2019

Status and distribution of colonial waterbirds in coastal Virginia: 2018 breeding season

B. D. Watts
The Center for Conservation Biology, bdwatt@wm.edu

B J. Paxton
The Center for Conservation Biology

R Boettcher
The Center for Conservation Biology

A L. Wilke
The Center for Conservation Biology

STATUS AND DISTRIBUTION OF COLONIAL WATERBIRDS IN COASTAL VIRGINIA: 2018 BREEDING SEASON

THE CENTER FOR CONSERVATION BIOLOGY

COLLEGE OF WILLIAM AND MARY

VIRGINIA COMMONWEALTH UNIVERSITY

Status and distribution of colonial waterbirds in coastal Virginia: 2018 breeding season

Bryan D. Watts
Barton J. Paxton
The Center for Conservation Biology
College of William and Mary
Virginia Commonwealth University
Williamsburg, VA 23187-8795

Ruth Boettcher
Virginia Department of Game & Inland Fisheries

Alexandra L. Wilke
The Nature Conservancy (Virginia Chapter)

Recommended Citation:

Watts, B. D., B. J. Paxton, R. Boettcher, and A. L. Wilke. 2019. Status and distribution of colonial waterbirds in coastal Virginia: 2018 breeding season. Center for Conservation Biology Technical Report Series, CCBTR-19-06. College of William and Mary & Virginia Commonwealth University, Williamsburg, VA. 28 pp.

Project Partners:

Virginia Department of Game & Inland Fisheries
The Nature Conservancy (Virginia Chapter)
Virginia Department of Environmental Quality (Coastal Program)
Virginia Department of Conservation and Recreation
United States Fish and Wildlife Service
United States Geological Survey
The Center for Conservation Biology

Front Cover Image: White Ibis with young. Photo by Bryan Watts.

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

Table of Contents

Contents

EXECUTIVE SUMMARY

Colonial waterbirds are highly visible components of coastal avifaunas that share the unusual characteristic of nesting in dense assemblages. One consequence of having large portions of populations nesting in few locations is that even restricted disturbance may have profound consequences on a population level. Development of conservation strategies for these sensitive species requires current status and distribution information. In the fall of 1992, a consortium of agencies and individuals agreed that a comprehensive monitoring program for the Virginia colonial waterbird community was needed and that assessments should be made on regular (initially every 10 years but reduced to 5 years in 2003) intervals for trend analyses. Systematic surveys have been conducted during the breeding seasons of 1993, 2003, 2008 and 2013. The 2018 survey reported here is the fifth in the time series. These surveys have covered colonial waterbird populations (24 species – Great Blue Herons were not included in 2008 and 2018 due to budgetary constraints) throughout the Coastal Plain province of Virginia.

We surveyed 270 waterbird colonies during the breeding season of 2018. Colonies supported an estimated 44,391 breeding pairs of 23 species. Gulls were the most abundant group with more than 19,700 breeding pairs. Terns and waders accounted for 8,361 and 6,386 pairs respectively. Although they have declined dramatically, Laughing Gulls continue to be the most abundant species and were three times more abundant than any other species, accounting for nearly 40% of the total waterbird community. The barrier island/lagoon system of the Eastern Shore was the most important region for the majority of colonial species encountered. In 2018, this region supported 22 of the 23 species evaluated. The Eastern Shore accounted for 58.8% and 46.6% of all breeding pairs and colonies respectively. For 17 of the 23 species, the region supported more than 50% of the known coastal population.

The colonial waterbird community as a whole in coastal Virginia has declined dramatically since 1993 (2018 survey did not include Great Blue Herons or all Great Egrets). Population estimates for 15 (68%) of the 22 species assessed declined between 1993 and 2018. Declines varied considerably between species with 14 species declining more than 40% and 9 species declining more than 60%. Cattle Egrets showed the highest loss rate (-96.7%), declining from an estimated 1,459 to only 48 pairs. Little Blue Herons declined by 83% from 374 to only 64 pairs. Seven species increased between 1993 and 2018. Dramatic expansions were documented for White Ibis, Double-crested Cormorant, and Brown Pelican.

Over the past 25 years, two major forces appear to be shaping the colonial waterbird community in Virginia. These include 1) regional shifts in population centers that are driving population increases in Virginia and 2) habitat degradation related to sea-level rise. With the exception of Great Egrets, all species that have increased over the past 20 years have experienced ongoing range expansions and are riding a population wave that is progressing through Virginia. This includes Great Black-backed Gull, Double-crested Cormorant, Brown Pelican, and White Ibis. Most of the decline in medium-sized waders is being driven by habitat loss related to erosion of islands. This erosion results from sea-level rise, is ongoing and represents a significant threat to these populations. Several ground-nesting seabirds are likely more directly impacted by the loss of viable habitat and

demographic impacts related to frequent flooding. The most notable example is the Laughing Gull that has experienced a catastrophic decline in both population and distribution.

BACKGROUND

Context

In Virginia, colonial waterbirds include herons, egrets, ibises, gulls, terns, skimmers, cormorants, and pelicans. These birds share the unusual characteristic of nesting in dense assemblages. The result of this behavior is that they typically breed in very few locations such that the loss of a few breeding areas may have profound consequences on a population level. Due to their position in the aquatic food web, they are considered to be good indicators of ecosystem health. The most significant threats to colonial waterbirds include human disturbance, predation, habitat loss, and contaminants. Protection of sensitive colonies clearly depends on the availability of timely locational information. Development of strategic management plans to protect these species and breeding areas requires a broader understanding of population distribution and trends.

For the years prior to the mid-1970s, systematic information on the abundance and distribution of colonial waterbirds in Virginia does not exist. Information during this period is available only from a smattering of nesting records (e.g. Murray 1952), accounts of individual colonies (e.g. Abbott 1955), and area bird lists (e.g. Grey 1950). During the 1975 and 1976 breeding seasons, the first systematic survey of wading bird colonies in coastal Virginia was completed in association with a broad-based survey covering the entire Atlantic Coast (Custer and Osborn 1977). During 1977, the first systematic survey of all colonial waterbird species was conducted in association with the "Maine to Virginia" project (Erwin and Korschgen 1979). In the early 1980s an additional survey was conducted in association with a broad status assessment (Spendelow and Patton 1988). All three of these surveys focused primarily on the coastal fringe and did not attempt to cover the entire Coastal Plain. In 1993, a systematic survey was conducted that covered the entire Coastal Plain from the outer coastline to the fall line (Watts and Byrd 1998). This survey was the most comprehensive assessment to date of the colonial waterbird community in coastal Virginia. The effort covered 446 colonies supporting an estimated 94,947 pairs of 24 species. In 1992, prior to the 1993 survey, a decision was made by the community of agencies and organizations concerned with waterbirds to repeat the survey on a regular schedule (initially 10 years but later reduced to 5) to monitor trends. In keeping with this agreement, the survey was repeated in 2003, 2008 and 2013 (Watts and Byrd 2006). This report provides a summary of the 2018 survey, the fifth in the series of benchmarks.

OBJECTIVES

The purpose of this investigation was to generate population estimates for colonial waterbird species nesting in the Coastal Plain of Virginia in 2018 (great blue herons were not included in the 2018 survey due to funding constraints). Information compiled is intended to:

1) Be integrated into state and regional databases to be used in the environmental review process.
2) Provide information for comparison to past and future surveys for the purpose of assessing long-term state and regional breeding population trends.
3) Be used in the formulation of state and regional management recommendations.

METHODS

Field Surveys

An extensive aerial survey was conducted using fixed-wing aircraft in 2018 that covered the western and eastern shorelines of the Chesapeake Bay, the upper Bay islands and the Delmarva Peninsula seaside. All barrier islands, Bay islands, and marshlands were overflown and searched for waterbird colonies. Great blue heron (the most widely distributed colonial species in Virginia) colonies were not surveyed such that flights of the Delmarva mainland, Western Shore tributaries and Southside (Chowan tributaries) were not covered by aerial surveys. The decision not to survey great blue herons had an impact on coverage of great egrets since this species is increasingly nesting within great blue heron colonies throughout the Western Shore tributaries and areas south of the James River. Aerial surveys were conducted by systematically flying over areas at an altitude of approximately 100-150 m and searching for evidence of breeding colonies. Once detected, a colony was circled long enough to allow observers to map the colony location and estimate its size. All colonies were given a unique alpha-numberic code and plotted on GPS-enabled laptops loaded with a recent set of aerial photographs. Groups of breeding pairs were considered independent colonies if they were: (1) separated from other groups within a continuous habitat by at least 400 m, (2) separated from other groups by a distinctive barrier, or (3) separated from other groups by a significant habitat discontinuity (e.g. birds in dune grassland adjacent to birds in a patch of deciduous saplings).

Follow-up ground counts were conducted for all locations except extensive colonies (gulls, cormorants, pelicans) within seaside and bay island marshes. These colonies are often in remote locations and are difficult to survey on the ground due to their aerial extent. It is more cost effective and logistically efficient to survey these colonies from the air.

Population Estimates

Colony size estimates were based primarily on counts of active nests, and occasionally on the number of adults present. The number of breeding adults was used when nest counts were impractical or when deemed inappropriate due to colony disturbance. Colony size was based on complete counts whenever possible. However, due to the large size of many colonies, estimates were derived for a large portion of the colonies. All estimates for aerial surveys were performed by the same observer. Many different observers were involved with ground surveys. To reduce observer bias across surveys, data resolution for estimates was reduced by rounding off reported numbers to the nearest value using the following graded scale: nearest 5 for <50, nearest 10 for 50-200, nearest 25 for 200-400, nearest 50 for 400-1,000, nearest 100 for 1,000-2,000, and nearest 200 for >2,000. Complete counts were used when reported without rounding.

Breeding chronology was taken into account when designing the survey. Coastal marshes and islands supporting gulls, terns, and allies were flown between mid-May and mid-June. Ground counts of urban areas were conducted during April, May, June, and July depending on the species involved. Ground counts of barrier islands, Bay islands, and marshlands were conducted during June and July.

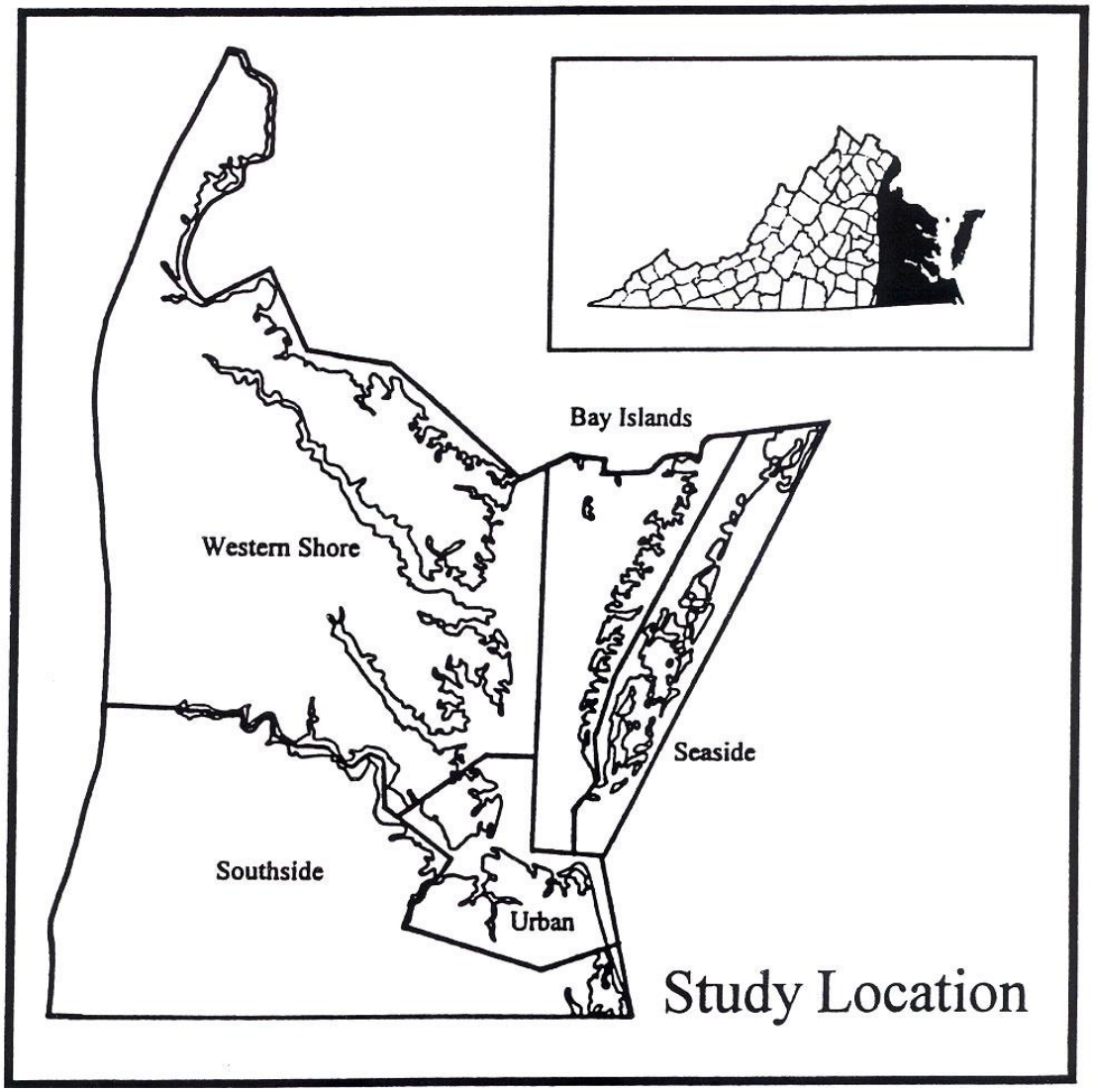
Due to the differences in breeding phenology and circumstances, different surveys were used to generate population estimates for different species. Ground surveys were used for all urban colonies and colonies on barrier and bay islands. Ground surveys were also used for colonies on marshlands with the exception of extensive gull colonies. Gull colonies often cover many hectares making estimation of nest numbers much easier from the air. Aerial photographs were used to estimate several large colonies including the brown pelican/cormorant colony on South Marsh, the brown pelican colony on Wreck Island and the complex of white ibis colonies on Wreck Island. Due to the high vegetation on the Hampton Roads Bridge Tunnel Island the colony estimation technique used in 2018 was different than what has been used previously. For common terns and black skimmers repeated surveys of marked birds were conducted and a simple Lincoln-Petersen estimator (Otis et al. 1978) was used to estimate population size. In addition, nestling counts were used to estimate the number of royal and sandwich terns under the assumption of a one-to-one relationship between chicks and pairs. The laughing gull colony on Wreck Island was in dense grass and covered several hectares. The perimeter of the colony was mapped, nest density was determined within three subsamples and the mean density was used to project colony size over the entire colony area.

Population estimates are presented as breeding pairs. Breeding pairs were estimated on a colony by colony basis and compiled to generate an overall population estimate. For colonies surveyed using nest counts or estimates, a one-to-one relationship between nests and pairs was assumed. For colonies surveyed using count or estimates of adults, a one-to-one relationship between adults and pairs was assumed. The portion of population estimates that were based on nests is provided to allow the reader to recalculate population estimates based on number of adults if so desired.

Geographic Regions

For the presentation of gross distribution patterns, the Coastal Plain was broken down into five geographic regions (Figure 1). Regions included were: 1) Eastern Shore seaside – barrier island/lagoon system along seaward margin of the Delmarva Peninsula northward to the Maryland/Virginia boundary line, 2) Bayside and Bay islands – western shoreline of the Delmarva Peninsula to the Maryland/Virginia border, and Chesapeake Bay islands of Virginia, 3) Urban – major urban areas of lower tidewater, including the cities of Virginia Beach, Norfolk, Portsmouth, Chesapeake, Newport News, and Hampton, 4) Western Shore – south shoreline of the Potomac River to the south shoreline of the James River including all areas from the western shore of the Chesapeake Bay west to the fall line, and 5) Southside – lands south of the James River to the Virginia/North Carolina border including all land between the Atlantic Ocean and the fall line (except areas designated as urban). Unlike in the 1993 (Watts and Byrd 1998), 2003 (Watts and Byrd 2006) and 2013 (Watts and Paxton 2014) surveys, the "Southside" region was not surveyed in 2018. Similarly, inland areas of the "Western Shore" region were not surveyed in 2018. These geographic areas support mixed Great Blue Heron and Great Egret colonies that were not the focus of the 2018 survey. For this reason, no population estimate for these species was generated that is comparable to the 1993, 2003 or 2013 estimates.

Figure 1. Map of study area. The Coastal Plain was subdivided into geographic regions including (1) Seaside, (2) Bay Islands, (3) Urban, (4) Western Shore, and (5) Southside.



RESULTS

Population Estimates

A total of 270 different waterbird colonies was mapped and surveyed during the 2018 breeding season. Colonies contained an estimated 44,391 breeding pairs of 23 species (Appendix I, Great Blue Herons were not included in survey). Colony size varied from 2 to 6,474 pairs with 82.6% of colonies containing less than 100 pairs and 93.0% containing less than 500 pairs. More than 55% of all colonies larger than 500 pairs were Laughing Gull colonies. The majority (75.6%) of colonies contained only one species and 94.8% contained three species or less. Eight mixed-species rookeries contained five species or more.

Abundance varied widely between species and species groups (Table 1). Gulls were the most abundant group with >19,700 breeding pairs. Terns and waders accounted for 8,361 and 6,386 pairs respectively. Although they have declined dramatically, Laughing Gulls continue to be the most abundant species and were three times more abundant than any other species, accounting for nearly 40% of the total waterbird community. Other than Laughing Gulls, only Double-crested Cormorants and Brown Pelicans exceeded 3,000 breeding pairs. The remaining 20 species accounted for less than 43% of the total breeding pairs.

Table 1. Estimated number of breeding pairs for all geographic regions combined in 2018. The category "colonies" refers to the numer of colonies that included each species. "%Nests" is the portion of the population estimate that was based on counts of nests rather than adults (see Methods). NS refers to "not surveyed."

Species	Colonies	Median	Range	% Nests	Pop. Est.
Waders					
White Ibis	3	324	24-1022	0	1746
Glossy Ibis	6	32	1-164	0	366
Great Blue Heron	NS	NS	NS	NS	NS
Great Egret	16	50	1-367	67.9	1527[a]
Snowy Egret	15	21	2-522	7.1	893
Tricolored Heron	11	19	2-141	0	351
Little Blue Heron	4	5	4-36	0	64
Cattle Egret	3	14	1-32	0	48
Green Heron	7	3	1-5	95.2	21
Black-crowned Night Heron	12	27	3-249	0	858
Yellow-crowned Night Heron	91	4	2-43	92.2	602

Species	Colonies	Median	Range	% Nests	Pop. Est.
Gulls					
Great Black-backed Gull	47	8	1-217	99.7	1119
Herring Gull	28	30	1-357	96.4	1957
Laughing Gull	21	220	3-4200	99.5	16653
Terns					
Gull-billed Tern	7	24	5-158	100	349
Caspian Tern	1	-----	-----	100	1
Royal Tern	3	367	291-3448[b]	100	4106
Sandwhich Tern	2	-----	2-100	100	102
Forster's Tern	39	32	9-105	100	1494
Common Tern	19	7	1-605	54.1	1318
Least Tern	46	7	1-258	95.0	991
Others					
Black Skimmer	7	39	2-602	38.4	1567
Double-crested Cormorant	6	162	8-4606	100	5012
Brown Pelican	2	-----	1493-1753	100	3246
Total	**270**	**12**	**2-6474**	**84.7**	**44391[a]**

[a]Great blue herons and great egrets were not surveyed along the tributaries of the western shore or throughout the swamps and Chowan watershed of Southside Virginia.

[b]The Hampton Roads Bridge Tunnel colony of royal terns was estimated using different techniques. On 14 June 2216 incubating adults were calculated. Repeated counts of marked adults resulted in a Lincoln-Peterson estimate of adults of 6885. On 4 July 2652 young were banded with an estimate of an additional 30% that were not captured. The latter estimate (3448) based on total young was used here assuming a one-to-one ratio of young to pairs.

Geographic Distribution

The barrier island/lagoon system of the Eastern Shore was the most important region for the majority of colonial species encountered (Table 2). In 2018, this region supported 22 of the 23 species evaluated. The only species not documented within this geographic area was the Green Heron. This species does breed within the area but the population is difficult to assess. The Eastern Shore accounted for 58.8% and 46.6% of all breeding pairs and colonies respectively. For 17 of the 23 species, the region supported more than 50% of the known coastal population. Many of these species were found almost exclusively in this region. The number of species supported by the other geographic regions varied widely. The Bay region supported 15 species whereas the urban and western shore supported 14 and 3 species respectively. The Bay region supported 7 species in common with the Eastern Shore that were not found elsewhere. The Bay region was the dominant region for the Double-crested Cormorant and Brown Pelican. Cities included in the urban region supported the dominant populations of Green Herons, Yellow-crowned Night Herons, Royal Terns and Sandwich Tern.

Table 2. Summary of species distributions across geographic areas. "Col" refers to the number of colonies within the respective regions. "Prs" indicates the estimated number of breeding pairs within each region. "%" indicates the percentage of the total population found within each region.

	Seaside			Bay Islands			Urban			Western Shore			Southside		
Species	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**
Waders															
White Ibis	3	1746	100	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Glossy Ibis	4	224	61.2	2	142	38.8	-----	-----	-----	-----	-----	-----	-----	-----	-----
Great Blue Heron	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Great Egret	9	789	51.7	4	127	8.3	3	611	40.0	NS	NS	NS	NS	NS	NS
Snowy Egret	10	704	78.8	4	168	18.8	1	21	2.4	-----	-----	-----	-----	-----	-----
Tricolored Heron	8	301	85.8	3	50	14.2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Little Blue Heron	2	55	85.9	2	9	14.1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Cattle Egret	2	33	68.8	1	15	31.2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Green Heron	-----	-----	-----	1	1	4.8	4	13	61.9	2	7	33.3	-----	-----	-----
Black-crowned Night Heron	9	758	88.3	3	100	11.7	-----	-----	-----	-----	-----	-----	-----	-----	-----
Yellow-crowned Night Heron	2	28	4.7	4	21	3.5	85	553	91.8	-----	-----	-----	-----	-----	-----
Gulls															
Great Black-backed Gull	25	820	73.3	21	289	25.8	1	10	0.9	-----	-----	-----	-----	-----	-----
Herring Gull	14	1560	79.7	13	332	17.0	1	65	3.3	-----	-----	-----	-----	-----	-----
Laughing Gull	20	12716	76.4	-----	-----	-----	1	3937	23.6	-----	-----	-----	-----	-----	-----

	Seaside			Bay Islands			Urban			Western Shore			Southside		
Species	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**	**Col**	**Prs**	**%**
Terns															
Gull-billed Tern	6	325	93.1	-----	-----	-----	1	24	6.9	-----	-----	-----	-----	-----	-----
Caspian Tern	1	1	100	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Royal Tern	2	658	16.0	-----	-----	-----	1	3448	84.0	-----	-----	-----	-----	-----	-----
Sandwich Tern	1	2	2.0	-----	-----	-----	1	100	98.0	-----	-----	-----	-----	-----	-----
Forster's Tern	34	1358	90.9	5	136	9.1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Common Tern	15	683	51.9	3	30	2.3	1	605	45.8	-----	-----	-----	-----	-----	-----
Least Tern	33	815	85.5	-----	-----	-----	12	132	13.9	1	6	0.6	-----	-----	-----
Others															
Black Skimmer	6	965	61.6	-----	-----	-----	1	602	38.4	-----	-----	-----	-----	-----	-----
Double-crested Cormorant	3	47	0.9	1	4606	91.9	1	197	3.9	1	162	3.3	-----	-----	-----
Brown Pelican	1	1493	46.0	1	1753	54.0	-----	-----	-----	-----	-----	-----	-----	-----	-----
Total	**126**	**26119**	**58.8**	**32**	**7779**	**17.5**	**108**	**10318**	**23.3**	**3**	**175**	**0.4**	**NS**	**NS**	**NS**

Population Changes

The colonial waterbird community as a whole in coastal Virginia has declined dramatically since 1993 (Table 3, 2018 survey did not include Great Blue Herons or all Great Egrets). There was no change in either the number or type of species breeding in the area. Population estimates for 15 (68%) of the 22 species assessed declined between 1993 and 2018. Declines varied considerably between species with 14 species declining more than 40% and 9 species declining more than 60%. Cattle Egrets showed the highest loss rate (-96.7%), declining from an estimated 1,459 to only 48 pairs. Little Blue Herons declined by 83% from 374 to only 64 pairs. Seven species increased between 1993 and 2018. Dramatic expansions were documented for White Ibis, Double-crested Cormorant, and Brown Pelican.

Table 3. Comparison of colony numbers and estimated number of breeding pairs for 1993, 2003, 2013, and 2018. Population estimates refer to breeding pairs.

Species	1993 Pop. Est.	2003 Pop. Est.	2013 Pop. Est.	2018 Pop. Est.
Waders				
White Ibis	3	77	369	1746
Glossy Ibis	1008	818	484	366
Great Blue Heron	9112	9136	7809	NS
Great Egret	2520	2720	2894	1527[a]
Snowy Egret	2329	882	903	893
Tricolored Heron	767	507	718	351
Little Blue Heron	374	310	178	64
Cattle Egret	1459	166	56	48
Green Heron	154	60	49	21
Black-crowned Night Heron	526	640	358	858
Yellow-crowned Night Heron	388	241	299	602
Gulls				
Great Black-backed Gull	514	1084	1172	1119
Herring Gull	8801	4521	3326	1957
Laughing Gull	45387	44953	24160	16653

Species	1993 Pop. Est.	2003 Pop. Est.	2013 Pop. Est.	2018 Pop. Est.
Terns				
Gull-billed Tern	606	322	294	349
Caspian Tern	8	1	9	1
Royal Tern	6250	2858	5321	4106
Sandwhich Tern	30	7	28	102
Forster's Tern	2939	2477	2431	1494
Common Tern	6781	1891	1985	1318
Least Tern	1171	843	925	991
Others				
Black Skimmer	3098	1828	1506	1567
Double-crested Cormorant	354	1338	2876	5012
Brown Pelican	368	1661	2454	3246
Total	**94947**	**79343**	**60604**	**44391**[a]

[a]Great blue herons and great egrets were not surveyed along the tributaries of the western shore or throughout the swamps and Chowan watershed of Southside Virginia.

Seaside Region

The barrier island/lagoon system along the seaward edge of the Delmarva Peninsula is the most important region for colonial waterbirds in Virginia. Since 1993, colonial waterbirds have been systematically surveyed within this geographic area in 1993, 1998, 2003, 2008, 2013 and 2018. In the majority of species, comparison of population estimates across these years (Table 4) show consistent trends. Snowy Egret, Cattle Egret, Green Heron, Yellow-crowned Night Heron, Glossy Ibis, Herring Gull, Laughing Gull, Gull-billed Tern, Royal Tern, Forster's Tern, Common Tern, and Black Skimmer all showed a consistent decline across the five surveys. Only species that have colonized the area since 1970 including White Ibis, Great Black-backed Gull, Double-crested Cormorant, and Brown Pelican have exhibited consistent increases. Patterns for other species were stable or showed weak trends.

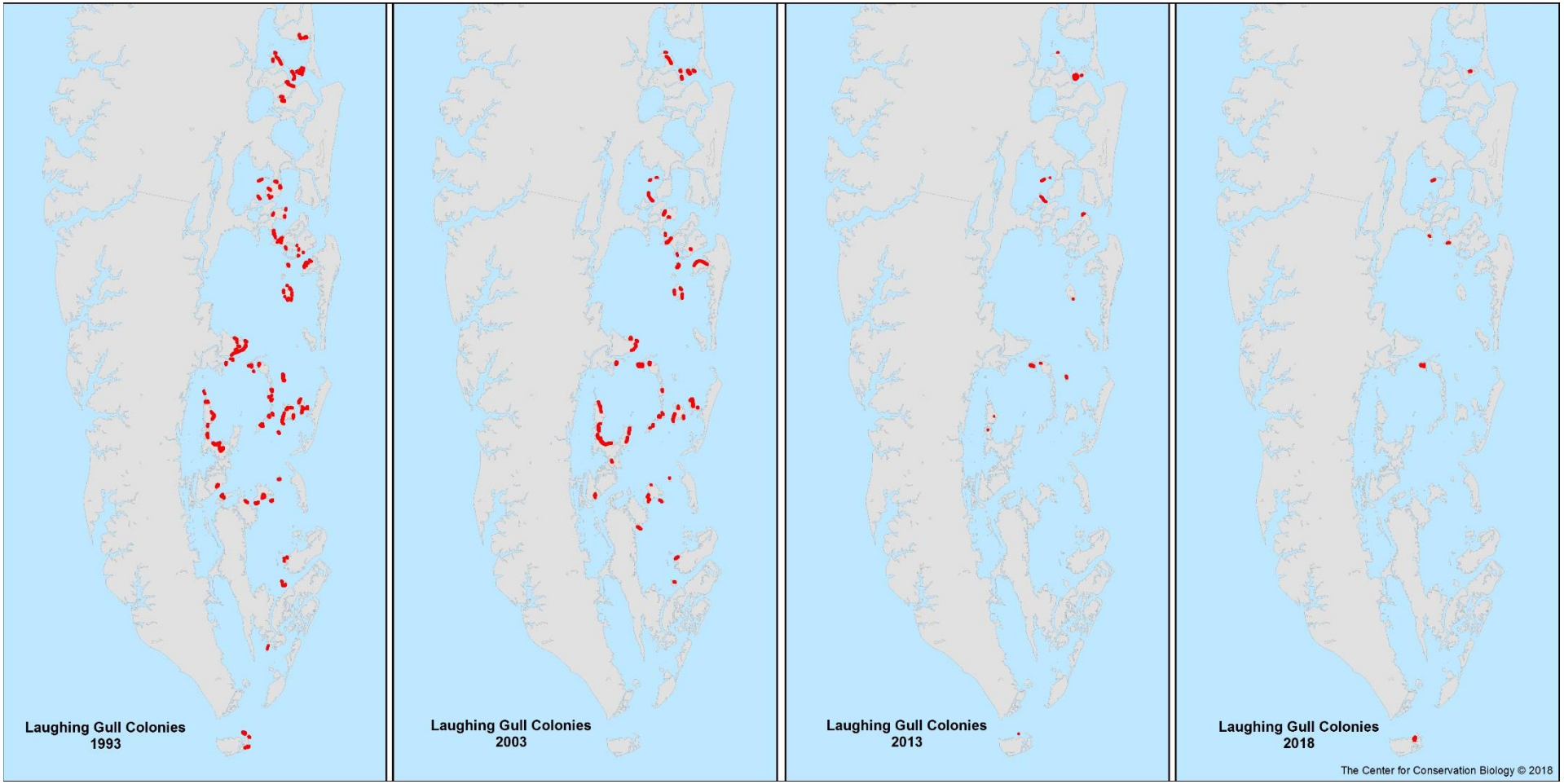
Table 4. Population estimates for colonial waterbirds within the barrier island/lagoon system of the Delmarva Peninsula. Values represent estimated number of breeding pairs. Data from 1993 are from Watts and Byrd 1998. Data from 1998 are from Truitt and Schwab 2001. Data from 2003 are from Watts and Byrd 2006. Data from 2008 are from Watts and Paxton 2009. Data from 2013 are from Watts and Paxton 2014.

Species	1993	1998	2003	2008	2013	2018
Waders						
White Ibis	3	18	77	119	369	1746
Glossy Ibis	779	822	669	521	384	224
Great Blue Heron	8	10	0	0	52	NS
Great Egret	885	976	467	642	692	789
Snowy Egret	1862	1212	624	575	755	704
Tricolored Heron	713	530	456	270	688	301
Little Blue Heron	330	195	249	137	150	55
Cattle Egret	854	540	146	95	48	33
Green Heron	47	3	0	0	0	0
Black-crowned Night Heron	442	359	590	539	277	758
Yellow-crowned Night Heron	63	36	2	0	2	28
Gulls						
Great Black-backed Gull	362	369	720	1206	868	820
Herring Gull	6106	4653	3417	2182	2945	1560
Laughing Gull	44387	43784	41692	33152	21414	12716
Terns						
Gull-billed Tern	604	478	304	295	255	325
Caspian Tern	7	4	1	0	9	1
Royal Tern	3250	3451	2058	2259	62	658
Sandwhich Tern	30	54	7	100	5	2
Forster's Tern	2169	2426	1521	1527	1137	1358
Common Tern	3247	1727	843	475	694	683
Least Tern	747	709	703	669	533	815

Species	1993	1998	2003	2008	2013	2018
Others						
Black Skimmer	2549	1766	1679	1151	1135	965
Double-crested Cormorant	0	6	10	65	67	47
Brown Pelican	324	470	454	728	597	1493
Total	**69968**	**64608**	**56689**	**46707**	**33138**	**26119**

Of particular note within this region was the catastrophic decline in the Laughing Gull population since 1993 and particularly since 2003. The population declined by nearly 70% in only 15 years. Declines were most pronounced within historic strongholds in Northampton County where the decline in both area used for nesting and breeding pairs declined by more than 90% (Figure 2).

Figure 2. Distribution of Laughing Gull colonies (1993, 2003, 2013, 2018) within marsh habitats along the lower seaside.



Discussion

During the 2018 breeding season, coastal Virginia supported a substantial community of colonial waterbirds. The size of this community exceeded estimates from the late 1970s (Erwin and Korschgen 1979) but was less than the 1993 and 2003 estimates (Watts and Byrd 1998, 2006). The seaside of the Delmarva Peninsula continues to be the single most important region for colonial waterbirds in coastal Virginia. However, most populations are experiencing declines within this region. There is a clear need to investigate the role of sea-level rise in declines. The Bay region also supported a diverse community of species but much lower numbers of individuals compared to the seaside. Urban areas supported half of all species with residential areas supporting significant populations of Yellow-crowned Night Herons, Great Egrets, and Green Herons. The Hampton Roads Bridge Tunnel Island supports the most significant seabird colony in the state but is now slated for loss due to bridge expansion.

Waders

Collectively, wader species (excluding Great Blue Heron and Great Egret that were not fully assessed in 2018) declined 30% between 1993 and 2018 from an estimated 7,008 pairs to 4,949 pairs. This decline is in spite of the exponential increase in White Ibis over the past ten years. Most of this overall decline was due to the continued degradation of mixed heronries both on the seaside and bay islands. These declines have been ongoing and represent a loss of some historic colonies during the past two decades. Other sites may be lost in the next decade. Particularly notable was the continued declines in Cattle Egrets, Little Blue Herons, Tricolored Herons, Snowy Egrets and Glossy Ibis. In contrast, White Ibis has exploded on the Seaside from 3 pairs in 1993 to 1746 in 2018.

White Ibis – Nesting of the White Ibis was first confirmed in Virginia in 1977 on Fisherman Island (Frohring and Beck 1978). Breeding was restricted to the barrier islands until 2013. Breeding areas have been surveyed each year since 1975 (Williams et al. 1990). Until recent years, birds were associated with a mixed-species heronry on Fisherman Island exclusively with no indication of further expansion (Williams et al. 1992). This heronry was abandoned in 2002 and has not been used since that time. In 2000, this pattern changed when birds appeared in the Cobb-Island heronry (Williams et al. unpublished data). This event was followed in 2001 when the Wreck-Island heronry was colonized. In recent years, White Ibis have colonized the heronry on Chimney Pole Marsh and then the colony on Wire Narrows. The population has grown from 3 pairs in 1993 to 369 pairs in 2013 to 1,746 pairs in 2018. Recent increases have clearly been driven by immigration. Further expansion is likely and colonization should be expected in other large heronries along the seaside and possibly within the upper Bay islands.

Glossy Ibis – The Glossy Ibis was first found breeding in Virginia on Hog Island in 1956 (Bock and Terborgh 1957). The breeding population increased dramatically throughout the 1960s reaching a high by the mid-1970s (Custer and Osborn 1977). Since this time the species has steadily declined on the barrier islands (Williams et al. 1990). By 1993, the coastal plain population had been reduced by more than 50% from historic highs (Watts and Byrd 1998). Between 1993 and 2018, the population has declined by 64%. Of particular importance moving

forward is the ongoing erosion of sites supporting mixed heronries on the bay islands. Losses in this region have accounted for most of the decline.

Great Blue Heron – Due to funding constraints, this species was not assessed throughout the Coastal Plain in 2018. Anecdotal observations while flying other surveys throughout the region suggest that colonies have continued to fragment and the species is becoming more widespread with more small colonies compared to the historic pattern of few large colonies (Watts, pers. Obs.).

Due to funding constraints, this species was not assessed throughout the Coastal Plain. The population has increased dramatically over the past 30 years and this trend appears to be continuing to present although trends vary between regions. Great Egrets have continued to move inland and now breed beyond the fall line into the Piedmont (Watts, per. Obs.). Between 2013 and 2018, the population has declined within the Seaside of the Delmarva and in urban areas. The population appears to have continued to increase along tributaries of the Western Shore and Southside.

Snowy Egret – Historically, Snowy Egrets bred as far north as New England. However, by the turn of the century, demand from the millinary trade had resulted in a contraction of the breeding range down to North Carolina (Ogden 1978). The first evidence of recolonization was in 1941 when birds were discovered breeding on the seaside of the Delmarva (Murray 1952). By the mid-1950s, this species was documented in all geographic areas of coastal Virginia except the southside region (e.g. Grey 1950, Abbott 1955). However, since the 1970s breeding has been restricted to the seaside of the Delmarva and the offshore islands of the upper Bay. Numbers have declined steadily on the barrier islands since the mid-1970s. The coastal plain-wide survey in 1993 was comparable to the surveys of the mid-1970s (Custer and Osborn 1977, Watts and Byrd 1998). Between 1993 and 2018 the population has declined by more than 60%. However, the population was relatively stable between 2003 and 2018. Loss of nesting substrate on the seaside and on bay islands continues to be a concern. The colony on Mumford Island in the York River was lost since the 2013 survey due to sea-level rise. Population strongholds continue to be Watts Island and the Chincoteague Causeway.

Tricolored Heron – The Tricolored Heron was first documented to nest in Virginia when breeding birds were discovered on the seaside of the Delmarva in 1941 (Murray 1952). Colonization of Virginia was part of a broader, northward range expansion that occurred between the 1940s and 1970s (Ogden 1978). In Virginia, the population apparently increased to a high that reached a plateau during the 1950s through the 1970s (Erwin and Korschgen 1979). The species has declined on the barrier islands since that time (Williams et al. 1990). The population estimate of 1993 (Watts and Byrd 1998) was more than 50% reduced from that of the mid-1970s (Custer and Osborn 1977). Following an increase between 2003 and 2013 the population has declined and in 2018 was only 46% of the 1993 estimate. Like the other mid-sized waders, this species is vulnerable to ongoing habitat changes.

Little Blue Heron – Little Blue Herons were one of the most abundant waders along the Atlantic Coast from the 1930s to the 1950s (Ogden 1978). Historic breeding records for this species exist for all of the geographic regions of coastal Virginia (Grey 1950, Murray 1952, Abbott 1955). The species declined dramatically from the 1950s to the 1970s (Erwin and Korschgen 1979) and is now found only on the seaside of the Delmarva Peninsula

and within 2 colonies on Chesapeake Bay islands. From 1993 to 2018, Little Blue Herons declined by an estimated 82.9% or an additional 63.3% since 2013. Nearly 65% of the population in 2018 was nesting on Wreck Island and the Chincoteague Causeway.

Cattle Egret – The Cattle Egret was first found breeding in Virginia in 1961 (Scott and Cutler 1961). Colonization of Virginia was part of a rapid, broad-front range expansion that followed first establishment in North America in 1953 (Crosby 1972, Telfair 1994). The Virginia population increased rapidly during the 1960s. Although there has been considerable year to year variation on the barrier islands, numbers have declined since the mid-1970s and precipitously since the mid-1990s. Cattle Egrets experienced a dramatic decline between 1993 and 2018 within all breeding areas. Only 15 pairs were detected on islands within the Chesapeake Bay. Birds disappeared from the Hopewell colony on the James River in the mid-1990s and have never returned. Birds are now restricted to just 2 locations including Watts Island and the Chincoteague Causeway.

Green Heron – Green Herons nest widely thorughout the Coastal Plain. Due to their broad distribution and cryptic coloration, none of the colonial waterbird surveys have adequately covered this species. Population estimates are inadequate to assess trends outside of the heronries that are surveyed regularly. Within the heronries that are surveyed regularly, Green Herons have declined dramatically within both the barrier island/lagoon system and the Chesapeake Bay islands. More moderate declines were documented in the traditional colonies within urban areas.

Black-crowned Night Heron – The breeding population of Black-crowned Night Herons in coastal Virginia declined by an estimated 80% between 1975 (Custer and Osborn 1977) and 1993 (Watts and Byrd 1998). However, the species increased throughout the broader Coastal Plain between 1993 and 2003 and this trend continued through the 2008 survey. Much of this increase may be attributed to expansion of numbers within the Watts Island and Tangier Island colonies since 2003. Between 2003 and 2013, Black-crowns declined 44% resulting in a 32% decline since 1993. However, Black-crowns had a good showing in 2018 with the highest number of pairs since before 1993. The increase is entirely due to gains in seaside colonies with current strongholds including Wreck Island, Cobb Island and the Chincoteague Causeway.

Yellow-crowned Night Heron – The Yellow-crowned Night Heron likely bred in Virginia in the 1800s but was apparently absent by the early 1900s. The first modern breeding record for Virginia was in 1947 (Darden 1947). This event corresponds with a range expansion from the southeast northward to New England (Watts 1995). In Virginia, Yellow-crowns increased within urban areas of Norfolk, Hampton, Virginia Beach, and Portsmouth at least through the early 1990s (Watts unpublished data). Between 1993 and 2003 the population declined primarily because of losses within Bay Island and Seaside mixed heronries. Since this time the population has recovered and is higher than in 1993. The increase reflects ongoing population expansion within urban neighborhoods of lower Tidewater.

Gulls

As a group, gulls declined by nearly 64% over the 25-year period from an estimated 54,702 breeding pairs in 1993 to 19,729 in 2018. This decline was due almost entirely to the catastrophic decline in Laughing Gulls between 2003 and 2018. Herring Gulls continue their long decline. Great Black-backed Gulls increased dramatically between 1993 and 2003 but have stabilized since that time.

Great Black-backed Gull – In 1970, the Great Black-backed Gull was found breeding on Fisherman Island (Scott and Cutler 1970). This event was part of a broader range expansion that began in the early 1900s and has moved down the Atlantic Coast (Good 1998). Since the 1970s, this species has rapidly colonized other locations on both the seaside and Chesapeake Bay islands. Between 1993 and 2003, the population more than doubled in size. Since 2003 the population has remained stable. Although the stronghold continues to be within the seaside, nearly as many colonies occur on the Bay islands and account for more than 25% of the population. The Hampton Roads Tunnel Island continues to be the only breeding location within the lower Bay. The colony located in 2008 on a small islet along the Guinea Marshes in Gloucester County has been lost to erosion.

Herring Gull – A single Herring Gull nest was found on the seaside near Cobb Island in 1948 (Murray 1952). By 1977, 9 colonies containing more than 2,900 pairs were reported (Erwin and Korschgen 1979). The 1993 survey located 35 colonies supporting an estimated 8,800 pairs. The breeding population on the barrier islands apparently reached a high in the late 1980s and has shown evidence of a decline since that time (Williams et al. unpublished data). Between 1993 and 2018 the Coastal Plain population declined by an estimated 77.8% or an additional 41% since 2003. Consistent declines were observed in both regions where breeding was documented in 1993. Most of the larger colonies continue to be on the Seaside including the Chincoteague Causeway colony, Coards Marsh and Little Cobb.

Laughing Gull – Virginia has apparently been a stronghold for breeding Laughing Gulls for centuries. This species has been the numerically dominant colonial waterbird during all comprehensive surveys conducted of the Coastal Plain. Between 1977 and 1993 there was a considerable increase in population estimates. Between 1993 and 1998, there was a very small decline in numbers on the seaside of the Delmarva Peninsula (Truitt and Schwab 2001). The barrier island population exhibited considerable variation after the mid-1970s but estimates over the past 20 years have consistently represented only 20-30% of those during the late 1980s. The population decline between 2003 and 2013 was catastrophic and the most significant result of the 2013 survey. Historic colony sites within the southern portion of the Delmarva seaside have now been abandoned for several years. Evidence of stress are now being seen within the topographically higher colonies in Accomack County along the Chincoteague Causeway. Collectively, the patterns of decline suggest impacts by tidal flooding that require further investigation. The colonies now along the Chincoteague Causeway, on Wreck Island and on the Hampton Roads Tunnel Island appear to be movements of colonies to higher ground.

Terns

As a group, terns declined 53% over the 25-year period from an estimated 17,785 pairs in 1993 to 8,361 breeding pairs in 2018. With the exception of Sandwich Terns, all remaining tern species experienced declines ranging from 15 to more than 80%.

Gull-billed Tern – The Gull-billed Tern has experienced extreme population swings in coastal Virginia over the past 200 years (Parnell et al. 1995). In the mid-1800s this species was considered to be abundant along the barrier islands. By the late 1800s and early 1900s they had been reduced to very low numbers by hunters supplying the millinery trade (Bailey 1913). Throughout the early 1900s numbers remained very low (Austin 1932). By the mid-1970s numbers appear to have recovered to those comparable with the 1800s. By 1993, the population had declined once again to approximately 20% of 1970s levels (Watts and Byrd 1998). Between 1993 and 2018 the number of occupied colonies declined from 30 to 7 and the number of breeding pairs declined by 42.4%. A bright spot of the 2018 survey was the substantial increase in Gull-bills from 294 pairs in 2013 to 349 pairs in 2018. This recovery is due to strong colonies on north Smith Island and Cedar Sandbar that collectively accounted for more than 72% of the population.

Caspian Tern – There is some evidence that Caspian Terns once bred in greater numbers along the Virginia barrier islands than they have from 1900 to present (reviewed by Weske et al. 1977). Egging and hunting apparently reduced their numbers in the 1880s to a low from which they have never fully recovered. Since 1900, Caspians have been documented in very low numbers breeding in scattered locations along the seaside and occasionally on Chesapeake Bay islands. They appear to be present consistently since the mid-1970s. In 1993 only 7 pairs were documented in 5 locations. During the 2003 survey, only a single pair was documented. In 2008, 2 pairs were documented on Clump Island in the upper Bay. In 2018, a single pair was found within the Royal Tern colony on Wire Narrows. The species has nested on this shell pile consistently since at least 1993.

Royal Tern – In Virginia, Royal Terns have apparently always been the most abundant of the large terns. Like many of the other terns, their numbers have fluctuated widely through the years due to natural and human perturbations. This species also appears to move over a larger spatial scale such that local population patterns may reflect movements rather than population changes. This possibility is supported by wide fluctuations in adjacent states (D. Brinker, S. Cameron unpublished data). Royal Terns have declined on the barrier islands since the early 1980s (Williams et al., unpublished data). The population estimate for the broader Coastal Plain in 1993 was comparable to estimates from the mid-1970s (Erwin and Korschgen 1979). Since 1993, the number of breeding pairs has declined 34.3%. Since 2003, numbers increased due entirely to the establishment of birds on the Hampton Roads Bridge Tunnel Island. Numbers have again declined and the Hampton Roads Bridge Tunnel Island colony accounts for 84% of the state population. Given the plans for this colony site and the loss of historic breeding sites to sea-level rise, we are likely to observe a population decline in the coming years.

Sandwich Tern – Virginia and occasionally Maryland represent the northern range limit for breeding Sandwich Terns. There is no evidence that this species was ever a common breeder in Virginia. Scattered records in the late 1800s and early 1900s imply that this species was an uncommon nester associated with Royal Tern colonies on the barrier islands (records reviewed by Weske et al. 1977). There is a paucity of reports throughout the middle

1900s until the late 1960s when the species was discovered nesting again on the barrier islands (Buckley and Buckley 1968). Breeding has been consistent on the barrier islands since the mid-1970s but has involved relatively few individuals. Numbers documented during the annual barrier island survey have fluctuated widely since the mid-1970s (Williams et al. unpublished data). The change from 30 pairs in 1993 to 7 pairs in 2003 to 100 pairs in 2008 to 28 pairs in 2013 and back to 102 pairs in 2018 reflect the dynamics of their occurrence in Virginia.

Forster's Tern – Like many of the other colonial species that nested historically in coastal Virginia, Forster's Terns were greatly impacted by market hunting from the 1870s though approximately 1910 (Howell 1911, Austin 1932). Due to their nesting habits, the status of Forster's Terns was less known compared to other tern species. Forster's nest in scattered colonies within the lagoon system on wrack deposited in the marshes or on other topographic highs. Their distributions are subject to change depending on the availability of nesting substrate. This makes them difficult to survey effectively. The first comprehensive survey of Forster's was in 1977 (Erwin and Korschgen 1977). By 1993, numbers appeared to have doubled (Watts and Byrd 1998) likely representing more complete coverage. Between 1993 and 2018 estimated population size declined by 49.2%. More significant is that most (38.5%) of this decline has occurred since 2013. Forster's appear to be suffering from sea-level rise similar to Laughing Gulls that utilize a comparable nesting substrate.

Common Tern - Historically, the Common Tern nested throughout coastal Virginia wherever there was suitable substrate away from predators. Like many of the other species, Common Terns were hunted to very low numbers by the turn of the 20th century but there were signs of recovery by the early 1930s (Austin 1932). Since the 1960s Common Tern colonies have been documented in many areas of the Coastal Plain. However, over the past 20 years colonies have disappeared from the western shore and lower tidewater. Since the 1980s, Common Terns have shown consistent declines on the barrier islands (Williams et al. unpublished data). However declines on the islands were compensated for by the formation of the largest colony in the state on the Hampton Roads Tunnel Island such that estimates from 1977 (Erwin and Korschgen 1979) and 1993 (Watts and Byrd 1998) were comparable. Between 1993 and 2018, Common Terns declined by 80.6% in coastal Virginia. Considerable declines have been documented in all 3 geographic regions that supported colonies in 1993. Much of the overall decline was accounted for by the recent losses within the tunnel island colony. Given the plans for this colony site and the loss of historic breeding sites to sea-level rise, we are likely to observe continued population declines in the coming years.

Least Tern – Historically, Least Tern colonies have been documented throughout many areas of coastal Virginia including up major tributaries to near tidal fresh waters. Abundant on the barrier islands this species was hunted relentlessly during the late 1800s to near extirpation. After release from hunting pressures, Least Terns rebounded rapidly. Numbers appear to have reached a high in the early 1980s and then declined steadily over the next 20 years (Beck et al. 1990). Between 1993 and 2003 the population declined 28% from 1171 to 843 breeding pairs. Since 2003 the population has recovered to 991 breeding pairs. In 2008, for the first time in Virginia, colonies were located on roof tops in urban areas. Colonies have been located on Lynnhaven Mall, Patrick Henry Mall, and a building on Langley Airforce Base (Lynnhaven Malle site was not documented as active in 2018). The formation of roof top colonies has been reported throughout the southeast and has been

anticipated for many years in Virginia. It is possible that additional colonies exist within lower tidewater or elsewhere that have not been discovered. Such colonies are subject to severe heat stress and active management is required to improve productivity.

Others

As a group, the three remaining waterbird species have increased 257% from 3,820 to 9,825 breeding pairs. This overall increase reflects the fact that both Double-crested Cormorants and Brown Pelicans are recent colonizers that are rapidly expanding. This increase masks the substantial decline in Black Skimmers.

Black Skimmer – The Black Skimmer appears to have been a common nester on the barrier islands for as far back as records are available. Due to their coloration, skimmers were not valued in the millinery trade and so were not hunted as actively as many of the other beach-nesting species. They also were favored by the locals and so did not experience the same degree of pressure from eggers. From most accounts, Black Skimmers were one of the numerically dominant species on the barrier islands throughout most of the 20th century. However, between the mid-1970s and the 1990s numbers on the barrier islands were reduced by 70%. This decline continued between 1993 and 2013 as the coastal population declined 51.4% from an estimated 3,098 to 1,506 breeding pairs. Since 2013 the population appears to have stabilized with strong colonies on the north end of Smith Island and on Cedar Sandbar. The other stronghold on the Hampton Roads Tunnel Island is now at risk of being lost due to plans for expansion of the bridge.

Double-crested Cormorant – Breeding of the Double-crested Cormorant in Virginia was first confirmed in 1978 on a small vegetated island in the James River near Hopewell (Scott 1978). Range wide cormorants have experienced wide fluctuations in numbers and distribution throughout the 20th century (Hatch 1984). Colonization of Virginia represents an expansion beyond the historic range following a low during the DDT era (1940s-1972) (Hatch and Weseloh 1999). After 1984, the Virginia population expanded rapidly to 5 colonies by 1995 containing more than 400 pairs (Watts and Bradshaw 1996). The seaside of the Delmarva was not colonized until 1995. Between 1993 and

2018 the population has increased by 1416% from 354 to 5,012 pairs. Most of this increase is accounted for by the rapid expansion of the Shanks Island colony. The colony has expanded from 6 pairs in 1993 to 907 pairs in 2003 to 1, 636 in 2008 to 2,369 in 2013 to 5,012 in 2018. Three colonies now exist on the seaside including 2 on duck blinds in Chincoteague Bay. It seems likely that this species will expand on the seaside as the breeding of brown pelicans expands.

Brown Pelican – The Brown Pelican was first found breeding in Virginia on Fisherman Island in 1987 (Williams 1989). During this same year, birds were also found nesting on Metomkin Island (Williams 1989). In 1992, an additional colony was formed in the upper Chesapeake Bay on Shanks Island north of Tangier (Brinker, pers. Comm..). In recent years, two colonies on the seaside have come and gone and the current colony on Wreck Island had expended substantially. Between 1993 and 2018 the Virginia population increased 882% from an estimated 368 to 3,246 breeding pairs. Colonization of Virginia represents a northward range expansion from North Carolina that extends beyond the historic range and follows recovery of southeastern populations from contaminants. Since its discovery, the Shanks Island colony has grown exponentially apparently fueled by

continued immigration. In 1993, there were only 53 pairs documented in this colony (Watts and Byrd 1998). By 1999, the colony supported 913 breeding pairs (Watts 1999). The colony reached a peak in 2013 with 1,857 pairs and has now declined to 1,753 pairs. The Wreck Island colony has shifted south on the island over the past couple of years, expanding dramatically and now including 1,493 pairs.

ACKNOWLEDGMENTS

Many individuals and organizations contributed to the success of the 2018 colonial waterbird survey in Virginia. We very much appreciate and admire the broad commitment by agencies and individuals to this bird community. Captain Fuzzzo Shermer provided expert flying services. We thank the many observers who participated in ground surveys, including Zach Bradford, M. Byrd, Dan Caitlin, Pam Denmon, Bridie Farmer, Catherine Galway, Alicia Garcia, Dan Gibson, Nick Gomer, Kelsi Hunt, Sarah Carpanty, Sara Maxwell, Zak Poulton, James Powell, Adam Priestly, Shannon Reinheimer, Chris Rowe, Lee Schuster, Erin Smith, Jeremy Tarwater, Marian Watts, Jimmy Wiebler, Bill Williams and Jeri Wisman. We thank Laura McKay for her continued support for bird monitoring in Virginia. Erica Lawler provided fiscal management from the College of William & Mary. Financial support was provided by the Virginia Department of Game & Inland Fisheries, the Virginia Coastal Zone Management Program and The Center for Conservation Biology, The Nature Conservancy, the Virginia Department of Transportation, and the U.S. Army Corps of Engineers. Additional agency partners include the U.S. Fish and Wildlife Service and the Natural Heritage Program of the Virginia Department of Conservation and Recreation.

LITERATURE CITED

Abbott, J. M. 1955. The Hollis Marsh Island heronry, Westmoreland County, Virginia. Raven 26:102-103.

Austin, O. L., Jr. 1932. Cobb Island. Bird-Banding 8:12-25.

Bailey, H. H. 1913. The birds of Virginia. J. P. Bell, Col, Inc. Lynchburg, VA.

Beck, R. A., J. W. Akers, J. W. Via, and B. Williams. 1990. Status and distribution of the Least Tern in Virginia – 1975 to 1988. Virginia Journal of Science. 41:404-418.

Bock, W. and J. Terborgh. 1957. Breeding of the Glossy Ibis in Virginia. Bird Banding 28:38.

Buckley, P. A. and F. G. Buckley. 1968. The current status of certain birds in the Virginia Capes area. II. April 1967-July 1968 observations. Raven 39:27-40.

Crosby, G. T. 1972. Spread of the Cattle Egret in the Western Hemisphere. Bird Banding 43:205-212.

Custer, T. W. and R. G. Osborn. 1977. Wading birds as biological indicators: 1975 colony survey. U.S. Fish and Wildlife Service Special Scientific Report – Wildlife No. 206. 28 pp.

Darden, C. W. 1947. Nest of a Yellow-crowned Night Heron. Raven 18:25-26.

Erwin, R. M. and C. E. Korschgen. 1979. Coastal waterbird colonies: Maine to Virginia, 1977. An atlas showing colony locations and species composition. U.S. Fish and Wildlife Service FWS/OBS-79/08.

Frohring, P. C. and R. A. Beck. 1978. First breeding record of the White Ibis (Eudocimus albus) in Virginia. American Birds 32:1.

Good, T. P. 1998. Great Black-backed Gull (Larus marinus). In The Birds of North America, No. 330 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Grey, J. H., Jr. 1950. Birds of the Cape Henry area. Raven 21:30-69.

Hatch, J. J. 1984. Rapid increase in Double-crested Cormorants nesting in southern New England. American Birds 38:899-902.

Hatch, J. J., and D. V. Weseloh. 1999. Double-crested Cormorant (Phalacrocorax auritus). In The Birds of North America, No. 441 (A. Poole and F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

Howell, A. B. 1911. A comparative study at Cobb's Island, VA. Auk 28:449-453.

Murray, J. J. 1952. A checklist of the birds of Virginia. Virginia Society of Ornithology.

Ogden, J. C. 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf Coastal Plains. Pp. 137-154. In Wading birds. National Audubon Society Research Report No. 7 (A. Sprunt IV, J. C. Ogden, and S. Winckler, Eds.) National Audubon Society, New York, NY.

Otis, D. L, K. P. Burnham, G. C. white, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62.

Parnell, J. F., R. M. Erwin, and K. C. Molina. 1995. Gull-billed Tern (Sterna nilotica). In The Birds of North America, No. 140 (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia and The American Ornithologists' Union, Washington, D.C.

Scott, F. R. and D. A. Cutler. 1970. Middle Atlantic Coast region. American Birds 24:688-670.

Spendelow, J. A. and S. R. Patton. 1988. National atlas of coastal waterbird colonies in the contiguous United States: 1976-1982. U.S. Fish and Wildlife Service Biological Report 88(5).

Telfair, R. C. II. 1994. Cattle Egret (Bubulcus ibis). In The Birds of North America, No. 113 (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia and The American Ornithologists' Union, Washington, D.C.

Truitt, B. R. and D. J. Schwab. 2001. 1998 Eastern Shore seaside barrier island/lagoon colonial waterbird survey. Raven 72:126-131.

Watts, B. D. 1995. Yellow-crowned Night Heron (Nyctanassa violacea). In The Birds of North America, No. 161 (A. Poole and F. Gill, Eds.) Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists Union, Washington, D.C.

Watts, B. D. and D. S. Bradshaw. 1996. Population expansion by Double-crested Cormorants in Virginia. Raven 67:75-78.

Watts, B. D. and M. A. Byrd. 1998. Status and distribution of colonial waterbirds in coastal Virginia. The Raven 69:20-31.

Watts, B. D. 2000. A study of waterbirds in Shanks Creek: An investigation on Smith Island, MD. Center for Conservation Biology Technical Report Series, CCBTR-00-12. College of William and Mary, Williamsburg, VA. 30 pp.

Watts, B. D. and B. J. Paxton. 2004. Digital atlas of colonial waterbirds in coastal Virginia: 2003 breeding season. Center for Conservation Biology Technical Report Series, CCBTR-04-05. College of William and Mary, Williamsburg, VA.

Watts, B. D. and M. A. Byrd. 2006. Status and distribution of colonial waterbirds in coastal Virginia: The 2003 breeding season. The Raven 77:3-22.

Watts, B. D. and B. J. Paxton. 2009. Status and distribution of colonial waterbirds in coastal Virginia: 2009 breeding season. Center for Conservation Biology Technical Report Series, CCBTR-09-03. College of William and Mary & Virginia Commonwealth University, Williamsburg, VA. 21 pp.

Watts, B. D. and B. J. Paxton. 2014. Status and distribution of colonial waterbirds in coastal Virginia: 2013 breeding season. Center for Conservation Biology Technical Report Series, CCBTR-14-03. College of William and Mary & Virginia Commonwealth University, Williamsburg, VA. 23 pp.

Weske, J. S., R. B. Clapp, and J. M. Sheppard. 1977. Breeding records of Sandwich and Caspian Terns in Virginia and Maryland. Raven 48:59-65.

Williams, B. 1989. The first breeding record of the Brown Pelican in Virginia: A chronology. Raven 60:1-3.

Williams, B., R. A. Beck, B. Akers, and J. Via. 1990. Longitudinal surveys of the beach nesting and colonial waterbirds of the Virginia barrier islands. Virginia Journal of Science. 41:380-388.

Williams, B., B. Akers, R. Beck, J. Via, and S. Rottenborn. 1992. The 1991 Virginia barrier islands beach-nesting and colonial waterbird survey. Raven 63:96-101.

Williams, B., B. Akers, M. Beck, R. Beck, and J. Via. 2000. The 1998 survey of the beach-nesting waterbirds of the Virginia barrier islands. Raven 71:42-45.

Williams, B., B. Akers, M. Beck, R. Beck, and J. Via. 2002. A summary report of the 2001 Virginia barrier islands beach-nesting and colonial waterbirds survey. Raven 73:10-16.

APPENDIX.

Appendix I. List of colonial waterbird species surveyed in coastal Virginia along with A.O.U. alpha codes.

Species	Alpha Code	Scientific Name
Great Black-backed Gull	GBBG	*Larus marinus*
Herring Gull	HERG	*Larus argentatus*
Laughing Gull	LAGU	*Larus atricilla*
Gull-billed Tern	GBTE	*Sterna nilotica*
Caspian Tern	CATE	*Sterna caspia*
Royal Tern	ROYT	*Sterna maxima*
Sandwich Tern	SATE	*Sterna sandwicensis*
Forster's Tern	FOTE	*Sterna fosteri*
Common Tern	COTE	*Sterna hirundo*
Least Tern	LETE	*Sterna antillarum*
Black Skimmer	BLSK	*Rynchops niger*
Double-crested Cormorant	DCCO	*Phalacrocorax auritus*
Brown Pelican	BRPE	*Pelacanus occidentalis*
White Ibis	WHIB	*Eudocimus albus*
Glossy Ibis	GLIB	*Plegadis falcinellus*
Great Blue Heron	GBHE	*Ardea herodias*
Great Egret	GREG	*Casmerodius albus*
Snowy Egret	SNEG	*Egretta thula*
Tricolored Heron	TRHE	*Egretta tricolor*
Little Blue Heron	LBHE	*Egretta cerulea*
Cattle Egret	CAEG	*Bubulcus ibis*
Green Heron	GRHE	*Butorides striatus*
Black-crowned Night Heron	BCNH	*Nycticorax nycticorax*
Yellow-crowned Night Heron	YCNH	*Nyctanassa violacea*