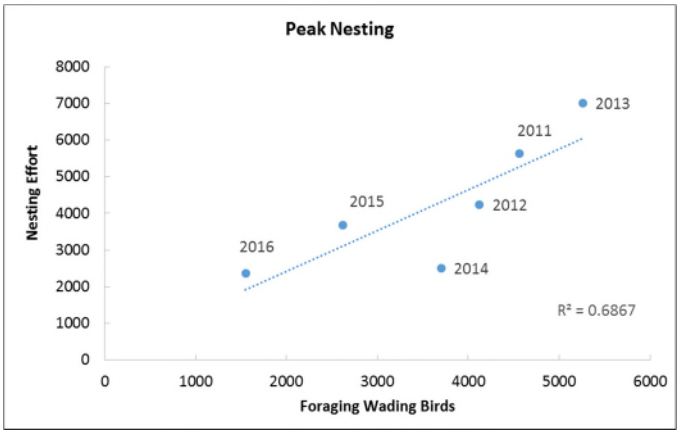

Figure 23. Correlation between peak nesting foraging bird totals and total nesting effort (provided by FAU). Species included: Great Egret, Snowy Egret, White Ibis, Tri-colored Heron, Little Blue Heron, Glossy Ibis, Wood Stork, and Roseate Spoonbill.

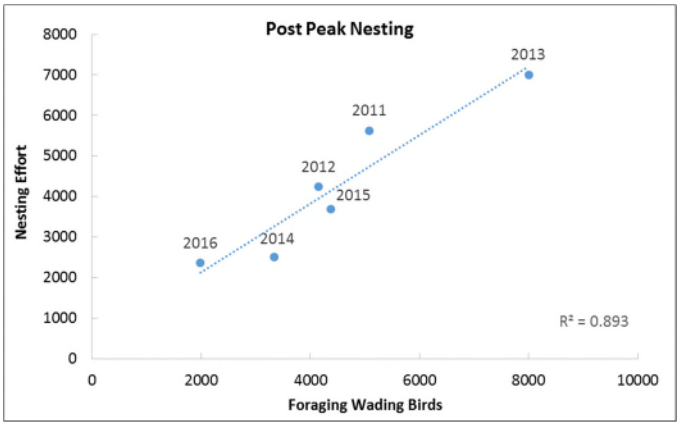

Figure 24. Correlation between post-peak nesting foraging bird totals and total nesting effort (provided by FAU). Species included: Great Egret, Snowy Egret, White Ibis, Tri-colored Heron, Little Blue Heron, Glossy Ibis, Wood Stork, and Roseate Spoonbill.

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KISSIMMEE BASIN

WADING BIRD NESTING

Birds are integral to the Kissimmee River floodplain ecosystem and highly valued by the public. The South Florida Water Management District (SFWMD) surveys wading bird nesting colonies and foraging wading bird abundance along the Kissimmee River as part of the Kissimmee River Restoration Evaluation Program (KRREP) (Williams et al. 2005a,b). 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 more than 1,000 nests (National Audubon Society 1936-1959; Florida Game and Fresh Water Fish Commission 1957). The Kissimmee River Restoration Project is expected to reproduce the necessary conditions to once again support such an assemblage.

To date, approximately 7,710 acres of wetland habitat (about half of the total project area) has been restored, and the interim response of foraging wading birds has exceeded restoration expectations when averaged over the interim period (2001 to 2016) (Cheek et al. 2014; SFWMD 2016). While there is no formal expectation for wading bird nesting effort, the number and size of colonies that have formed along the river since restoration began in 2001 has been below historic levels (Williams et al. 2005a; Cheek 2016).

While foraging conditions on the floodplain can become optimal for wading birds during parts of the year (see the Wading Bird Foraging Abundance section), the current timing and magnitude of floodplain inundation and recession is not optimal for rookery formation due to constraints and other demands on water control operations that may limit prey availability. All restoration construction is scheduled for completion by 2019, when implementation of the Headwaters Revitalization Schedule will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions at the appropriate spatial and temporal scales for wading bird nesting colonies. Wading bird responses to the river restoration project will be monitored for 5 years after construction completion.

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, the SFWMD performed three surveys (March 2 and 30, and April 21, 2016) to visit known wading bird nesting colonies on Lake Kissimmee, along the Kissimmee River, and on Lake Istokpoga. Two flight-line direction count surveys were conducted from a boat near Bumblebee Island on April 27 and 28 to try to determine where nesting birds were foraging. Observers sat on both sides of a helicopter flying at an altitude of 244 m while flying between known colonies within the Kissimmee River Restoration Project Area, which includes Lakes Kissimmee, Cypress and Hatchineha, and Lake Istokpoga. Once a colony was located, the principal observer recorded nesting species and the number of active nests while another observer took photographs. Nest counts were obtained from the digital photos to improve the accuracy of initial counts made from the air. Detectability of nests during aerial surveys typically is less than 100%, so the numbers of nests reported here represent the maximum number of observed nests for each species. This is particularly pertinent for the small, dark-colored wading birds such as Little Blue Heron (LBHE), Glossy Ibis (GLIB), Tricolored Heron (TRHE), Yellow-crowned Night Heron (YCNH), and Black-crowned Night Heron (BCNH) (Frederick et al. 1996). Thus, the colony totals presented in **Tables 21** and **22** are considered conservative. Nest fate and nesting success were not monitored.

RESULTS

Five colonies were active during the 2016 season within the KRREP area and Lakes Istokpoga and Kissimmee (**Tables 21** and **22**; **Figure 25**). All colonies were dominated by White Ibis (WHIB) nests (1,296), followed by smaller numbers of Cattle Egret (CAEG; 646), Great Egret (GREG; 487), and Great Blue Heron (GBHE; 45) nests. The largest of these colonies was Bumblebee Island in Lake Istokpoga (1,847 nests), followed by Rabbit Island (526 nests), Chandler Slough East (85 nests), River Ranch C-38 (12 nests), and S65-C Structure (4 nests) (**Figure 25**).

Similar to last season, none of the colonies occurred within 3 km of the partially restored portions of the Kissimmee River, but several did occur in unrestored portions of the river, including north, east, and south of the restoration area (**Figure 25**). The Kissimmee River Restoration Area is within the potential foraging range of nesting waders at the S65-C Structure colony (4.3 km) and the Chandler Slough East colony (13.3 km), while the Bumblebee Island colony is approaching the farthest limits of regular foraging for most species at approximately 15 km away. The Rabbit Island and River Ranch Island colonies (40.6 km and 23 km, respectively) are too far north of the restoration area for regular foraging by nesting species.

Most nesting by aquatic wading bird species and CAEG continues to occur outside of the KRREP area on islands in the Upper Kissimmee Basin and Lake Istokpoga. To date, only one colony of aquatic bird species (S-65C Structure colony) has formed within 5 km of the partially restored portion of the Kissimmee River, and during most years, it has contained fewer than 50 nests of aquatic species. The continued small numbers of aquatic species nesting along the restored portion of the river suggests that prey availability on the floodplain is not yet sufficient to support successful breeding for these wetland-dependent birds. Another possible factor preventing breeding colony site formation within the restoration area is lack of suitable habitat conditions during the January to June breeding season (e.g., woody substrate surrounded by water, nesting materials, and nearby foraging areas) (White et al. 2005).

Survey efforts next season will focus primarily within 10 km of the Kissimmee River Restoration Project Area and the Kissimmee River Headwaters in Lakes Kissimmee, Hatchineha, and Cypress.

Table 21. Peak (maximum) number of wading bird nests within the Kissimmee River Restoration Project Area* (2003-2016; sites were surveyed during March and April 2016).

Year	CAEG	GREG	GBHE	SMDH	SMWH	Total Nests	Total Colonies	Nests of Aquatic Species
2003	20					20	1	0
2004						0	0	0
2005		81				81	2	81
2006	500	133	9			642	4	142
2007	226			1		227	1	1
2008		2	4			6	1	6
2009	240	126	27	14		407	3	167
2010	891	35	31	37		994	2	103
2011	751	14	35	35	8	843	2	92
2012	1,202		18	108	18	1,346	2	144
2013	599	33	37			669	5	70
2014**	5	23	28	1		57	5	52
2015		94	31			125	4	125
2016***	291	316	20			627	4	336

Note: WHIB, GLIB, BCNH, and WOST nests were not observed (count = 0).
* Kissimmee River Restoration Project Area sites include Lakes Kissimmee, Cypress and Hatchineha, and colonies within approximately 10 km of the C-38 Canal/backfill, including multiple Kissimmee Prairie sites, Bluff Hammock, Cypress West, Oak Creek Marsh, C-38 Caracara Run, Chandler Slough East, Chandler Slough New, Chandler Slough, Cypress West, Orange Grove, Orange Grove NW, Orange Grove SW, Pine Island Slough, S-65C Boat Ramp, S-65C Structure, S-65D Boat Ramp, Seven Mile Slough, Pool E Spoil Island, and S-65E colony.
** Expanded survey effort in 2014.
*** Reduced survey effort in 2016, but results from the Rabbit Island colony in Lake Kissimmee were added to the table this year.

Table 22. Peak (maximum) number of wading bird nests within Lake Istokpoga (Bumblebee Island) (2010-2016; sites surveyed during April 2016).

Year	CAEG	GREG	WHIB	GBHE	Total Nests	Total Colonies	Nests of Aquatic Species
2010	103	325	110	75	613	1	510
2011	381	200	50	45	676	1	295
2012	75	175	--	75	325	1	250
2013	250	343	--	55	648	1	398
2014	658	210	75	55	998	1	340
2015	434	180	829	--	1,443	1	1,009
2016	355	171	1,296	25	1,847	1	1,492

Note: SMDH, GLIB, BCNH, SMWH, and WOST nests were not observed (count = 0).

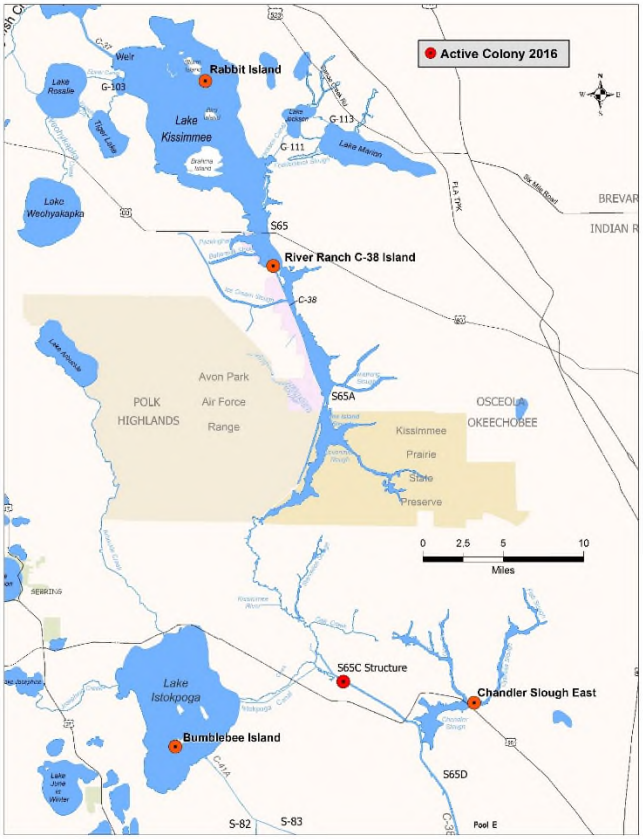

Figure 25. Nesting colony locations in Lake Kissimmee, Lake Istokpoga, and within the Kissimmee River Restoration Project Area (i.e., within approximately 10 km of the C-38 canal backfill) during 2016.

WADING BIRD FORAGING ABUNDANCE

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

- Mean annual dry season density of long-legged wading birds (excluding CAEG) on the restored floodplain will be ≥30.6 birds/km² (Williams et al. 2005a).

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

Methods

East-west aerial transects (n = 218) were established at 200-m intervals beginning at the S-65 structure and ending at the S-65D structure (see **Figure 25**). During weekly flights from November to May, a minimum of 20% of the 100-year floodplain was surveyed in the restored and unrestored portions of the river/floodplain. Surveys were conducted via helicopter flying at an altitude of 30.5 m and a speed of 80 km/hr. A single observer counted all wading birds and waterfowl within 200 m of one side of the transect line. Because it is not always possible to distinguish TRHE from adult LBHE during aerial surveys, the two are lumped together as "small dark herons". Likewise, SNEG and immature LBHE were classified as "small white herons".

Results

Prior to the restoration project, dry season abundance of long-legged wading birds in the Phase I restoration area averaged (±standard error) 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 [2002-2016] = 42.3 ± 6.3 birds/km²) (**Figures 26** and **27**) (see SFWMD 2016 for description of restoration phases). The annual 3-year running mean (2002 to 2016) is 41.7 ± 4.3 birds/km², significantly greater than the restoration expectation of 30.6 birds/km² (t-test, p = 0.03, SAS Institute 2011; Williams et al. 2005a). However, each 3-year running mean was not significantly different from the restoration target of 30.6 birds/km² when examined on an annual basis (t-test, SAS Institute 2011). Mean monthly wading bird abundance within the restored portions of the river during the 2015-2016 season was 40.1 ± 7.4 birds/km², bringing the 3-year (2014 to 2016) running average to 40.9 ± 9.6 birds/km².

Rainfall during the 2016 dry season was well above average in the Upper and Lower Kissimmee Basins (151% and 190%, respectively), resulting in above-average floodplain depths and three significant reversals in water depth. Wading bird abundance was high during the initial fall recession in November and December, with more than 210 birds/km² observed during the November 20 survey (**Figure 28**). Bird numbers then declined from 74.3 birds/km² on December 30 to 23.8 birds/km² on January 13, when floodplain stage began to rise to greater than 2.0 ft deep by February 7 during the first of four dry season reversals (SFWMD 2016). Bird numbers remained relatively low from January 13 through March 2, when water levels were too deep (>1.3 ft) for foraging over most of the floodplain. Bird numbers increased to 52.4 birds/km² when water depths receded to approximately 0.7 ft on March 9, then declined to 4.4 birds/km² on April 6 when floodplain depths increased to more than 2.2 ft. Bird numbers reached a final peak of the season of 28.7 birds/km² by April 27 as water receded to 0.54 ft on May 4, before rising to its greatest depth of the dry season at more than 3.2 ft deep on May 24.

WHIB dominated numerically (61%), followed in order of abundance by GLIB (14%), GREG (8.0%), small white herons (SNEG and juvenile LBHE combined) (6.5%), GBHE (4.0%), small dark herons (TRHE and adult LBHE combined) (2.0%), Roseate Spoonbill (ROSP) (1.2%), BNHE and YCNH (1.1%), and Wood Stork (WOST) (0.8%).

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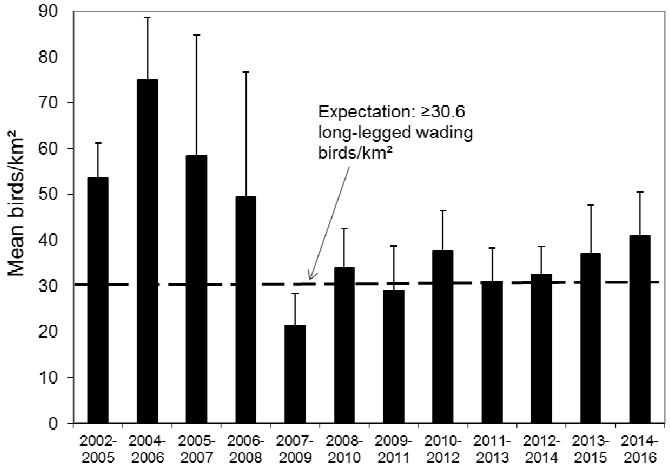

Figure 26. Post-restoration abundance as 3-year running averages ± standard error of long-legged wading birds per square kilometer (birds/km²), excluding Cattle Egrets, during the dry season (December to May) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River. Each 3-year running mean was not significantly different from the restoration target of 30.6 birds/km² when examined on an annual basis (t-test, SAS Institute 2011).

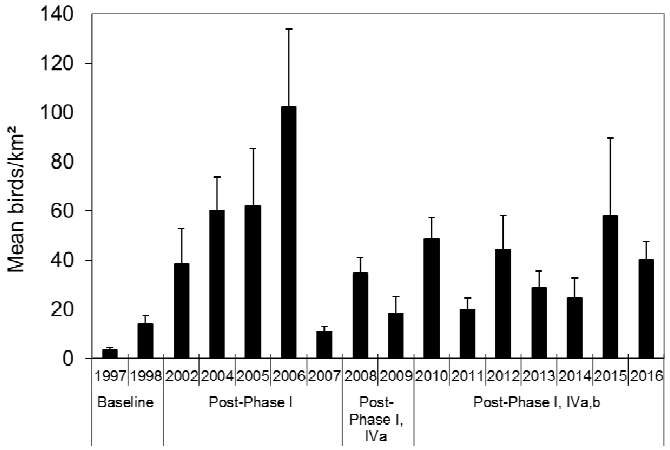

Figure 27. Baseline and post-Phases I, IVA, and IVB mean abundance ± standard error of long-legged wading birds/km² (excluding Cattle Egrets), during the dry season (December to May) within the 100-year floodline of the Kissimmee River.

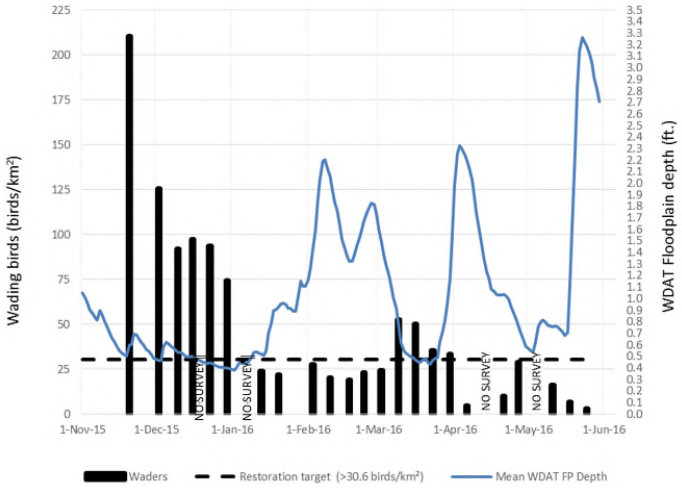

Figure 28. Wading bird abundance and mean floodplain depth in the Kissimmee River Restoration Area (Phases I, IVA, and IVB) during the 2016 dry season (December to May). Floodplain depth is obtained from the South Florida Water Depth Assessment Tool (SFWDAT 2015).

SAVANNAS PRESERVE STATE PARK

During late March 2016, Florida State Park staff resumed surveys of two historic wading bird rookeries at Savannas Preserve State Park (**Figure 29**). These rookeries originally were surveyed between 1995 and 2003 by the South Florida Water Management District.

METHODS

The South Marsh Rookery, south of Walton Road (27.2769, -80.2474), is an island in Lake Eden consisting of pond apple with cattail and sawgrass edges. It was surveyed in late March by canoe and showed no nesting activity, though Great Egret (GREG), Great Blue Heron (GBHE), Yellow-crowned Night Heron (YCNH), Tricolored Heron (TRHE), Anhinga (ANHI), and White Ibis (WHIB) adults were present in small numbers. The last recorded nesting at this site was in May 2000, with small numbers of ANHI, GBHE, and Little Blue Heron (LBHE) nests. There are reports of increased nesting activity later in the season, and plans are set to survey the site on a regular basis next season.

The North Marsh Rookery (27.268849, -80.244743) is a shrub island within the basin marsh north of Walton Road., just north of the canoe launch area. This island primarily consists of pond apple and wax myrtle with sawgrass edges. Surveys were done by canoe from north to south of the shrub island along the western edge. The eastern portion of the island is inaccessible by canoe due to thick vegetation, thus some nests may have been missed. This site was surveyed three times, in late March, early May, and late June (**Table 23**). Nest numbers in 2016 appear to be similar to data collected between 1995 and 2003.

FUTURE PLANS

Plans are set to continue surveys at both sites between January and July 2017.

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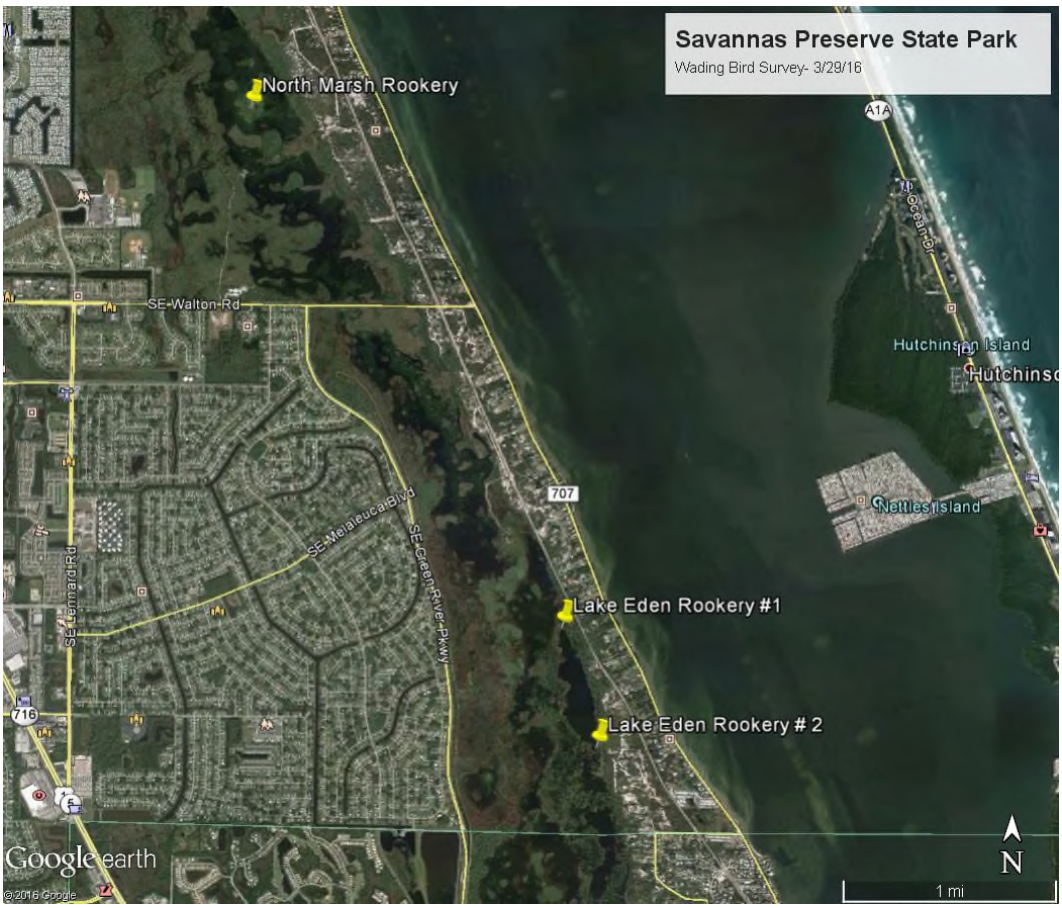

Figure 29. Location of wading bird nesting colonies at Savannas Preserve State Park during the 2016 nesting season.

Table 23. Peak nest numbers Savannas Preserve State Park.

Colony	GREG	CAEG	GBHE	LBHE	YCNH	TRHE	WHIB	GLIB	ANHI	SNEG
North Marsh Rookery	5	3	4	*	*	*	*	4	2	2
Lake Eden	*		*		*	*	*		*	

* Species present but nests not detected.

VARIOUS LOCATIONS

METHODS

The Florida Fish and Wildlife Conservation Commission (FWC) conducted nest counts at four rookeries in 2016.

Bird Island (27.190281, -80.187908) is a spoil island in the Indian River Lagoon. It is cooperatively managed and monitored on a monthly basis throughout the year with Martin County. Counts are conducted from a boat circling the island, and it is certain that many interior nests are not counted.

Ballen Isles (26.830148, -80.109158) is a small island located within the Ballen Isles Country Club. Counts are conducted on foot from the north and south sides of the island.

Sawgrass Ford (26.149837, -80.337621) is a spoil island behind the Sawgrass Ford dealership. It was accessed by kayak to conduct counts in March and April.

Wakodahatchee Wetlands (26.479889, -80.142326) is a created wetland where many species breed. FWC staff counted Wood Storks (WOST) on visits in March and May. Other species were counted monthly by volunteers. Counts are conducted from the boardwalk.

RESULTS

Peak nests counts for each species in each rookery are provided in **Table 24**.

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Table 24. Peak number of nests at various locations from January to July 2016.

Colony	ANHI	BRPE	CAEG	DCCO	GBHE	GREG	LBHE	ROSP	SNEG	TRHE	WOST
Bird Island	1	66	0	18	0	6	0	2	0	0	24
Ballen Isles	1	0	0	17	0	18	0	0	1	0	28
Sawgrass Ford	20	0	0	3	0	36	0	0	0	11	52
Wakodahatchee	41	0	24	8	6	20	4	0	4	13	59
Total	**63**	**66**	**24**	**46**	**6**	**80**	**4**	**2**	**5**	**24**	**163**

J.W. CORBETT WILDLIFE MANAGEMENT AREA

INTRODUCTION

This year was the second year of formal monitoring of wading bird colonies to determine location and size on J.W. Corbett Wildlife Management Area (Corbett WMA) as part of the Florida Fish and Wildlife Conservation Commission's (FWC's) Wildlife Conservation Prioritization and Recovery Program (WCPR). One colony was identified containing more than 50 nests and one colony contained fewer than 50 nests. In addition, three active Sandhill Crane nests and one Sandhill Crane nest pad without adults were observed during the April survey.

From 2006 to 2010, wading bird colonies were noted as incidental observations. Five different colony locations were identified during this time period (including the large colony identified this year) with relatively small numbers of nesting adults (2 to 40 per observation) and nests (20 or fewer per observation). It is unclear whether the increase in numbers of wading bird nests at the large colony is an actual increase in wading bird breeding or due to more thorough monitoring, or both.

METHODS

From late March to late April, systematic aerial surveys and one ground survey were conducted to locate colonies and estimate numbers of nesting wading birds. Two observers sat on either side of a helicopter traveling at an altitude of 300 to 400 feet and a speed of 40 to 60 knots. Transects were spaced 0.5 miles apart and oriented in an east-west direction. In late May, an aerial site check of known colonies was conducted. Due to unexpectedly large numbers of nesting birds seen in 2015, digital aerial photos of colonies were taken to help obtain accurate estimates of numbers of birds. A ground survey was conducted in late September to increase the accuracy of estimates from aerial surveys; nests were counted along a transect, and the results were extrapolated to estimate the number of nests for the entire island. This transect was altered from last year's due to the unexpected presence of pre-fledglings in the colony (Black-crowned Night Herons [BCNH] and Cattle Egrets [CAEG]).

RESULTS

Peanut Pond

The Peanut Pond colony occupies a willow head of approximately 1.34 acres. Based on aerial surveys and ground transect counts, approximately 281 nests were initiated at the Peanut Pond colony. The majority of these were Great Egret (GREG) nests. Tricolored Herons (TRHE), Little Blue Herons (LBHE), CAEG, BCNH, and Anhingas (ANHI) were seen nesting also; Snowy Egrets (SNEG) were detected during aerial surveys, but were not seen nesting (**Table 25**).

There are plans to work with FWC's Fish and Wildlife Research Institute to further develop the protocol and train staff to enable more accurate counts of each species' numbers of nesting adults and chicks. The goal, as described in the WCPR and related standard monitoring protocol, is to provide a basic summary of the distribution and status of wading bird colonies within Corbett WMA.

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Table 25. Peak nest counts by species in colonies at J.W. Corbett Wildlife Management Area during March to April 2016.

Colony	Latitude	Longitude	GREG	SNEG	CAEG	LBHE	TRHE	BCNH	ANHI	Colony Total
Peanut Pond	26.84195	-80.3225	242	*	14	20	2	1	2	281
Trail 7	26.84347	-80.3565	--	5	--	1	--	--	--	6
Total			**242**	**5**	**14**	**21**	**2**	**1**	**2**	**287**

* Species detected but not seen nesting.

PALM BEACH COUNTY NATURAL AREAS

Staff at Palm Beach County Environmental Resources Management surveyed wading bird colonies at Natural Areas from February to August 2016 to assess nesting effort (**Table 26**). Two small wading bird colonies, the Pine Glades and Cypress Creek colonies, were known from previous years but had not been formally surveyed until this year. Staff also looked for another suspected colony in Loxahatchee Slough Natural Area without success; large groups of wading birds were active in the area as in past years, but presence and location of these groups were inconsistent and staff were unable to confirm nesting.

METHODS

From February to August, staff conducted monthly surveys from the ground by truck or airboat, recording numbers of adults and nests as well as presence of chicks. During each visit, counts were made from multiple vantage points encircling the colonies to ensure full coverage. The Cypress Creek colony is harder to accurately assess due to dense vegetation obscuring view of the nests. To check the accuracy of counts, after nesting ended at the Cypress Creek colony staff conducted a survey walking into the colony to count nests remaining. Twenty-five nests were counted during the walking survey and 30 nests were counted during regular monthly surveys. These data support the accuracy of regular monthly surveys; wading bird nests are fragile and fall apart easily once they are not maintained by adult birds, so fewer nests are expected to be seen post-breeding, especially because peak nesting according to regular monthly counts occurred from mid-April to early May.

RESULTS

The Pine Glades and Cypress Creek colonies are located in northwestern Palm Beach County within a pine flatwoods-marsh-cypress swamp habitat matrix. There has been intense restoration activity on both Natural Areas, including filling ditches and creating shallow-water wetlands from old agricultural fields, resulting in increased foraging habitat for wading birds.

The Pine Glades colony occurs on a willow head that is approximately 1.1 acres; it is adjacent to an old borrow pit and surrounded by agricultural land that has been restored to deepwater marsh habitat that holds water most of the year. The Cypress Creek colony occupies an approximately 0.4-acre island of mixed willow and cypress that bisects a deeper pond. The pond and island are located within a shallow wet prairie surrounded by pine flatwoods.

The majority of nests at both colonies were made by Great Egrets (GREG). Cattle Egrets (CAEG) also nested at both colonies but in low numbers. Little Blue Herons (LBHE) and Tricolored Herons (TRHE) nested at Cypress Creek, while the Pine Glades colony included Anhingas (ANHI) in addition to GREG. Peak nesting at the Cypress Creek colony occurred in late April and early May, although TRHE were not seen nesting until June 28. Nesting at Pine Glades peaked in early June, with most nests observed on June 10.

Next season, efforts will focus on thoroughly surveying the Loxahatchee Slough Natural Area for wading bird nesting activity and on measuring fledging success.

Table 26. Peak nest counts by species observed on Palm Beach County colonies between February and August 2016.

Colony	Latitude	Longitude	GREG	CAEG	LBHE	TRHE	ANHI	Total
Cypress Creek	26.94936	-80.18768	15	9	4	2	0	**30**
Pine Glades	26.93611	-80.25591	14	2	0	0	6	**22**

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STATUS OF WADING BIRD RECOVERY

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

The main indicator species are Great Egret (GREG), Snowy Egret (SNEG), WHIB, and WOST. Although the Tricolored Heron (TRHE) originally was included in this list (Ogden et al. 1997), the species has proven extremely difficult to consistently monitor due to the inability to see their dark plumage during aerial surveys. Ogden et al. (1997) lumped 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). In practice, the distinction is unimportant because both species appear to be declining and are nowhere near any of the population restoration targets. This section summarizes data for the three Water Conservation Areas (WCAs) and mainland Everglades National Park (ENP).

RESULTS

Numbers of Nesting Pairs

The 3-year (2014 to 2016) running average for nesting pairs are 5,328 pairs for GREG, 837 pairs for SNEG, 17,379 pairs for WHIB, and 995 pairs for WOST (**Table 27**). Trends for GREG over time (**Figure 30**) for this measure increased markedly from 1988 to 2004, and have been stable or slightly declining since, with the 3-year running average meeting or exceeding restoration criteria for 20 consecutive sampling periods since 1996. Trends for SNEG also increased markedly between 1986 and 2004, but have dropped dramatically since 2005, with the 2016 season showing continued declines compared to the previous 5 years. Three-year running averages of breeding SNEG have been consistently well below the target restoration goal in the time they have been monitored (since 1986). The 3-year running average has increased markedly for WHIB between 1986 and 2001 (2.7 X), and remained variable but arguably stable for nearly a decade (2002 to 2011). The final period in this record (2011 to 2016) showed substantial fluctuation in WHIB nesting, with 50% reduction in three of the years, and three of the five years in that period being well below the average of the previous decade. Given the poor breeding conditions during the 2016 El Niño season, WHIB nesting numbers in 2016 seemed in line with the previous 15 years. WHIB nesting populations have met or exceeded the breeding population criterion for the past 15 years. WOST showed a marked increase from averages in the 2 to 300 pairs range (1986 to 1992) to averages above 1,000 pairs after 1999. WOST have equaled or exceeded the restoration population criterion during 4 of the last 13 years, but were well below (38%) the minimum targets in 2016. Together, these statistics illustrate that there has been a very 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 most years. SNEG, however, continue to nest in declining numbers and have never met restoration targets. In addition, there is evidence from systematic ground surveys in WCA-3 (see Water Conservation Areas 2 and 3, and A.R.M. Loxahatchee National Wildlife Refuge section) that breeding populations of the other two small herons in the genus *Egretta* (TRHE and Little Blue Herons [LBHE]) are declining sharply in the Everglades also.

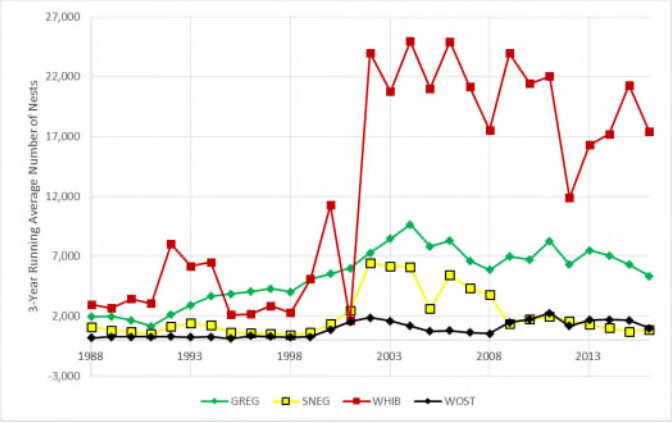

Figure 30. Trends in 3-year running average of nesting pairs of the four target species since 1986.

Table 27. Three-year running averages of the number of nesting pairs for the four indicator species in the Everglades.

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
Target Minima	4,000	10-20k	10-25k	1.5-2.5k

Note: Bold entries are those that meet minimum criteria.

Colony Location

More than 90% of the nesting of the indicator species 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 it is the reduction of freshwater flows to this coastal region that 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 31**), and during the last several years has ranged between 15% and 46%. In 2016, the proportion was 19.8%.

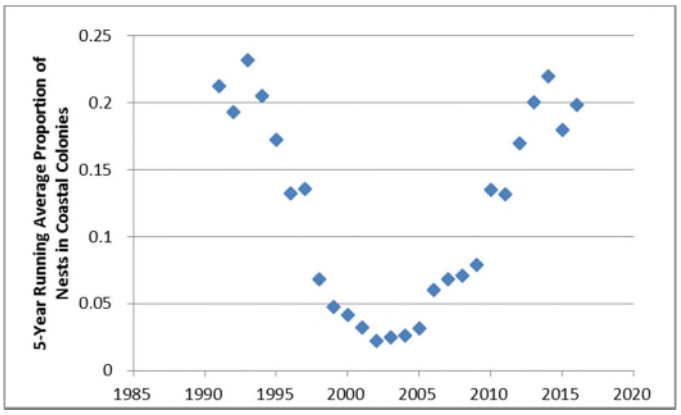

Figure 31. Proportion of all mainland Everglades nesting that is located in the coastal estuarine zone, 1986 to 2016.

Ratio of Visual to Tactile Foragers

This performance measure recognizes that the breeding wading bird community has shifted from being numerically dominated by tactile foragers (storks and ibises) during the pre-drainage period to one in which visual foragers such as GREG are numerically dominant. This shift is thought to have occurred as a result of impounded, stabilized, or over-drained marsh, which leads to the declining availability of larger forage fishes (WOST) and crayfishes (ibises). These conditions also seem to favor species like GREG that are less reliant on the entrapment of prey and can forage in groups and alone 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 performance measure has shown some improvement since the mid-1990s (movement from 0.66 to 3.5), the ratio is still an order of magnitude less than the restoration target. The 5-year running average for this measure in 2016 was 3.06.

Timing of Nesting

This performance measure applies only to the initiation of nesting for WOST, which has shifted from November-December (1930s through 1960s) to January-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 stork 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. Although some years in the mid-2000s stimulated earlier nesting, there has been no lasting improvement. The 2016 season start (late March) was quite late compared to recent years (late January) and the November-December benchmark.

Exceptionally Large Ibis Aggregations

Exceptionally large breeding aggregations of ibises were characteristic of the pre-drainage system and are thought to be indicators of the ability of the wetland system 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 more than 16,977 nests each year, or the 70th percentile of the entire period of record of annual

nesting. The interval between large ibis nesting events in the pre-drainage period was 1.6 years, and this serves as the target for restoration. This performance measure has improved markedly since the 1970s, with the target achieved in 9 of the last 10 years. The 2016 ibis nesting did not reach the criterion, and the interval averaged over the last 5 years is 1.4 years, slightly more frequent than in the 1930s.

DISCUSSION

Taken together, these measures of wading bird nesting suggest that while there have been real improvements in several of the performance measures during the past one or 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 ibis nesting years has met the restoration target for 9 of the past 10 years. There has been real progress in the location of nesting, but the proportion nesting in the coastal zone remains low (5-year running average of 20% compared to 50% target), and there is much room for improvement. Several measures are not improving. The numbers of SNEG are declining and remain far from restoration targets. There is little evidence that the timing of nesting for WOST is improving, and this measure may be getting worse. 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 probably have responded in the last two decades to a combination of altered water management regimes, good weather, and hydropattern by nesting more consistently in the coastal zone and by increasing populations of WHIB and WOST. 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 remains a solid indicator. The lack of movement of the other measures suggests that the current 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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