

STATUS AND DISTRIBUTION OF COLONIAL WATERBIRDS IN COASTAL VIRGINIA: THE 2003 BREEDING SEASON

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ABSTRACT

We conducted a systematic survey of colonial waterbirds in coastal Virginia during the breeding season of 2003. More than 800 surveys were conducted of 446 colonies during the breeding season of 2003. Colonies contained an estimated 79,343 breeding pairs of 24 species. Gulls were the most abundant group with more than 50,000 breeding pairs. Terns and waders accounted for 8,399 and 15,557 pairs respectively. Laughing gulls were several times more abundant than any other species and represented 56.7% of the total waterbird community. Great Blue Herons were the most widely distributed species with more than 200 colonies documented. The barrier island/lagoon system of the Eastern Shore was the most important region for the majority of colonial species encountered. This region supported 22 of the 24 species found in coastal Virginia and accounted for greater than 70% and 35% of all breeding pairs and colonies, respectively. For 18 of the 24 species, the region supported more than 50% of the known coastal population.

The colonial waterbird community in coastal Virginia declined by more than 16% during the 10 years between 1993 and 2003. Losses were widespread with 17 of 24 species exhibiting negative trends. The magnitude of declines varied between species with 10 species declining by more than 40% and 4 species declining by more than 70%. Cattle Egrets showed the highest loss rate, declining from an estimated 1,459 to only 166 pairs over the 10-yr period. Seven species increased between 1993 and 2003. Dramatic expansions were documented for White Ibis, Great Black-backed Gull, Double-crested Cormorant, and Brown Pelican. The overall waterbird community declined within all geographic regions except the western shore. Due to the area's importance to the overall community, declines on the seaside of the Delmarva Peninsula accounted for more than 85% of the broader coastal decline.

INTRODUCTION

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 in the state include human disturbance, predation, habitat loss, and contaminants. Protection of sensitive colonies depends on the availability of current locational information. Development of strategic management plans to protect these species and breeding areas requires a broader understanding of population trends.

In 1993, a systematic survey of colonial waterbird species 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. After the conclusion of the 1993 survey, the consortium of partners that participated in the survey collectively agreed to maintain a survey interval of 10 years to track long-term trends. The 2003 breeding season represents the 10-year anniversary of the 1993 survey.

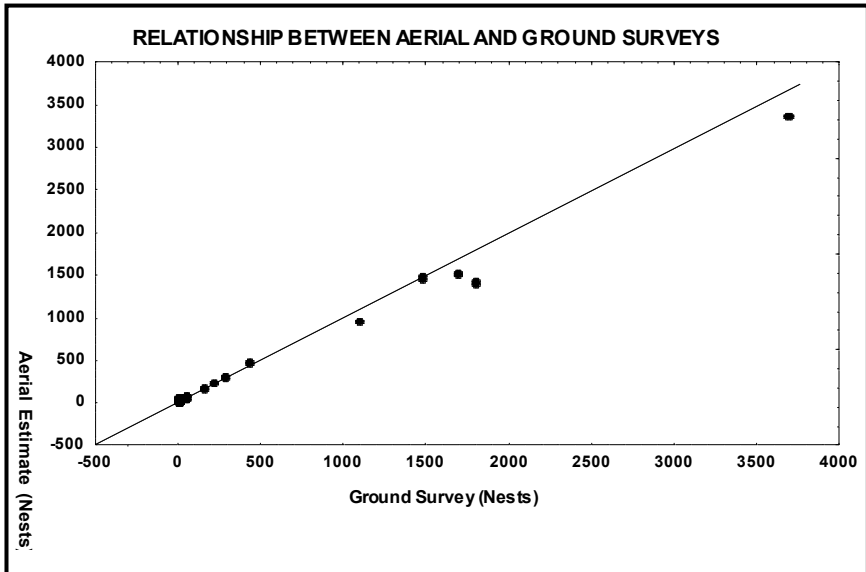
The purpose of this effort was to generate population estimates for all colonial waterbird species nesting in the Coastal Plain of Virginia in 2003. Information compiled is intended to (1) be integrated into biological databases to be used in the environmental review process, (2) provide information for comparison to past and future surveys for the purpose of assessing long-term population trends, and (3) be used in the formulation of management recommendations.

METHODS

Field Surveys – An extensive aerial survey was conducted using fixed-wing aircraft in 2003 during early stages of the breeding season. All mainland waterways, barrier islands, Bay islands, and marshlands were overflown and searched for wading bird colonies. Due to their wide distribution and large numbers, only the largest inland reservoirs and farm ponds were surveyed. Because Great Blue Heron colonies often form near the headwaters of small streams, a special attempt was made to follow all tributaries to their origin. 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-numeric code and plotted on 7.5 min topographic quadrangles. 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 inland Great Blue Heron colonies and most gull colonies. Great Blue Heron colonies were widespread and often situated in remote locations or over extensive swamps. Financial and logistical constraints did not allow for ground surveys of these sites. Many gull colonies were distributed over large areas. We believe that aerial surveys of these colonies are more effective and less disruptive compared to ground surveys.

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. In order to evaluate the level of error in aerial estimates 20 colonies were chosen for aerial/ground comparisons. Aerial estimates and complete ground counts were conducted within 10 days of each other. Included were colonies of Great Blue Herons, Laughing Gulls, Herring Gulls, Forster's Terns and Common Terns. Colonies ranged in size from less than 20 to several thousand. Average disparity between paired surveys was $8.9 \pm 1.69\%$ (Mean \pm SE). Agreement between aerial and ground surveys was very good for colonies below 500 pairs (Figure 1). Beyond 500 pairs, aerial surveys underestimated colony size by 5-15%. This level of error is consistent with the reduction in data resolution used for population estimates in 1993 (Watts and Byrd 1998) as outlined below.



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. Mainland areas likely to support early nesting waders were flown from early April to mid-May. 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, and June. Ground counts of barrier islands, bay islands, and marshlands were conducted during June and July.

Due to the differences in breeding chronology and circumstances, different surveys were used to generate population estimates for different species. Numbers from aerial surveys were used for inland wader colonies. 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 Laughing Gull colonies. Laughing Gull colonies often cover many hectares making estimation of nest numbers much easier from the air.

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.

Geographic Regions – For the presentation of gross distribution patterns, the Coastal Plain was broken down into five geographic regions (Figure 2). 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).

Population Estimates – A total of 446 different waterbird colonies was mapped and surveyed during the 2003 breeding season. Colonies contained an estimated 79,343 breeding pairs of 24 species (see Watts and Paxton 2004 for species/colony details and Appendix I for species names). Colony size varied from 2 to 4,700 pairs with 76.2% of colonies containing less than 100 pairs and 91.0% containing less than 500 pairs. More than 70% of all colonies larger than 500 pairs were Laughing Gull colonies. The majority (74.0%) of colonies contained only one species and 94.6% contained three species or less. Seven mixed-species rookeries contained seven species or more.

Abundance varied widely between species and species groups (Table 1). Gulls were the most abundant group with >50,000 breeding pairs. Terns and waders accounted for 8,399 and 15,557 pairs respectively. Although waders accounted for less than 20% of estimated pairs, they accounted for more than 50% of colonies. Great Blue Herons were the most widely distributed species with more than 200 colonies. Laughing gulls were several times more abundant than any other species

TABLE 1. Estimated number of breeding pairs for all geographic regions combined in 2003. The category “colonies” refers to the number 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).

Species	Colonies	Median	Range	%Nests	Pop. Est.
Waders					
White Ibis	2	----	32-45	0	77
Glossy Ibis	11	62	16-290	2.9	818
Great Blue Heron	203	14	2-1500	>99.9	9136
Great Egret	35	60	2-385	79.7	2720
Snowy Egret	16	48	6-209	15.5	882
Tricolored Heron	11	30	2-195	4.9	507
Little Blue Heron	8	38	3-140	12.3	310
Cattle Egret	6	20	1-74	0.6	166
Green Heron	12	5	1-14	98.1	60
Black-cr Night Heron	14	21	4-325	1.6	640
Yellow-cr Night Heron	40	4	2-55	99.2	241
Gulls					
Great Black-backed Gull	31	23	1-200	46.5	1084
Herring Gull	38	63	1-617	51.9	4521
Laughing Gull	60	450	6-4800	95.8	44953
Terns					
Gull-billed Tern	17	14	1-101	66.1	322
Caspian Tern	1	1	1	100	1
Royal Tern	4	500	203-1855	28.0	2858
Sandwich Tern	2	----	3-4	0	7
Forster's Tern	58	25	1-350	65.8	2477
Common Tern	37	32	1-791	60.9	1891
Least Tern	24	12	1-200	23.3	843
Others					
Black Skimmer	14	60	1-1037	8.5	1828
Dble-crested Cormorant	5	267	10-469	100	1338
Brown Pelican	4	476	52-679	100	1661
Total	446		1-4800	81.8	79343

and accounted for 56.7% of the total waterbird community. Other than Laughing Gulls, only Great Blue Herons, Great Egrets, Herring Gulls, and Royal Terns exceeded 2,500 breeding pairs. The remaining 19 species accounted for less than 20% of the total breeding 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 2003, this region supported 22 of the 24 species found in coastal Virginia and accounted for greater than 70% and 35% of all breeding pairs and colonies, respectively. For 18 of the 24 species, the region supported more than 50% of the

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.

Species	Seaside			Bay Islands			Urban			Western Shore			Southside		
	Col	Prs	%	Col	Prs	%	Col	Prs	%	Col	Prs	%	Col	Prs	%
Waders															
White Ibis	2	77	100.0	----	----	----	----	----	----	----	----	----	----	----	----
Glossy Ibis	8	669	81.8	3	149	18.2	----	----	----	----	----	----	----	----	----
Great Blue Heron	----	----	----	17	576	6.3	4	51	0.6	158	7112	77.8	24	1397	15.3
Great Egret	9	467	17.2	3	470	17.3	3	586	21.5	12	359	13.2	9	838	30.8
Snowy Egret	9	624	70.7	6	178	21.2	----	----	----	1	80	9.1	----	----	----
Tricolored Heron	7	456	89.9	4	51	10.1	----	----	----	----	----	----	----	----	----
Little Blue Heron	5	249	80.3	3	61	19.7	----	----	----	----	----	----	----	----	----
Cattle Egret	5	146	88.0	1	20	12.0	----	----	----	----	----	----	----	----	----
Green Heron	----	----	----	2	7	11.7	7	25	41.6	3	28	46.7	----	----	----
Black-crowned Night Heron	9	590	92.2	4	50	7.8	----	----	----	----	----	----	----	----	----
Yellow-crowned Night Heron	1	2	0.8	1	4	1.7	38	234	96.3	1	3	1.2	----	----	----
Gulls															
Great Black-backed Gull	15	720	66.4	15	353	32.6	1	11	1.0	----	----	----	----	----	----
Herring Gull	18	3417	75.6	17	1066	23.6	1	24	0.5	2	14	0.3	----	----	----
Laughing Gull	58	41692	92.7	1	550	1.2	1	2711	6.1	----	----	----	----	----	----
Terns															
Gull-billed Tern	16	304	94.4	----	----	----	1	18	5.6	----	----	----	----	----	----
Caspian Tern	1	1	100.0	----	----	----	----	----	----	----	----	----	----	----	----
Royal Tern	2	2058	72.0	2	800	28.0	----	----	----	----	----	----	----	----	----
Sandwich Tern	2	7	100.0	----	----	----	----	----	----	----	----	----	----	----	----
Forster's Tern	51	1521	61.4	7	956	38.6	----	----	----	----	----	----	----	----	----
Common Tern	31	843	44.6	4	248	13.1	2	800	42.3	----	----	----	----	----	----
Least Tern	22	703	83.4	----	----	----	1	140	16.6	----	----	----	----	----	----
Others															
Black Skimmer	12	1679	91.8	1	65	3.6	1	84	4.6	----	----	----	----	----	----
Double-crested Cormorant	1	10	0.7	2	907	67.8	1	154	11.5	1	267	20.0	----	----	----
Brown Pelican	1	454	27.3	3	1207	72.7	----	----	----	----	----	----	----	----	----
Total	162	56,689	71.5	45	7,718	9.7	48	4,838	6.1	166	7,863	9.9	25	2,235	2.8

known coastal population. Many of these species were found almost exclusively in this region. Only the Great Blue Heron, Great Egret, Green Heron, Yellow-crowned Night Heron, Double-crested Cormorant, and Brown Pelican were more abundant in other regions. The number of species supported by the other four geographic regions varied widely. The Bay region supported 19 species whereas the urban, western shore, and southside regions supported 12, 7, and 2 respectively. The Bay region also supported 8 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 the Brown Pelican. Cities included in the urban region supported substantial populations of Common Terns, Least Terns, Laughing Gulls, Double-crested Cormorants, Great Egrets, Green Herons, and Yellow-crowned Night Herons. This was the dominant region for the Yellow-crowned Night Heron. The western shore was the dominant region for the Great Blue Heron and the Green Heron. Greater than 78% of the Great Blue Heron colonies were located within this area. The southside region supported substantial populations of both Great Blue Herons and Great Egrets.

Population Changes – The colonial waterbird community in coastal Virginia declined by more than 16% during the 10 years between 1993 and 2003 (Table 3). There was no change in either the number or type of species breeding in the area. Despite considerable turnover in colonies, the total number of colonies was identical between the two surveys. Population estimates for 17 of 24 species declined. Declines varied considerably between species with 10 species declining more than 40% and 4 species declining more than 70%. Cattle Egrets showed the highest loss rate, declining from an

TABLE 3. Comparison of colony numbers and estimated number of breeding pairs for 1993 and 2003. The category “colonies” refers to the number of colonies that included each species. Population estimates refer to breeding pairs.

Species	1993 Colonies	1993 Pop. Est.	2003 Colonies	2003 Pop. Est.	% Change
Waders					
White Ibis	1	3	2	77	+2466.7
Glossy Ibis	11	1008	11	818	-18.8
Great Blue Heron	156	9112	202	9136	+0.3
Great Egret	45	2520	35	2720	+7.9
Snowy Egret	15	2329	16	882	-62.1
Tricolored Heron	11	767	11	507	-33.9
Little Blue Heron	10	374	8	310	-17.1
Cattle Egret	9	1459	6	166	-88.6
Green Heron	22	154	13	60	-61.0
Black-crowned Night Heron	13	526	14	640	+21.7
Yellow-crowned Night Heron	35	388	40	241	-37.9
Gulls					
Great Black-backed Gull	26	514	31	1084	+110.9
Herring Gull	35	8801	38	4521	-48.6
Laughing Gull	110	45387	60	44953	-0.9
Terns					
Gull-billed Tern	30	606	17	322	-46.9
Caspian Tern	5	8	1	1	-87.5
Royal Tern	3	6250	4	2858	-54.3
Sandwich Tern	2	30	2	7	-76.7
Forster's Tern	72	2939	58	2477	-15.7
Common Tern	40	6781	37	1891	-72.1
Least Tern	26	1171	24	843	-28.0
Others					
Black Skimmer	25	3098	14	1828	-41.0
Double-crested Cormorant	4	354	5	1338	+278.0
Brown Pelican	2	368	4	1661	+351.4
Total	446	94947	446	79343	-16.4

estimated 1,459 to only 166 pairs. Seven species increased between 1993 and 2003. Dramatic expansions were documented for White Ibis, Great Black-backed Gull, Double-crested Cormorant, and Brown Pelican.

Changes in population estimates varied widely between species and across geographic areas (Table 4). The overall waterbird community declined within all geographic regions except the western shore. Due to the area's importance to the overall community, declines on the seaside of the Delmarva Peninsula had a dramatic impact

on the coastal plain as a whole. Breeding pairs within this region dropped from 69,968 to 56,689 and accounted for more than 85% of the overall coastal decline. In general, the direction and magnitude of changes for species within this region drove their overall changes. Some notable exceptions were Great Blue Heron and Great Egret. Several colonization events occurred

TABLE 4. Changes in population estimates for colonial waterbirds between 1993 and 2003 for specific geographic regions. Values presented represent % change as calculated by (2003 est. - 1993 est./1993 est.)(100). "Col." Indicates that the region was colonized between 1993 and 2003.

Species	Seaside	Bay Islands	Urban	Western Shore	Southside
Waders					
White Ibis	+2466.7	----	----	----	----
Glossy Ibis	-14.1	-34.9	----	----	----
Great Blue Heron	-100.0	+171.7	+10.9	+6.4	-35.4
Great Egret	-47.2	+840.0	-25.4	+86.0	+38.1
Snowy Egret	-66.5	-61.9	----	Col.	----
Tricolored Heron	-36.0	-5.5	----	----	----
Little Blue Heron	-24.5	+38.6	----	----	----
Cattle Egret	-82.9	-94.7	----	-100.0	----
Green Heron	-100.0	-87.9	-32.4	+133.3	----
Black-crowned Night Heron	+33.5	-40.4	----	----	----
Yellow-crowned Night Heron	-96.8	-55.5	-25.9	Col.	----
Gulls					
Great Black-backed Gull	+98.9	+56.9	Col.	----	----
Herring Gull	-44.0	-60.4	Col.	Col.	----
Laughing Gull	-6.1	-31.3	Col.	----	----
Terns					
Gull-billed Tern	-49.7	----	+800.0	----	----
Caspian Tern	-85.7	----	----	----	----
Royal Tern	-36.7	-73.3	----	----	----
Sandwich Tern	-76.7	----	----	----	----
Forster's Tern	-29.9	+24.2	----	----	----
Common Tern	-74.0	-38.0	-74.5	----	----
Least Tern	-5.9	----	-67.0	----	----
Others					
Black Skimmer	-34.1	-81.4	-57.8	----	----
Double-crested Cormorant	Col.	+15016.7	+9.2	+32.2	----
Brown Pelican	+40.1	+2643.2	----	----	----
Total	-19.0	-21.2	-4.8	+7.3	-19.3

during the 10-year period. Gulls continued the geographic expansion observed in recent decades to colonize the urban and western shore regions. A Snowy Egret colony was surveyed in Gloucester County that had formed in the past few years. Double-crested Cormorants bred for the first time on the seaside of the Delmarva in the mid-1990s.

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. In addition to the 1993 survey, a systematic survey of the seaside region was conducted in 1998. In the majority of species, comparison of the 1993, 1998, and 2003 surveys (Table 5) shows consistent trends over time. Snowy Egret, Tricolored Heron, Cattle Egret, Green Heron, Yellow-crowned Night Heron, Herring Gull, Laughing Gull,

Gull-billed Tern, Common Tern, and Black Skimmer all showed a consistent decline across the three surveys. White Ibis, Great Black-backed Gull, and Double-crested Cormorant showed consistent increases. Patterns for other species exhibited mixed

trends between surveys.

TABLE 5. 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.

Species	1993	1998	2003
Waders			
White Ibis	3	18	77
Glossy Ibis	779	822	669
Great Blue Heron	8	10	0
Great Egret	885	976	467
Snowy Egret	1862	1212	624
Tricolored Heron	713	530	456
Little Blue Heron	330	195	249
Cattle Egret	854	540	146
Green Heron	47	3	0
Black-crowned Night Heron	442	359	590
Yellow-crowned Night Heron	63	36	2
Gulls			
Great Black-backed Gull	362	369	720
Herring Gull	6106	4653	3417
Laughing Gull	44387	43784	41692
Terns			
Gull-billed Tern	604	478	304
Caspian Tern	7	4	1
Royal Tern	3250	3451	2058
Sandwich Tern	30	54	7
Forster's Tern	2169	2426	1521
Common Tern	3247	1727	843
Least Tern	747	709	703
Others			
Black Skimmer	2549	1766	1679
Double-crested Cormorant	0	6	10
Brown Pelican	324	470	454
Total	69968	64608	56689

community exceeded estimates from the late 1970s (Erwin and Korschgen 1979) by more than 44% but was less than the 1993 estimates (Watts and Byrd 1998) by more than 16%. The seaside of the Delmarva Peninsula continues to be the single most important region for colonial waterbirds in coastal Virginia. This small area supported more than 70% of all breeding pairs and was the dominant region for 17 of 24 species surveyed. 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 and significant populations of selected species. The western shore and southside regions were most significant for supporting a large number of Great Blue Heron and Great Egret colonies.

The entire colonial waterbird community declined more than 16% from 94,947 breeding pairs in 1993 to only 79,343 breeding pairs in 2003. Much of this decline is accounted for by declines in the barrier island / lagoon system. Five species increased by more than 20% over the 10-year period. Many of these population increases have

DISCUSSION
 During the 2003 breeding season, coastal Virginia supported a substantial community of colonial waterbirds. The size of this

followed colonization events where populations do not appear to have reached stable levels (e.g. Double-crested Cormorants, Brown Pelicans, Great Black-backed Gulls). Thirteen of 24 species declined by more than 20% with 10 of those declining more than 40%. Some species experiencing recent declines have followed population increases associated with earlier colonization events (e.g. Glossy Ibis, Cattle Egret). For some of these species it remains difficult to separate the relative influences of local condition from regional population phenomena on population trends. Caution should be used when attempting to attribute declines to local factors. However, all of the species that nest on open barrier beaches experienced substantial declines. Many of these species have nested on the islands as far back as records exist. Their declines may be linked to continuing increases in predator populations on the islands. If so, these populations should respond to predator management where feasible. A summary of specific groups is given below.

As a group, waders declined 16.5% over the 10-year period from an estimated 18,640 pairs to 15,557 pairs. Nearly 90% of this overall decline was due to the dramatic loss of waders on the seaside. These declines have been ongoing and represent a loss of some historic colonies during the decade and a reduction in birds within a couple of key colonies. Particularly notable were reductions in most mid-sized herons. Other more moderate reductions were documented in urban colonies and large colonies within the southside region.

White Ibis – Nesting of the White Ibis was first confirmed in Virginia in 1977 on Fisherman Island (Frohning and Beck 1978). Breeding has been restricted to the barrier islands. 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's Island exclusively with no indication of further expansion (Williams et al. 1992). In 1998, this pattern changed when birds appeared in the Cobb-Island heronry (Williams et al. 2000). This event was followed in 2001 when the Wreck-Island heronry was colonized (Williams et al. 2002). The expansion from Fisherman Island likely resulted from mammalian predation. The heronry was abandoned in 2002 and has not been used since that time.

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 1960's 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 2003, the population has declined by more than 18%. This decline is due to reductions within two barrier island colonies (Fisherman and Cobb Islands) and one Bay island colony (Watts Island). Colonies elsewhere have remained fairly stable.

Great Blue Heron – The Virginia population of Great Blue Herons has increased dramatically since the 1960s. In 1964, only 5 colonies of this species were known for coastal Virginia. In 1975, 15 colonies were surveyed containing more than 2,400 pairs (Custer and Osborn 1977). In 1984, 31 colonies were known supporting nearly 3,600 pairs (Beck unpubl. data). In 1993, 156 colonies were documented supporting more

than 9,000 pairs. The 2003 survey documented 202 colonies supporting 9,136 pairs. This represents a 30% increase in the number of colonies over the 10-year period. An increase in the number of colonies within some geographic areas and fragmentation of existing colonies in others have contributed to this pattern. The number of colonies and birds increased dramatically along the bayside of the Delmarva Peninsula, Mobjack Bay, and the Rappahannock River. These areas supported relatively few colonies prior to 1993. A number of larger colonies that have been active for 10-15 years have become increasingly fragmented into smaller colonies in recent years. The factors contributing to the breakdown of these colonies are not clear. The 2003 survey documented fewer colonies and pairs within both the Chickahominy River and southside Virginia. In general, the numbers of Great Blues documented during the 2003 survey was less than what has been observed during Bald Eagle surveys in recent years suggesting that the population increase between 1993 and 2003 may be underestimated. The breeding season of 2003 was a poor year for Great Blues due to very high rainfall.

Great Egret – The Virginia population of Great Egrets has increased more than 3 fold in the past 30 years. Trends have been similar to the Great Blue Heron. As with Great Blue Herons, the poor breeding season of 2003 appears to have masked what has been a much larger increase in inland areas since 1993. This species has historically had a breeding distribution skewed to the coast. In recent years, an increasing number have colonized inland Great Blue colonies particularly within the extensive swamps of the Chickahominy, Blackwater, Nottoway, and Meherrin drainages. Populations increased in all areas except the urban and seaside regions. The number of urban colonies declined from 7 to 3 over the 10-year period. One of the colonies located in 2003 had formed in 2002 indicating that 5 colonies were lost during the decade. The conflict between egrets and residential landowners has continued to move birds out of lower tidewater since the mid-1980s (Watts unpublished data). The decline in breeding pairs on the seaside of the Delmarva Peninsula has occurred both within the barrier island colonies and the mixed heronries around and south of Chincoteague Bay. The loss of the Fisherman Island colony in 2002 accounted for approximately 30% of the decline. Remaining declines involved the colonies south of Chincoteague Bay.

Snowy Egret – Historically, Snowy Egrets bred as far north as New England. However, by the turn of the century, demand from the millinery 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 2003 the population declined by more than 60%. Nearly 80% of this decline was accounted for by the

seaside region. Although declines are continuing on the barrier islands, the colonies around Chincoteague Bay are responsible for more than 85% of the seaside declines. Declines within the upper Bay are primarily due to losses on Watts Island. During the 2003 survey a new colony of 80 pairs was discovered on a small marsh islet within the Guinea Marshes of Gloucester County. This is the first breeding record for this species along the western shore for more than 40 years.

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 1950's 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). Between 1993 and 2003, the population declined by 34%. Nearly all of this decline is accounted for by losses in the Chincoteague Bay heronries. Nesting birds on the Chesapeake Bay islands have been stable. Despite the loss of the Fisherman Island colony, birds on the barrier islands have shown a small increase between 1993 and 2003 (although estimate for 2003 was considerably higher than recent years).

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 3 colonies on Chesapeake Bay islands. From 1993 to 2003, Little Blue Herons declined by an estimated 17%. Virtually all of this decline was due to losses within the barrier island heronries. The loss of the Fisherman Island heronry accounted for approximately half of this decline. The additional loss of the species from the Chimney Pole Marsh heronry and declines in the Cobb Island heronry account for most of the remainder.

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 2003 within all breeding areas. Only 20 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. Most of the declines documented on the seaside were within the extensive heronries in Chincoteague Bay.

Green Heron – Green Herons nest widely throughout 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). Within the barrier island/lagoon system, this trend continued through the 1998 survey (Truitt and Schwab 2001). The increase observed during the 2003 survey is not consistent with recent trends after 1998. Numbers nesting on the island of the Chesapeake Bay declined over this period. Comparison of 1992 and 2003 for the barrier islands suggests that the species has been stable over this time period (2003 was an exceptional year compared to other recent years). The only real increase detected was within mixed heronries around Chincoteague Bay.

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). Since 1993, the population has declined by nearly 38%. This decline is evident within all regions that supported birds in 1993. Pairs are absent or much reduced within many of the urban neighborhoods where they were documented in the 1980s and early 1990s (Watts unpublished data). The population on the barrier islands has declined since the mid-1970s and Yellow-crowns are now rare breeders. Most of the reduction along the seaside over the 10-year period was accounted for by the loss of a significant colony in Chincoteague. Bay islands have only supported a small number of pairs in recent years.

As a group, gulls declined by more than 7.5% over the 10-year period from an estimated 54,702 breeding pairs in 1993 to 50,558 in 2003. Nearly all of this decline was due to losses of Herring Gulls. Great Black-backed Gulls increased considerably over the period and Laughing Gulls declined by less than 1%.

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. By 1993, most Herring Gull colonies contained small numbers of Great Black-backed Gulls (Watts and Byrd 1998). Between 1993 and 2003, this species has continued to expand both in numbers and distribution. Colonization of the Hampton Roads Tunnel Island represents the first toe hold in the lower portion of the Bay. This species may be increasing at the expense of other waterbird species.

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 2003 the Coastal Plain population declined by an estimated 49%. Consistent declines were observed in both regions where breeding was documented in 1993. The 2003 survey adds further support to the documented decline within the barrier island/lagoon system between 1993 and 1998 (Truitt and Schwab 2001). In the past 2 years, new colonies have been recorded on the Hampton Roads Tunnel Island (Beck unpublished data) and near the mouth of the York River (this survey). These events are first breeding records for urban and western shore regions of the Coastal Plain.

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 has exhibited considerable variation since the mid-1970s but estimates over the past 15 years have consistently represented only 20-30% of those during the late 1980s. The population estimate seaside in 2003 was consistent with the gradual decline observed in 1998. The 2003 breeding season appeared to be particularly difficult for marsh colonies. A series of extreme tides kept marsh islands within the southern portion of the lagoon system under water for most of the season. Breeding pairs were forced to move to the northern portion of the system where marshes are higher. For this reason, many of the traditional colonies were not occupied and colonies around Chincoteague Bay were much larger than during most years.

As a group, terns declined over the 10-year period by more than 50% from an estimated 17,785 to 8,399 breeding pairs. This was the greatest decline of all the broad taxonomic groups with every species showing declines of more than 15%. Species experiencing the deepest declines were those most closely associated with open beach habitats.

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 1900's 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). On the seaside, the 1998 and 2003 surveys show continuing declines (Watts and Byrd, 1998, Truitt and Schwab 2001). Between 1993 and 2003 both the estimated population size and the number of occupied colonies had declined by approximately 50%.

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). Eggging 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. Although the Virginia population of Caspians appears to be very small in recent decades, it is also likely that this species is not well surveyed. Unlike Royal and Sandwich Terns that nest in large conspicuous colonies, Caspians often nest as single pairs on shell piles in the lagoon system or within small colonies of other smaller terns.

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 on both the seaside and on the Chesapeake Bay islands has declined dramatically. However, this is in contrast to a slight increase in numbers on the seaside between 1993 and 1995 (Truitt and Schwab 2001).

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 decline from 30 pairs in 1993 to 7 pairs in 2003 is within the range of annual variation.

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). Between 1993 and 2003 estimated population size declined by more than 15%. However, this species is particularly vulnerable to high tides. Tidal inundation within the lagoon system during the breeding season of 2003 was well above normal with much of the southern portion being underwater for extended periods of time. How these weather events may have influence the survey is not known.

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 2003, Common Terns declined by more than 70% in coastal Virginia. Considerable declines were 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. The recent invasion of this site by Laughing Gulls has reduced the Common Tern population by more than 75%. This loss was not absorbed in other regions.

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 have declined steadily since that time (Beck et al. 1990). Between 1993 and 2003 the population has declined 28% from 1171 to 843 breeding pairs. Although there have been modest declines on the barrier islands over this time, most of this decline is accounted for by a drop in the Grandview Beach and Craney Island colonies. A large amount of unoccupied habitat remains on both the western shore and along the barrier islands. Human disturbance and predation pressure appear to have made these areas unsuitable.

As a group, the three remaining waterbird species examined have increased more than 26% from 3,820 to 4,827 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 has continued between 1993 and 2003 as the coastal population declined 41% from an estimated 3,098 to 1,828 breeding pairs. This decline has been consistent for all geographic regions supporting colonies. Numbers on the Hampton Roads Tunnel Island have declined in response to the Laughing Gull invasion. Numbers on Great Fox Island and surrounding areas in the upper Chesapeake Bay were reduced in 2003 compared to 1993. Productivity on the barrier island has been very poor for many years. In recent years, mammalian predators appear to be limiting both distribution and productivity on the islands.

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 2003 the population increased by 278% from 354 to 1,338 pairs. The majority of this increase is accounted for by the rapid expansion of the Shanks Island colony. Six pairs were first found nesting in the Brown Pelican colony in 1993. By 2003, this colony contained 907 pairs.

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). Since that year, breeding on the barrier islands has been restricted to Fisherman Island. In 1992, an additional colony was formed in the upper Chesapeake Bay on Shanks Island north of Tangier (Brinker, pers. Comm.). The Fisherman and Shanks Island colonies have been the only breeding locations known since 1992. 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). Between 1993 and 2003 the Virginia population increased 351% from an estimated 368 to 1661 breeding pairs. The Fisherman Island colony has increased and then declined over this time period. Growth in the Shank's Island colony has slowed in the past few years suggesting that it may be reaching capacity.

Sources of Error in Estimates – There are numerous sources of potential error associated with the survey techniques and the population estimates presented above. The first is that some colonies may have gone undetected, leading to an

underestimate of population size. The magnitude of this error varies among species but is most severe in species that are widely distributed, nest singly or in small colonies, and are difficult to detect from the air. Population estimates for these species would be greatly improved by extensive ground surveys. For example, extensive ground surveys for Yellow-crowned Night Herons in urban areas increased the known Virginia population by 500% in just 3 years (Watts 1995). However, broad surveys of similar species have not been practical, probably resulting in gross underestimates of population size. For the majority of species examined here, the influence of this source of error is likely small. The obvious exception to this is the Green Heron. This species breeds singly or in small groups throughout the Coastal Plain. Survey approaches used here do not adequately represent status.

A second source of error inherent to the population estimates is observer bias. Number estimates vary among individual observers. Because the same observer may repeatedly make the same errors, variability in the overall estimate is reduced by using the same observer. As mentioned above, all aerial estimates were made by the same individual. Even though several individuals participated in ground surveys, the majority of colonies were surveyed by relatively few individuals. No attempt was made to adjust estimates for observer bias. Accuracy of aerial estimates was assessed in the methods section.

A third source of error is the timing of surveys. Ideally, surveys should be timed to reflect peak breeding activity within colonies. However, peak breeding differs between species and may vary considerably between years and between colonies within years. This uncertainty may be overcome by conducting multiple surveys. Multiple surveys were not practical due to the extent of this study and for many species may be detrimental to breeding success. As mentioned above, nesting phenology was taken into account when designing the survey and when generating population estimates. It is not possible, at this time, to assess the significance of this source of error on overall population estimates.

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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.
- Frohning, 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, New York.

- 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.). Philadelphia: The Academy of Natural Sciences; Washington, D. C.: The American Ornithologists' Union.
- 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. 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. CCBTR-04-05. Center for Conservation Biology, College of William and Mary, Williamsburg, VA.
- 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.