Wading Bird Colony Location, Size, and Timing in Lake

Okeechobee 2022 Annual Report

To

U.S. Army Engineer Research and Development Center
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EXECUTIVE SUMMARY

This document describes project activities from 1 October 2021 to 30 September 2022 and summarizes data from the 2022 Lake Okeechobee wading bird breeding season. The project objectives are to document and monitor wading bird colony locations, size, and timing for three focal species, Snowy Egrets (SNEG, *Egretta thula*), Great Egrets (GREG, *Ardea alba*), and White Ibis (WHIB, *Eudocimus albus*), and monitor nesting success of Wood Stork (WOST, *Mycteria americana*) and Roseate Spoonbill (ROSP, *Platalea ajaja*).

We conducted monthly aerial surveys from 14 March to 2 June and detected 8 on-lake and 3 off-lake colonies. Peak nest abundance for focal species (GREG, SNEG, and WHIB) was 1,887 nests, which is 42.8% lower than average since 2008. GREG, SNEG, and WHIB nest abundance were estimated to be 27.6%, 36.5%, and 48.1% lower than the average since 2008.

We monitored the timing and survival of nests along paired transects at two spoil island colonies (Little Bear Beach and Clewiston Spit). Median estimated clutch initiation date was 24 March, 25 March, 18 March, 24 March for GREG, SNEG, TRHE, and WHIB, respectively. The median estimated clutch initiation date for GREG was nine days later than the average since 2009, four days later for SNEG, eight days earlier for TRHE, and 15 days earlier of WHIB. Overall nest survival of GREG (100%) and WHIB (70%) were 33% and 3% higher than the average since 2012, respectively. High nest survival for GREG may be explained by an incidental small sample size on the nesting transects in 2022 (n = 8). Overall nest survival of small herons (69%) is 7% lower than the average since 2011.

Forty WOST nests and 16 ROSP nests were detected at an off-lake colony (Gator Farm), 17 ROSP nests were detected at a spoil island colony (Clewiston Spit), and 5 ROSP nests were detected at a marsh colony (Moore Haven NW). This is the second consecutive year since 2015 that ROSP have been observed nesting at on-lake colonies. We detected 57 WOST fledglings and 53 ROSP fledglings in photos taken during the aerial survey on 19 May. WOST have nested and successfully fledged chicks at the Gator Farm in 10 of the last 15 years (2007-2010 and 2016-2022). ROSP have nested at the Gator Farm in low numbers (4-20 nests) from 2016 to 2022 and successfully fledged chicks each year since 2018. Though nest abundance remains small, these species appear to be a regular part of the bird community at Lake Okeechobee.

Nesting occurred at ten colonies in 2022. Moonshine Bay (*n* = 584), a marsh colony, and Little Bear Beach (*n* = 564), a spoil island, supported the largest number of GREG, SNEG, and WHIB nests. Marsh colonies supported most nests in 2022 (53%), which is typical of a year with moderate water levels (average lake stage >14.1 ft), because most of the colonies are near foraging habitat and surrounded by water, decreasing predation risk.

PROJECT MANAGEMENT OVERVIEW

Progress accomplished during this period

All field work for the 2022 breeding season was accomplished as stated in the work plan. We flew 4 aerial surveys (14 March, 18 April, 19 May, and 2 June). Transects were established at 2 breeding colonies (Little Bear Beach & Clewiston Spit) which we monitored once every 4-12 days. We monitored the nests of 40 TRHE, 119 SNEG, 71 unidentified small heron nests, 8 GREG, 23 GLIB, and 86 WHIB.

Anticipated needs or issues

There are currently no unaddressed needs or issues.

Funding status

Cooperative Agreement executed November 11, 2020 extending funding through September 30, 2024.

Employees working on this project for part of the year

Dale Gawlik, Michelle Petersen, Evan Furrer, and Julian Von Kanel.

Presentations

NA

Publications in review or print

Essian, D.A, R. Paudel, and D.E. Gawlik. 2022. Predicting effects of water management on breeding abundance of three wading bird species. Journal of Wildlife Management. 86:e22155 https://doi.org/10.1002/jwmg.22155.

Larson, R.C. and D.E. Gawlik. 2022. Call rate as an index of nest count in wading bird colonies. Ibis 165, 504-516.

BACKGROUND

Wading Birds as Performance Measures

Large numbers of colonial wading birds were once a distinctive feature of south Florida wetlands. Anthropogenic changes to the natural hydrologic regime over the last hundred years have been extensive, altering suitable wading bird habitat at a landscape scale and resulting in nesting declines system-wide (Frederick et al., 2009). Restoring breeding wading bird populations to pre-drainage conditions is a primary objective of the Comprehensive Everglades Restoration Plan (CERP). The status of system-wide wading bird populations is assessed by examining four variables: numbers of nesting birds, locations of nesting colonies, timing of nesting, and frequency of supra-normal events. Wading birds are considered indicators of the overall health of the Greater Everglades ecosystem and provide performance measures by which to evaluate the CERP (RECOVER, 2006).

Aerial Surveys at Lake Okeechobee

The first aerial surveys conducted on wading bird colonies on Lake Okeechobee began in 1957 and proceeded inconsistently until 1976. Nest counts recorded during these annual surveys ranged from

130 nests in 1971 to 10,400 nests in 1974. These aerial surveys may have underestimated clutch initiations since they were only performed once during the nesting season which typically occurs from February to June. In 1977, aerial surveys shifted to systematic monthly surveys to better assess the effects of water management on wading bird populations (David 1994; Smith and Collopy, 1995). The four wading bird species historically surveyed were WHIB, GREG, Great Blue Heron (*Ardea herodias*), and SNEG. These species were surveyed annually to detect wading bird responses to water level changes on the Lake.

Current Monitoring

In May of 2005, Florida Atlantic University (FAU) began monitoring the timing, size, and location of wading bird colonies at Lake Okeechobee as part of the CERP Monitoring and Assessment Plan (MAP). On June 3, 2005, an aerial survey was conducted at the onset of the wet season as the Lake level began to rise. From 2006 to 2022, FAU conducted monthly aerial surveys of breeding wading birds to assess the performance measures outlined in MAP using standard MAP wading bird survey protocols. In addition to monthly aerial surveys, FAU monitored nest survival by visiting a subset of colonies weekly. On-the-ground surveys validated data collected during aerial surveys and determined nest survival. Aerial and ground surveys provided a measure of the ecological condition of the Lake for routine water management purposes.

RESULTS AND DISCUSSION

Hydrology

Rainfall and lake stage data were obtained from the South Florida Water Management District (SFMWD) 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 (NGVD 1929) and locations are in North American Datum 1983 (NAD 1983). Stage data from 2008 represents the lake levels under the current Lake Okeechobee Regulation Schedule.

Water levels during the 2022 nesting season, 01 January to 30 June, were similar to the 2018 nesting season (mean lake stage was 13.91 ft in 2018 and 13.84 ft in 2022, respectively). Water conditions in 2022 were characterized by average lake stage, moderate recession rate, and frequent (8) reversals (0.02-in rise on 9 February, 0.01-in rise in stage per day from 13 March to 18 March, 0.01-in rise on 3 April, 0.01-in rise on 5 April, 0.04-in rise in stage per day from 19 May to 21 May, 0.04-in rise in stage per day from 28 May to 30 May, 0.04-in rise in stage per day from 1 June to 13 June, 0.01-in rise in stage per day from 19 June to 21 June, and a 0.01-in rise in stage per day from 25 June to 28 June (**Figure 1**). On 01 January, lake stage was at 15.49 ft. The lake receded at a mean rate of 0.13 in/wk from 01 January to 13 March before rainfall caused the lake stage to increase from 14.16 ft on 13 March to 14.18 ft on 18 March. Except for two minor reversals in early April, the lake receded at a mean rate of 0.17 in/wk from 19 March to 19 May when rainfall caused the lake stage to increase from 12.65 ft on 19 May to 12.73 ft on 21 May. The lake receded at a rate of 0.16 in/wk from 21 May to 28 May before rainfall caused the lake stage to increase from 12.55 ft on 28 May to 12.63 ft on 30 May. The lake experienced a reversal period caused by rainfall from early to mid-June, increasing from 12.59 ft on 1 June to 13.01 ft on 13 June. The lake receded at a rate of approximately 0.07 in/wk from 13 June to 19 June when rainfall caused a minor reversal of 0.01-in rise in stage from 19 June to 21 June. The lake receded at an average rate of 0.02 in per day from 21 June to 25 June before rainfall caused the lake stage to increase from 12.89 ft on 25 June to 12.93 ft on 28 June. The final recorded lake stage for the 2022 season was 12.92 ft on June 30.

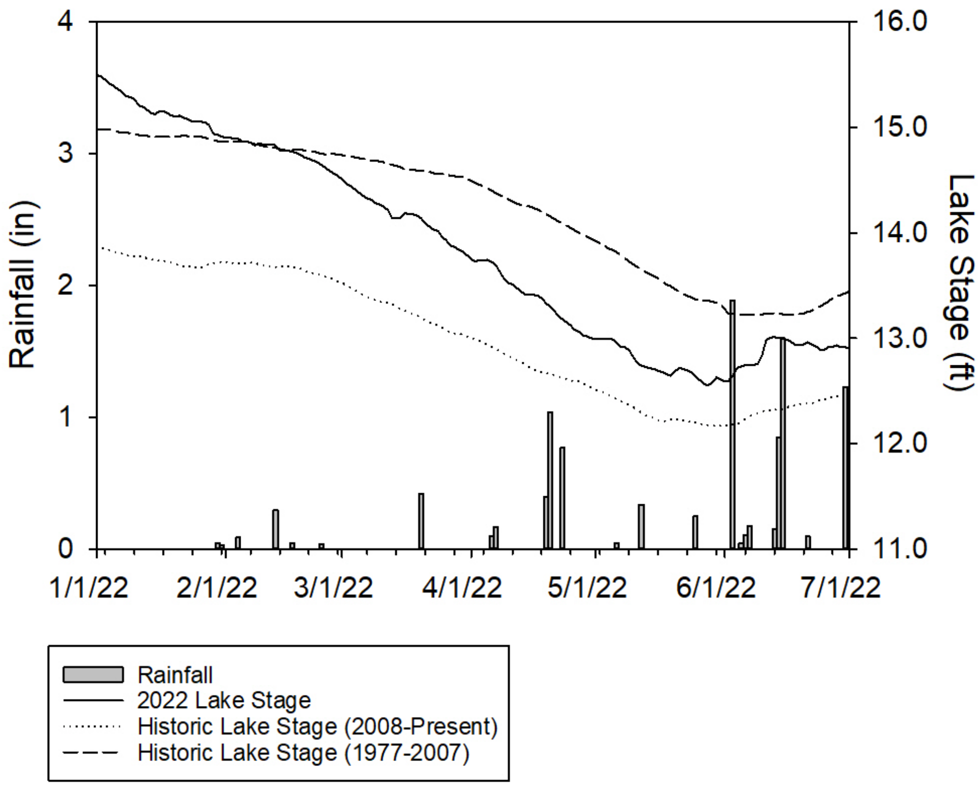

Figure 1. Hydrologic patterns on Lake Okeechobee from January to July 2022 and mean lake stage from 1977-2007 and from 2008-Present, since the 2008 Lake Okeechobee Regulation Schedule (LORS2008) was implemented.

Nesting and foraging conditions

High lake stages at the beginning of 2022 were a result of above average rainfall during the 2021 wet season and resulted in moderate habitat availability in January, February, and March, when the littoral zone was partially flooded. Habitat availability peaked on 08 March and decreased from 09 March to the start of the wet season on 30 June. Habitat availability on the lake peaks at a moderately high lake stage (14.3 ft), and sharply declines at higher and lower lake stages (**Figure A2**). The proportion of the littoral zone available as foraging habitat on the Lake during the breeding season was above average (2022 = 0.65; 2011-2021 = 0.51; SE = 0.20) but there were 8 reversals that could reduce foraging habitat availability, but significant abandonment was not noticed.

Colony locations

Ten colonies (**Figure 2**) supporting 1,887 GREG, SNEG, and WHIB nests were detected, which is 42% lower than the average from 2008-2021 (3,279 ± 1,970 SD). Colonies were detected at three created spoil islands (Little Bear Beach, Clewiston Spit, and Pahokee Airport), five natural willow colony in the marsh (Eagle Bay Island North/East, Eagle Bay Island South, Clewiston Marsh, Moore Haven, Moonshine Bay), and three off-lake, created islands (Lakeport Marina, Gator Farm, Gun Range). Moonshine Bay was the largest colony, supporting 660 GREG, SNEG, and WHIB nests (**Table 1**).

During wet years, such as 2021, wading birds nest in short-hydroperiod colonies more frequently than in dry years, because colonies are surrounded by water, making them inaccessible to mammalian predators and decreasing the distance to suitable foraging habitat in the marsh. Colonies that are surrounded by long-hydroperiod marsh, such as Eagle Bay, are an exception because they remain inundated and are closer to suitable foraging habitat at the western edge of the littoral zone during dry years.

Colonies built on created spoil islands and off-lake colonies are typically active every year, likely because they are always surrounded by deep water and are high enough to allow their trees to survive even in exceptionally high lake stages. Spoil island colonies have supported 27% of on-lake nests in dry years (mean lake stage <12.9 ft), 29% in moderate years (13.0 –14.0 ft), and 17% in wet years (>14.1 ft) since 2008, when the current lake schedule went into effect. Variation in nest abundance is higher in spoil island colonies (coefficient of variation at spoil island colonies = 84%) than marsh colonies (2008-2021 mean coefficient of variation at natural colonies = 73%) because the small size of spoil colonies limits total nest numbers, resulting in lower annual productivity in spoil island colonies (Chastant et al. 2016). Nevertheless, spoil island colonies continue to be an important contributor to the Lake’s wading bird numbers, providing the only suitable nesting substrate during some years.

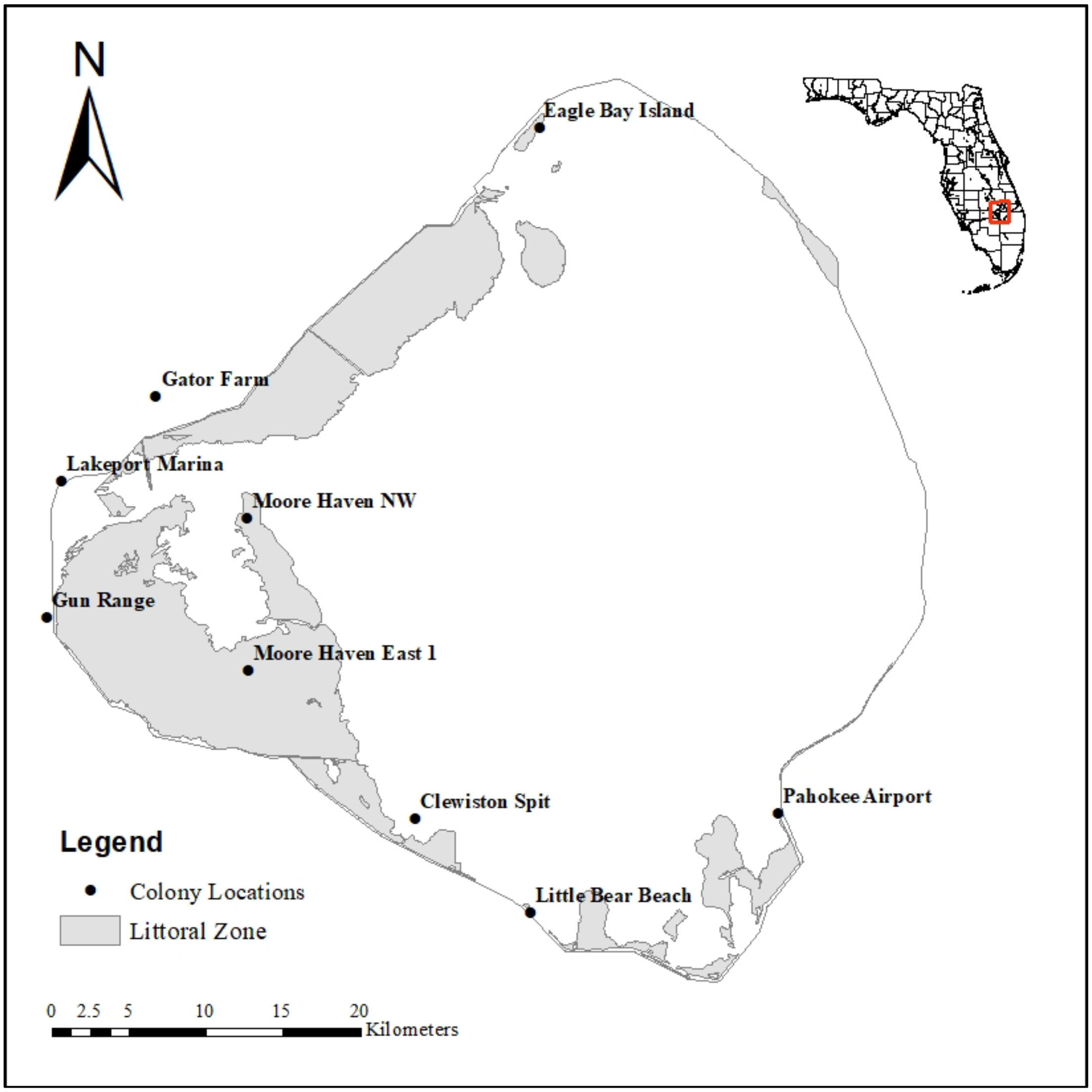

Figure 2. Map of wading bird colonies detected on Lake Okeechobee from February through June 2022.

Table 1. Geographic coordinates (NAD 83) and species-specific peak nest abundances in detected colonies during the 2022 breeding season at Lake Okeechobee.

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

[1]CAEG and ANHI were excluded from totals since they are not wetland wading birds.

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

Nest abundance

To avoid double counting birds as a result of colony turnover, we used peak monthly nest abundance for each species to estimate the total number of nests in 2022. Peak nest abundance was 565, 536, and 786 for GREG, SNEG, and WHIB respectively (1,887 nests; **Table 2**). Peak nest abundance was 42% lower than the average since 2008, when the current lake schedule went into effect (3,279 ± 1,970; all averages use SD). GREG, SNEG, and WHIB nest abundance were 20%, 62%, and 33% lower than the average since 2008, respectively (706 ± 476 GREG; 1,394 ± 1,056 SNEG; 1,179 ± 874 WHIB).

Mean nest abundance of the three focal species on the Lake was higher from 2008-2022 (3,186 ± 1,933) than from 1977-1992 (2,319 ± 1,681; **Figure 3**). SNEG and GREG nest abundance increased since 2007, compared to 1977-1992 ($P < 0.001$), while WHIB nest abundances remained relatively unchanged ($P > 0.13$). A continuing trend identified in this study is the importance of Lake Okeechobee in supporting nesting SNEG, relative to the other nesting regions in South Florida. Since 2009, the Lake has supported approximately 49% of SNEG nesting in the Greater Everglades, suggesting that Lake Okeechobee provides critical habitat for this species nesting in South Florida.

Table 2. Timing and nest numbers for species breeding in wading bird colonies at Lake Okeechobee in 2022.

Month	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	AHNI
March	**565**	106	394	34	14	**7**	4	124	--	0	8
April	451	**786**	453	**40**	**35**	7	--	143	**445**	338	4
May	199	246	**536**	30	29	3	**17**	**199**	100	837	20
June	29	184	157	32	4	--	2	30	10	**1236**	--

Note: Bold Values denote peak nest effort for species.

Timing

The median clutch initiation date for GREG (24 March ± 7.7 days) was nine days later than the average since 2009 (13 March ± 7.2 days). Median clutch initiation date for SNEG (25 March ± 11.43 days) was four days later than the average since 2009 (21 March ± 6.1 days) and median clutch initiation for TRHE (18 March ± 15.4 days) was eight days earlier than the average since 2009 (26 March ± 8.5 days). Median clutch initiation date for WHIB (24 March ± 10.97 days) was 15 days earlier than the average since 2009 (8 April). Peak nest numbers were observed in March, May, and April for GREG, small herons, and WHIB (**Table 2**).

Nest initiations for SNEG, GREG, WHIB and TRHE peaked between 6 March and 31 March, despite a reversal occurring from 14 March to 18 March. There has been no apparent relationship observed between the timing of nest initiations and overall nest survival of focal species, but the temporal pattern of nest initiation by species is consistent with previous years at the Lake and in other regions, with GREG initiating nests earlier than small herons (Ogden 1994, Smith and Collopy 1995, Klassen et al. 2016).

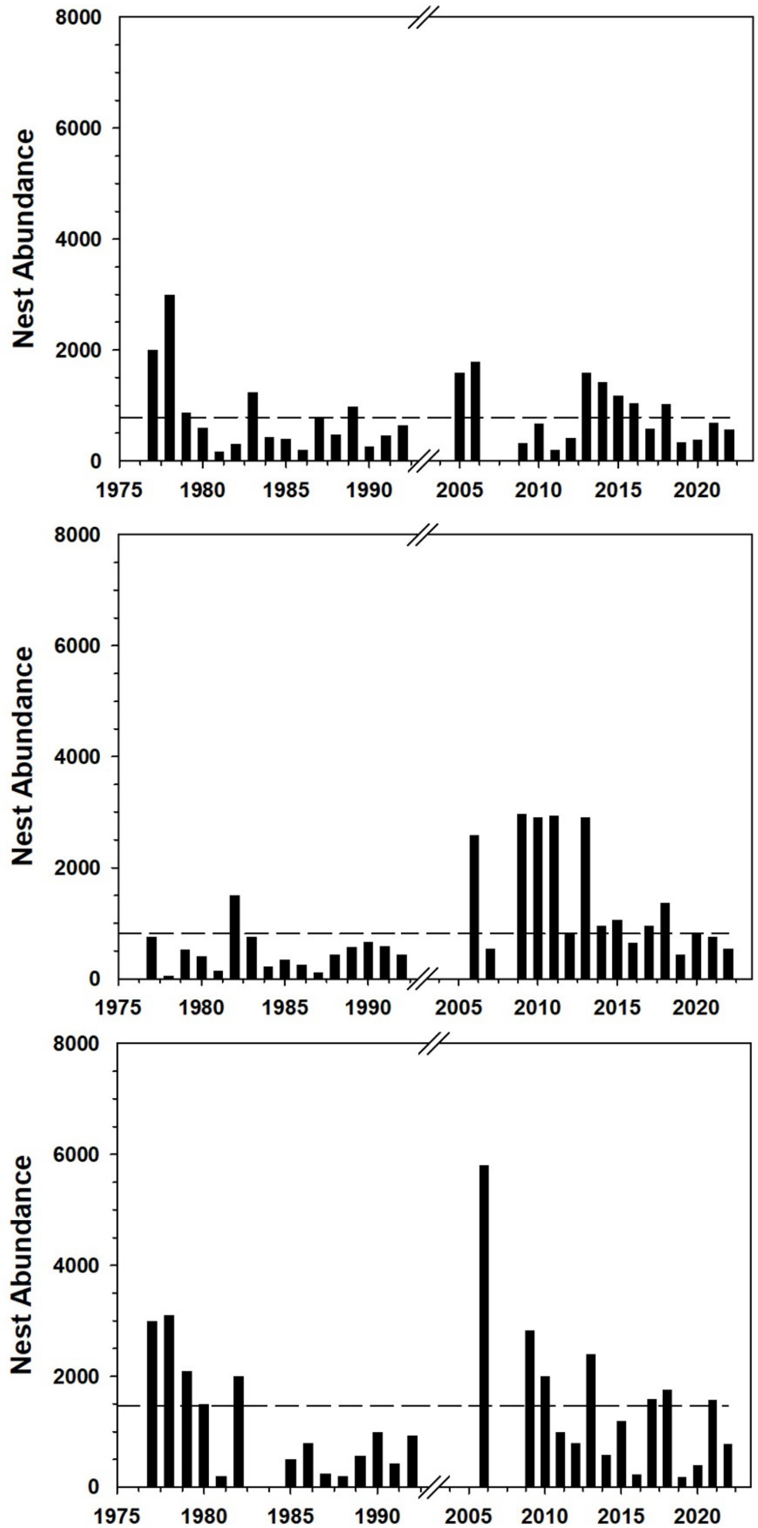

Figure 3. Estimates of nest abundance from Lake Okeechobee aerial surveys during the 1977-1992, 2006-2007, and 2009-2022 nesting seasons. Mean nest abundance is represented by the horizontal line.

WOST and ROSP nest abundance

Forty WOST nests and 17 ROSP nests were detected at Gator Farm, an off-lake colony located north of the Moonshine Bay area (**Figure 2**). Seventeen ROSP nests were also detected at Clewiston Spit, five ROSP nests were detected at Moore Haven NW. This is the second time since 2015 that ROSP have been observed nesting in on-lake colonies, and nests at Clewiston Spit and Moonshine Bay were successful. From the detected nests,we counted 57 WOST fledglings and 52 ROSP fledglings in photos taken during the aerial survey on 19 May. ROSP nest success for on-lake colonies was 69% and the mean fledge success (number of chicks/nest) was 2.5 ± 0.09. WOST have nested at the Gator Farm in 11 of the last 16 years (2007-2010 and 2016-2022) and have successfully fledged chicks every year nesting has occurred. ROSP have nested at natural colonies in the littoral marsh (n = 3 in 2009; n = 2 in 2013, n = 1 in 2021, n = 5 in 2022), at a created spoil island colony (n = 1 in 2015; n = 3 in 2021, n = 17 in 2022), and at the Gator Farm (n = 4 - 24 nests from 2016-2022) where they successfully fledged chicks from 2018-2022.

The pattern of the presence and absence of WOST nesting on the Lake hints at a connection with the Everglades. WOST nested on the Lake in 2007 and in 2016, both years of very low WOST nesting in the Everglades. This pattern suggests that the Lake may provide alternate nesting habitat for some WOST when conditions are poor in the Everglades.

Nest survival

We estimated nest survival (proportion of nests that fledge at least one nestling) using logistic exposure models to account for biases resulting from variation in the initial nest ages at monitored nests (Shaffer, 2004). Generalized linear models were fitted with a loglink distribution function. The model estimates daily survival rate (DSR), which can be converted to overall survival rate ($DSR^{interval\ length}$). We developed separate models for the incubation and nestling periods because there were clear differences in nest survival rates between the two. Interval lengths were 21 days during the incubation period for small herons and 26 days for GREG (Parsons and Master 2020; McCrimmon et al. 2020) The nestling period interval lengths were 14 days for all species. Nest survival for GREG in 2022 was 1.0 ± 0 (n = 8), which is 43% higher than the overall survival since 2012 (0.70 ± 0.15 n = 562). Small heron nest survival in 2022 was 0.70 ± 0.46 (n = 232), which is 1% lower than the survival rate from 2012 (0.71 ± 0.10; n = 3,075). Nest survival for WHIB in 2022 was 0.78 ± 0.42 (n = 86), which is 7% higher than the overall nest survival since 2011 (0.71 ± 0.07; n = 529). Mean fledge success for GREG, small heron, and WHIB was 1.93 ± 0.02.

Average apparent GREG nest survival from 2012-2022 (65%) exceeded apparent nest survival from 1989-1992 (apparent survival ranged from 40-63%; Smith and Callopy 1995). GREG survival rates ranged between 0.10 in 2019 and 1.0 in 2022 (Essian et al. 2019). Since 2012, nest survival for GREG was below 55% in 2012 (53%) and 2019 (10%), which were both dry years (mean lake stages of 11.7 ft, 12.1 ft, respectively). Similarly, nest models have predicted that GREG nest survival decreases at low lake stages (<13 ft) and increases at moderate to high lake stages (13.5-15 ft) (Essian et al. 2022). The increase in GREG nest survival at moderate to high lake stages may be partially responsible for the increased GREG survival during 2022.

Since 2012, small heron nest survival rates ranged between 0.60 in 2015 and 0.83 in 2019. Small heron survival in 2022 (70%) was similar to 2011 (70%) and 2018 (72%), though all years were hydrologically different. Small heron nest survival has been correlated to the hydrological regime of the current year (Essian et al. 2019), with higher survival rates observed during years with high recession rates and available foraging habitat.

Since 2012, WHIB nest survival rates ranged from 0.63 in 2012 to 0.78 in 2021. WHIB survival in 2022 (78%) was similar to 2021 (76%), a hydrologically similar year. Frederick and Ogden (2001) hypothesized that in the Everglades drought promotes prey availability in the subsequent 1-2 years, perhaps through an increase in nutrients released from sediments upon reflooding, or through predator release and drought. The years 2019 and 2020 were characterized by low water levels so it is possible that the increased survival was a response to increased prey abundance, this seems unlikely. Previous studies (Essian et al. 2022) have found a weak relationship between the number of days that are dry in the previous two water years and prey densities within the foraging ranges of wading birds ($F = 2.87$, $R2 = 0.03$, $p = 0.09$).

CONCLUSION

Above average lake stages in January followed by a moderate dry down, resulted in relatively moderate conditions in the littoral zone during the 2022 breeding season. The frequent water-level reversals did not appear to cause significant abandonment but could have led to the lower-than-average nest initiations for GREG, SNEG, and WHIB. The recession rate during the 2022 breeding season was moderate throughout the breeding season. This resulted in a decreased foraging habitat availability at the start of the breeding season and likely reduced prey concentration capacity later in the breeding season. However, nest abundances and nest survival of the focal species have been higher under the current lake management schedule (2008–2022) compared to the previous period (1977–1992), supporting management of lake stages at moderate levels.

ACKNOWLEDGMENTS

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APPENDIX I.

METHODS

Nest abundance estimates

From March through June 2022, FAU personnel monitored the location, timing, and number of clutch initiations in wading bird nesting colonies on the Lake. Systematic aerial surveys were conducted in a fixed-wing aircraft flying at an altitude of 244 m and an average speed of 115 mph. One transect paralleled the eastern rim of the Lake from Eagle Bay Island to the Clewiston Lock. Remaining transects were oriented east–west, spaced at an interval of 3 km and traversed the littoral zone (**Figure A1**). A small alligator farm northwest of the Lake by County Road 721 was also included in the survey route since the site was known to have previously supported nesting WOST.

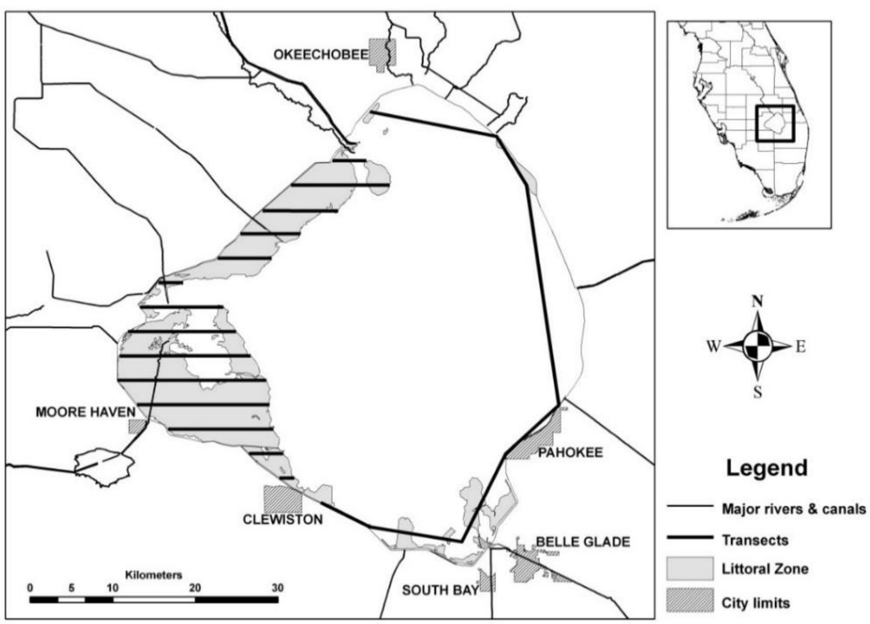

Figure A1. Map of systematic aerial transects flown over Lake Okeechobee during the 2022 wading bird breeding season.

Two dedicated observers surveyed for nests of focal species (SNEG, GREG, and WHIB) along aerial transects. As small, dark-colored wading birds are exceedingly difficult to detect from aircraft, aerial monitoring protocols target white wading birds. Colonies were defined as any assemblage of ≥ 2 nests that were separated by ≥200 m (Smith and Collopy 1995). Once a colony was detected, the aircraft circled down to an altitude of 400 ft to allow observers to estimate the number of nests for each species present in the colony. Total clutch initiations for focal species were recorded, as well as photographs and geographic coordinates of the colony. Ground surveys were performed by airboat to verify colony counts and species composition estimates. Distances between colonies were calculated using ArcGIS.

Ground surveys were performed by foot at three colonies to validate aerial survey counts, determine nest survival, and count small, dark-colored wading birds. At two colonies (Little Bear Beach and Clewiston Spit) two 50-m transects were established so that they were situated 30-m apart and ran parallel to each other. Random transects were established by selecting a random bearing and distance (0-50 m) from a random entry point. Transects were established approximately parallel to each other so researchers could return to the entry point via the second transect and minimize colony disturbance. The two monitored colonies were spoil islands, which are generally narrow (<30 m wide) strips of land with patchily distributed nest substrate. Therefore, the position of randomly established transects were adjusted so they did not extend past the edges of islands or run entirely through unsuitable nesting habitat (unvegetated patches). At each colony, researchers walked transects and marked new nests within a 5-ft buffer along each transect with flagging tape and assigned an identification number. Species, clutch size, nest stage, and nest fate were recorded for each nest.

Timing

Timing of nesting by WOST is already a CERP indicator of restoration success in the Everglades (Frederick et al., 2009). Timing may also be important for other species of wading birds, since wading birds are generally sensitive to reversals (Beerens et al., 2015; Herring et al., 2010; Smith and Collopy, 1995), and reversals are stronger and occur more frequently in last half of the dry season. In historical reports, timing of clutch initiations was reported as the date of first nest detection for each species. Peak number of active nests were reported at a monthly scale, as seen in the South Florida Wading Bird Reports, or they were reported graphically at a biweekly scale (e.g. Smith and Collopy 1995). These methods of reporting the timing of wading bird nesting are coarse and difficult to interpret. Since 2009, nest monitoring has been conducted on the ground, which allows better estimates of individual clutch initiation dates.

The hatch date of each chick was directly observed (e.g. chicks pipping) or estimated based on the estimated age of the oldest chick in each clutch. Clutch initiation date was estimated by subtracting number of days in an average incubation period (26 days for GREGs, and 21 days for small herons) from the estimated hatch date. Median clutch initiation dates were calculated for each species

Nesting and Foraging Conditions

Proportion of ArcGIS raster cells (100 x 100ft) in the littoral zone available to foraging by wading birds (<1 ft depth, non-woody vegetation) is estimated using vegetation mapping, LIDAR depth estimates, and lake stage estimates from the South Florida Water Management District (SFMWD) DBHYDRO database.

We obtained spatial data of Lake Okeechobee littoral vegetation classes from the South Florida Water Management District, and excluded woody and dense herbaceous vegetation classes, which wading birds do not typically use as foraging habitat (Smith et al. 1995).

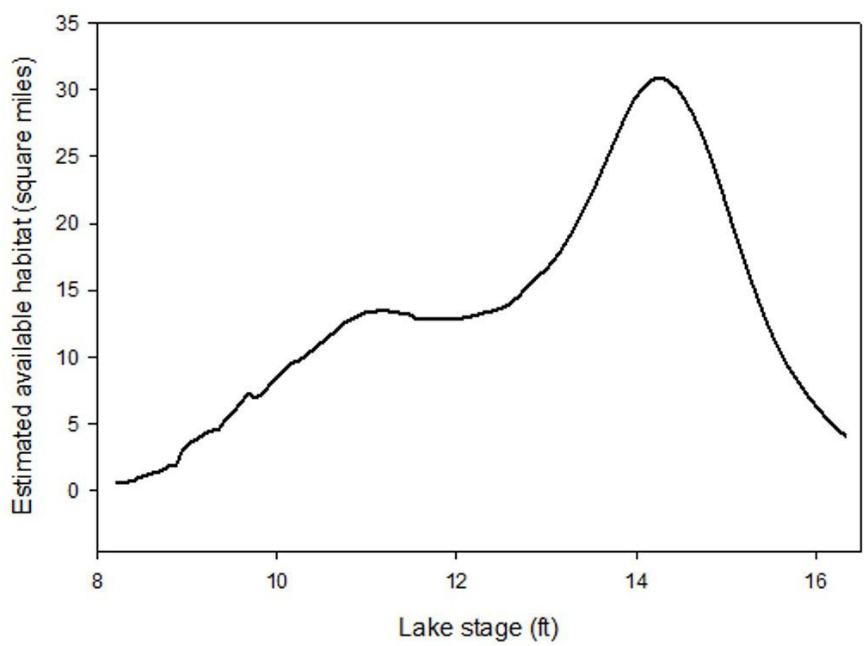

Figure A2. Habitat suitability curve for Lake Okeechobee. Habitat availability was estimated based on vegetation mapping last updated in 2012 and LIDAR depth estimates last updated in 2011.