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NESTING POPULATIONS OF DOUBLE-CRESTED CORMORANTS, GREAT BLUE HERONS, AND GREAT EGRETS IN THE UNITED STATES AND CANADA: IMPLICATIONS FOR MANAGEMENT

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Abstract: Populations of piscivorous birds in North America are receiving increasing attention in the southeast United States because of depredations at aquaculture facilities. We obtained recent (most since 1994) estimates for the number of nesting double-crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and great egrets (*Casmerodius albus*) in the United States (US) and Canada from published references and by conducting telephone interviews with state and provincial biologists. Using previously-published data, we also determined annual rates of change in the number of cormorants since about 1990. Estimates for minimum numbers of nesting pairs (minimum numbers of colonies) of double-crested cormorants, great blue herons, and great egrets were 356,000 (824), 133,000 (3,345), and 36,000 (421), respectively. Most cormorants and herons nested in the Interior Region (67% and 56%, respectively). In contrast, 74% of egrets nested in the Southeast Region. Overall, double-crested cormorants increased about 1.4% annually in the US and Canada during the early 1990s. The greatest decline (-7.9% annual change) was for the West Coast-Alaska Region. The greatest increase (5.8% annual change) was for the Interior Region. The increase in the Interior Region was a consequence primarily of a 23% annual increase in the number of nesting pairs of cormorants in states and provinces bordering the Great Lakes. These baseline population data are essential for monitoring trends in nesting populations and for developing informed management decisions. However, the completeness, quality, and timing of surveys varied substantially among jurisdictions; therefore, initial population figures and rates of population change are conservative estimates and should be used with caution. We recommend coordination of methodology and timing of future surveys among political jurisdictions (at least within regions) to improve accuracy of estimates and allow more meaningful comparisons of population status. Based on these estimates, the <8,000 double-crested cormorants, <3,000 great blue herons, and <2,000 great egrets killed annually via depredation permits at aquaculture facilities in the southeast US conservatively represented <3% of the respective nesting populations (<1% of the total populations) in the US and Canada. Thus, the number of these species killed at southeast US aquaculture facilities has had minimal effect on continental or regional nesting populations. We recommend continued monitoring of nesting populations in relation to lethal control at aquaculture facilities to ensure that population viability of piscivorous birds is not adversely affected.

Key Words: annual increase, *Ardea herodias*, Canada, *Casmerodius albus*, double-crested cormorant, great egret, great blue heron, nesting, *Phalacrocorax auritus*, population, United States

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Piscivorous birds at aquaculture facilities in southeast United States (US) are of concern as their feeding activities may result in economic losses to producers (Mott 1978). Double-crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and great egrets (*Casmerodius albus*) are species most frequently

associated with depredations of fish at aquaculture facilities in this region (Mastrangelo et al. 1997). For example, 57% of Mississippi Delta catfish growers reported cormorants to be a problem on their farms (Stickley and Andrews 1989). Most depredation problems occur in

winter when birds from northern US and Canada migrate to the southeast US (Dolbeer 1991).

The U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS) program is responsible for addressing depredations caused by migratory birds in the US (Acord 1995). Following on-site inspections of aquaculture facilities, WS personnel then recommend integrated damage management plans that emphasize non-lethal techniques (Mastrangelo et al. 1997). If non-lethal control is determined inadequate for reducing damage, management plans may be amended to include recommendations to the U.S. Fish and Wildlife Service (USFWS) for issuance of depredation permits to kill piscivorous birds.

Belant et al. (in press) determined that <8,000 double-crested cormorants, <3,000 great blue herons, and <2,000 great egrets were killed annually from 1987-1995 to protect aquaculture facilities in the southeast US (USFWS Region 4). Concerns have been expressed regarding the effects of lethal control of piscivorous birds using depredation permits at aquaculture facilities on local, regional, and national bird populations (Trapp et al. 1995). However, no study has addressed this fundamental issue. Our objectives were to (1) obtain the most recent population estimates for nesting double-crested cormorants, great blue herons, and great egrets, (2) determine the rate of change in populations of double-crested cormorant populations by region during the early 1990s, and (3) evaluate the effects of lethal control of these species at aquaculture facilities in the southeast US on respective nesting populations.

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METHODS

Previous estimates (1975-1992) for the number of nesting double-crested cormorants were obtained from Hatch (1995). To obtain the most recent population estimates for cormorants, great blue herons, and great egrets, we conducted telephone interviews from May-October 1996 with biologists from each state (excluding Hawaii), province, and territory in the US and Canada when publications or reports were unavailable. Information requested included the number of nesting pairs and colonies present and the survey technique used to obtain the estimate. As described by Hatch (1995), each estimate provided was placed in 1 of 4 categories of decreasing precision, ranging from a recent complete count to conjecture based on old or incomplete information. Population estimates for each species were grouped into 1 of 4 regions: 1) Interior, 2) Atlantic, 3) Southeast, and 4) West Coast-Alaska (Fig. 1) (modified from Hatch 1995).

For double-crested cormorants, we determined the mean percent annual change (MPAC) in the number of nesting pairs using the formula:

$$MPAC = (N_2/N_1)^{1/y} - 1$$

where N_1 is the number of nesting pairs observed during the first estimate (from Hatch 1995) and N_2 is the number of nesting pairs observed during the second estimate, y years later.

RESULTS

Double-crested Cormorants

Most (70%) of the 63 State/Provincial estimates were made in 1994-1996. The number of nesting double-crested cormorants in the US and Canada has increased about 1.4% annually from 1990-1994 (about 336,790 to 356,051 nesting pairs) (Table 1). Most birds occurred in the Interior (67%, 239,853 pairs), followed by the Atlantic (24%, 85,510 pairs), West Coast-Alaska (5%,

17,084 pairs), and Southeast (4%, 13,604 pairs) Regions.

The greatest regional decline (-7.9% annual change) occurred in the West Coast-Alaska. The greatest regional increase (5.8% annual change) occurred in the Interior. The increase in the Interior was a consequence primarily of a 23% annual increase in the number of nesting pairs of cormorants in states and provinces bordering the Great Lakes, particularly Ontario. Cormorants adjacent to the Great Lakes increased from about 41,540 pairs in 1992 to about 76,667 pairs in 1995 (Appendix 1). There were ≥ 824 double-crested cormorant nesting colonies (≥ 313 in the Atlantic, ≥ 253 in the Interior, 243 in the West Coast and Alaska, and ≥ 15 in the Southeast Regions).

Great Blue Herons

Seventy-two percent of the 61 State/Provincial estimates were made in 1994-1996. We conservatively estimated $>133,034$ nesting pairs of great blue herons in the US and Canada (Table 1). Most birds occurred in the Interior (56%, $\geq 75,052$ pairs), followed by the Atlantic (25%, $\geq 33,046$ pairs), Southeast (14%, $\geq 18,613$ pairs), and West Coast-Alaska (5%, $>6,323$ pairs) Regions. There were $\geq 3,345$ great blue heron colonies ($\geq 1,736$ in the Interior, ≥ 731 in the Atlantic, ≥ 577 in the West Coast-Alaska, and ≥ 301 in the Southeast Regions).

Great Egrets

Of the 61 State/Provincial estimates, 87% were made in 1994-1996. We conservatively estimated $\geq 35,908$ nesting pairs of great egrets in the US and Canada (Table 1). Most birds occurred in the Southeast (74%, $\geq 26,424$ pairs), followed by the Interior (19%, $\geq 6,954$ pairs), Atlantic (4%, 1,377 pairs), and West Coast-Alaska (3%, $\geq 1,153$ pairs) Regions. There were ≥ 421 great egret colonies (≥ 238 in the Southeast, ≥ 77 in the Interior, ≥ 60 in the Atlantic, and 46 in the West Coast-Alaska Regions).

DISCUSSION

The number of double-crested cormorants increased rapidly from the 1970s to the early 1990s (Hatch 1995). For example, the number of cormorant nests bordering the Great Lakes

increased from 89 in 1970 to 38,000 in 1991, an annual increase of 29% (Weseloh et al. 1995). The number of cormorants in the northeast US (Atlantic population) increased from 17,100 to 34,200 nesting pairs from 1977 to the mid 1980s, then increased slightly to 37,600 pairs in the early 1990s (Krohn et al. 1995). Our most recent estimates of cormorant numbers suggest that the overall rate of growth in the US and Canada has declined substantially during the early 1990s.

Although the number of nesting pairs of double-crested cormorants in the US and Canada increased only slightly during the early 1990s, regional populations have varied more dramatically. We are uncertain of the causes for recent declines in nesting populations of double-crested cormorants in the Atlantic and West Coast-Alaska Regions. In the Atlantic population, reduced suitability of colony sites may have been responsible for recent population declines (Krohn et al. 1995). Local declines in the number of cormorants has occurred in the West Coast and Alaska from habitat loss, pollution, human disturbance, and introduced predators (Carter et al. 1995).

The continued increase of double-crested cormorants in the Interior population was a consequence primarily of dramatic population increases in states and provinces bordering the Great Lakes. The number of cormorants in this area has increased from 38,000 pairs in 1992 (Weseloh et al. 1995) to $>76,000$ pairs in 1995 (this study). Continued increases in nesting pairs of cormorants near the Great Lakes have been attributed to reductions in contaminant levels, low human persecution, high reproductive success, and increased availability of prey (e.g., alewife [*Alosa pseudoharengus*]) (Weseloh et al. 1995). Exploitation of catfish as a winter food in the southeast US, especially the Mississippi delta area, also may have enhanced survival of cormorants (Williams 1992), particularly cormorants arriving from Great Lakes populations. The majority of cormorants nesting around the Great Lakes winter in the southeast US (Dolbeer 1991).

The reported population estimates do not include sub-adult nor non-breeding adult birds; thus, total

populations of cormorants, herons, and egrets are greater. For example, 0.6 to 4.0 non-breeding cormorants for every breeding pair have been estimated for several populations (McLeod & Bondar 1953, Price & Weseloh 1986, Watson et al. 1991). Therefore, we conservatively estimate the total number of cormorants in the US and Canada at 1 to 2 million individuals.

MANAGEMENT IMPLICATIONS

This report provides updated estimates for nesting populations of double-crested cormorants in the US and Canada and the first comparable estimates for great blue herons and great egrets. These baseline data are essential for monitoring future trends in nesting populations and for developing informed management decisions. However, the initial population estimates and rates of population change presented in this report should be used with caution. As with a similar study of laughing gulls (see Belant & Dolbeer 1993), disparity among jurisdictions in survey techniques, intensity of searches, observer differences, and the time at which surveys were conducted precluded statistical analyses of data. Comparisons of rates of change for double-crested cormorants also were confounded by different methods of data collection. We recommend coordination of survey methodology among political jurisdictions (at least among regions) to allow direct comparisons of population status and to reduce biases (see Erwin et al. 1984).

The <8,000 double-crested cormorants, <3,000 great blue herons, and <2,000 great egrets killed annually under depredation permits at aquaculture facilities in the southeast US (Belant et al., in press) conservatively represented <3% of the respective nesting populations in the US and Canada. When non-breeding birds are included, the kill may represent <1% of the US and Canadian populations. Also, numerous state and provincial populations of cormorants are increasing, particularly those adjacent to the Great Lakes that migrate to the southeast US (Dolbeer 1991). Therefore, we believe that the number of double-crested cormorants, great blue herons, and great egrets killed at aquaculture facilities in the Southeast from 1987 to 1995 has had minimal effect on continental or regional nesting

populations. Additional information is necessary to determine if local populations have been affected. We recommend continued monitoring of nesting populations in relation to lethal control at aquaculture facilities to ensure that population viability of piscivorous birds is not affected adversely.

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Table 1. Regional estimates of nesting pairs of double-crested cormorants (DCCO), great blue herons (GTBH), and great egrets (GREG) in the United States and Canada, and estimated mean percent annual change in DCCO populations, about 1990-1994.

Region	DCCO			GTBH		GREG	
	Estimated # nesting pairs (# colonies)	Approx. year of estimate	Mean % annual change	Estimated # nesting pairs (# colonies)	Approx. year of estimate	Estimated # nesting pairs (# colonies)	Approx. year of estimate
Atlantic	≥85,510 (≥313)	1993	6.5	≥33,046 (731)	1992	1,377 (≥60)	1995
Interior	≥239,853 (≥253)	1994	5.8	≥75,052 (≥1,736)	1993	≥6,954 (≥77)	1995
Southeast	13,604 (≥15)	1994	2.6	≥18,613 (≥301)	1994	≥26,424 (≥238)	1994
West Coast-Alaska	17,084 (243)	1993	-7.9	>6,323 (≥577)	1993	≥1,153 (46)	1995
Total	≥356,051 (≥824)	1994	1.4	≥133,034 (≥3,345)	1993	≥35,908 (≥421)	1995

Appendix 1. State and Provincial estimates of nesting pairs of double-crested cormorants (DCCO), great blue herons (GTBH) and great egrets (GREG) in the United States and Canada, and estimated mean percent annual change in DCCO populations, about 1990-1994.

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	Year	GTBH	Year	GREG	Source
			estimated # nesting pairs (# colonies) ¹	Year 2			estimated # nesting pairs (# colonies) ¹		estimated # nesting pairs (# colonies) ¹	
1. <u>Atlantic</u> (Northeast Coast)										
Connecticut	1992	1995	623 ^a	716 (11) ^a	4.7	1995	? ³	1995	122(6) ^a	J. Victoria, Conn. Dep. Environ. Prot., unpubl. data
Maine	1992	1994	28,004 ^b	≥20,692(117) ^c	-14.0	1994	≥606(15) ^c	1994	≥2(1) ^c	B. Hoover, U.S. Geol. Surv., unpubl. data
Massachusetts	1992	1994-95	7,000 ^b	7,274 (28) ^a	1.3 - 1.9	1994-95	0(0)	1994-95	77(7) ^a	B. Hoover, U.S. Geol. Surv., unpubl. data
New Brunswick	1990	1990	7,800 ^b	7,800 ^b		1990	1,400 ^b	1996	0	Erskine (1992)
New Hampshire	1992	1995	325 ^b	≥483 (1) ^b	14.1	1983-92	1,353(123) ^c	1993	0	J. Kantor, N.H. Fish and Game Dep., unpubl. data (DCCO, GREG); Martin (1993) (GTBH)
New Jersey	1992	1992	109 ^a	109 (≥1) ^a		1995	860(20) ^c	1995	486(25) ^c	Hatch (1995) (DCCO); D. Jenkins, N.J. Div. Fish, Game, Wildl., pers. comm. (GTBH, GREG)
New York-Atlantic	1992	1995	2,513 ^a	≥3,528 (8) ^a	12.0	1996	0	1995	541(17) ^a	L. Sommers, N.Y. Dep. Environ. Conserv., unpubl. data (DCCO, GREG); B. Miller, N.Y. Dep. Environ. Conserv., pers. comm. (GTBH)
Newfoundland	1975-89	1975-89	261 ^c	261 ^c		1996	0	1996	0	Hatch (1995) (DCCO), A.Smith (GTBH) and B. Turner (GREG) Can. Wildl. Serv., pers. comm.
Nova Scotia	1992	1993	15,200 ^b	13,500 (67) ^c	-11.2	1980-88	2,027(59) ^c	1996	0	G. Milton, unpubl. data (DCCO); A. Smith, Can. Wildl. Serv., unpubl. data (GTBH); P. Mills, Can. Wildl. Serv., pers. comm. (GREG)

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	Year	GTBH	Year	GREG	Source	
			estimated # nesting pairs (# colonies) ¹	Year 1 ²			Year 2		estimated # nesting pairs (# colonies) ¹		estimated # nesting pairs (# colonies) ¹
Prince Edward Island	1990	1995	7,000 ^b	6,619(6) ^c	-1.1	1990	1,800(~14)	1995	0	A.McLennan, Prince Edward Isl. Environ. Resour., unpubl. data (DCCO, GREG); Erskine (1992), Smith (1980) (GTBH)	
Quebec	1992	1993-96	27,300 ^b	22,400(68) ^a	-4.8 to -17.9	1991-1995	25,000(500) ^b	1994	12(1) ^a	M. LeBage, Minist. De La Environ., pers. comm.	
Rhode Island	1992	1994	1,700 ^a	2,082(5) ^c	10.7	1994	0	1994	137(3) ^c	B. Hoover, U.S. Geol. Surv., unpubl. data	
St. Pierre et Miquelon	1987	1989	40 ^b	46(1) ^b	7.2	1989	0	1989	0	Cairns, et al. (1989)	
Subtotal	~1991	~1993	97,875	≥85,510(≥313)	-6.5	1992	≥33,046(≥731)	1995	~1,377(≥60)		
2. <u>Interior</u>											
Alberta	1992	1996	7,000 ^c	~7,000(~22) ^c	0	1996	~1,500(~75) ^c	1996	0	S. Brecktel, Alta. Dep. Environ. Prot., pers. comm. (DCCO, GREG); Alta. Dep. Environ. Prot. Wildl. Manage. Div. (1996) (GTBH)	
Arkansas	1991	1991	15 ^a	15 ^a						Hatch (1995) (DCCO)	
Colorado	1990	1990	1,000 ^c	1,000(~13) ^c		1996	486(9) ^{a4}	1996	10(1) ^{a4}	Hatch (1995), Andrews & Righter (1992) (DCCO); J. George, Colo. Div. Wildl., pers. comm. (GTBH, GREG)	
Illinois	1992	1995	355 ^c	675(6) ^c	23.9	1995	9,800(54) ^c	1995	1,855(21) ^c	V. Kleen, Ill. Dep. Nat. Resour., unpubl. data	

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	GTBH		GREG		Source
			estimated # nesting pairs (# colonies) ¹			Year	estimated # nesting pairs (# colonies) ¹	Year	estimated # nesting pairs (# colonies) ¹	
			Year 1 ²	Year 2						
Indiana	1992	1996	0	0		1993	6,320(78) ^c	1996	0	J. Castrale, Ind. Dep. Nat. Resour., pers. comm. (DCCO, GREG); Castrale (1994) (GTBH)
Iowa	1992	1995	400 ^c	689(4) ^c	19.9	1995	3,790(37) ^c	1995	234(4) ^c	L. Hemesath, Ia. Dep. Nat. Resour., unpubl. data
Kansas	1985	1996	20 ^c	100 ^d	15.8	1996	3,000(100) ^d	1996	120 ^d	B. Busby, Kans. Biol. Surv., pers. comm., (DCCO, GREG); S. Roth, pers. comm. (GTBH)
Kentucky	1991	1994	0	0		1994	1,750(24) ^a	1994	25(2) ^a	Palmer-Ball & Wethington (1994)
Manitoba	1992	1992	125,000 ^c	125,000 ^c		1989	10,000 ^{ds}	1996	0	Hatch (1995) (DCCO); R. Larche, Manit. Dep. Nat. Resour., unpubl. data (GTBH); R. Larche, pers. comm. (GREG)
Michigan	1988-90	1988-90	7,975 ^b	7,975 ^b		1987	1,064(32) ^c	1987	31(3) ^c	Hatch (1995) (DCCO); Scharf (no date) (GTBH, GREG)
Minnesota	1990	1991-95	7,970 ^c	≥6,439(≥37) ^c	-4.2 to -19.2	1991-95	≥10,850(≥221) ^c	1991-95	≥1,811(≥24) ^c	M. Miller, Minn. Dep. Nat. Resour., unpubl. data
Missouri	1992	1995	0	0		1995	≥7,500(~250) ^c	1995	144(5) ^c	J. Wilson, Mo. Dep. Conserv., pers. comm.
Montana	1992	1988-95	850 ^c	~1,475(~17) ^b		1988-95	~2,411(~82) ^c	1995	0	K. Jurist, Mont. Nat. Her. Found., unpubl. data
Nebraska	1992	1992	850 ^c	850 ^c		1980-93	~970(~69) ^c	1996	0	Hatch (1995) (DCCO); J. Dinan, Nebr. Game and Parks Comm., unpubl. data (GTBE, GREG)

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO			mean percent annual change	GTBH		GREG		Source
			estimated # nesting pairs (# colonies) ¹		Year		estimated # nesting pairs (# colonies) ¹	Year	estimated # nesting pairs (# colonies) ¹		
			Year 1 ²	Year 2							
New Mexico	1992	1996	730 ^b	730(5) ^c	0	1996	150(10) ^b	1996	10 ^b	S. Williams, N. M. Dep. Game and Fish, unpubl. data	
New York-Interior	1992	1995	5,890 ^a	≥8,097(≥19) ^a	11.2	1996	>1,837(2) ^d	1996	0	L. Sommers, N.Y. Dep. Environ. Conserv., unpubl. data (DCCO, GREG); B. Miller, N.Y. Dep. Environ. Conserv., pers. comm. (GTBH)	
North Dakota	1992	1992	1,200 ^d	>1,200 ^d		1996	<1,000 ^d	1996	~30 ^c	G. Burkee, Minot State Univ., pers. comm.	
Northwest Territories	1996		? ³			1996	0	1996	0	B. Bromley, Northwest Territ. Dep. Renew. Resour., pers. comm.	
Ohio	1992	1995	180 ^a	~1,500(1) ^c	102.7	1995	~2,280(3) ^c	1995	~1,157(2) ^c	M. Shieldcastle and B. Buckingham, Ohio Dep. Nat. Resour., pers. comm.	
Oklahoma	1992	1995	0	46(1) ⁶		1995	≥30(1) ⁶	1995	515(1) ⁶	R. Shephard, U.S. Fish Wildl. Serv., pers. comm.	
Ontario	1992	1993-96	16,170 ^{a,c}	~43,981(~86) ^a	28.4 to 172.0	1990-91	~9,121(~520) ^b	1996	90(6) ^d	D. Weseloh, Can. Wildl. Serv., pers. comm. (DCCO, GREG); Collier et al. (1992) (GTBH)	
Pennsylvania	1991	1996	0	0		1995	835(15) ^c	1996	155(1) ^c	D. Brauning, Penn. Game Comm., pers. comm. (DCCO, GREG); Brauning (1996) (GTBH, GREG)	
Saskatchewan	1991	1991	19,547 ^c	19,547 ^c			? ³			Hatch (1995) (DCCO); E. Wiltse, Sask. Environ. Resour. Manage., unpubl. data (GTBH)	

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	Year	GTBH		GREG		Source
			estimated # nesting pairs (# colonies) ¹				estimated # nesting pairs (# colonies) ¹	estimated # nesting pairs (# colonies) ¹			
			Year 1 ²	Year 2							
South Dakota	1992	1991	850 ^c	>2,962(≥11) ^{c,7}		1991	>106(>48) ^{c,7}	1988-91	>244(>6) ^c	Peterson (1995)	
Tennessee	1991	1996	10 ^c	11(1) ^a 1.9		1993	2,477(24) ^b	1991	100-200(>1) ^d	G. Lee, pers. comm. (DCCO); B. Hatcher, Tenn. Wildl. Resour. Agency, unpubl. data (GTBH); R. Wheat, U.S. Fish Wildl. Serv., pers. comm. (GTBH); B. Hatcher, pers. comm. (GREG)	
Vermont	1992	1995	555 ^a	2,211(5) ^a 58.5		1985	491(30) ^c	1996	0	M. Ferguson, Vt. Dep. Fish and Wildl., pers. comm.	
West Virginia	1990	1996	0	0		1995-96	≥284(≥6) ^a	1996	0	S. Butterworth, W. Va. Dep. Nat. Resour., pers. comm.	
Wisconsin	1992	1994	3,000 ^c	8,000 ^a	63.3	1996	1,000-2,000 ^d	1995	≥373 ^c	S. Matteson, Wis. Dep. Nat. Resour., pers. comm.	
Wyoming	1986	1994	3,000 ^b	≥350(25) ^d	-23.6	1994	>500(~46) ^c	1996	0	A. Cerovski, Wyo. Game and Fish Dep., unpubl. data	
Yukon Territory		1996		0		1996	0	1996	0	D. H. Mossop, Yukon Terr. Dep. Renew. Res., pers. comm.	
Subtotal	~1991	~1994	202,567	≥239,853(≥253)	5.8	1993	≥75,052(≥1,736)	1995	≥6,954(≥77)		
3. <u>Southeast</u>											
Alabama	1992	1996	0	0		1996	≥1,200 ^d	1996	≥600 ^d	R. Clay, Ala. Dep. Conserv. and Nat. Resour., pers. comm.	
Delaware	1992	1996	0	0		1996	530(6) ^a	1996	842(2) ^a	B. Hoover, U.S.Geol. Surv., unpubl. data	

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	Year	GTBH	Year	GREG	Source
			estimated # nesting pairs (# colonies) ¹	Year 2			estimated # nesting pairs (# colonies) ¹		estimated # nesting pairs (# colonies) ¹	
Florida	1986-89	1986-89	12,000 ^c	12,000 ^c		1993	>629 ^d	1993	>4,268 ^d	Hatch (1995) (DCCO); G. Reynolds, Fla. Game and Freshwater Fish Comm., unpubl. data, (GTBH, GREG)
Georgia	1991	1996	3 ^d	? ³		1996	? ³	1996	? ³	T. Schneider, Ga. Dep. Nat. Resour., pers. comm.
Louisiana	1990	1996	100 ^d	<200 ^c	<12.2	1996	>893(≥28) ^b	1990-95	>4,608(64) ^b	W. Vermillion, La. Dep. Wildl. and Fish., unpubl. data
Maryland	1992	1995	300 ^c	491(2) ^a	17.8	1995	5,573(57) ^a	1995	918(20) ^a	G. Therres, Md. Dep. Nat. Resour., unpubl. data
Mississippi	1992	1993	0	0		1994	843(10) ^a	1994	1,533 (6) ^a	P. Mastrangelo, U.S. Dep. Agric., pers. comm. (DCCO); A. Mueller (1995) (GTBH, GREG)
North Carolina	1992	1995	20 ^c	0		1995	0	1995	2,018(22) ^a	B. Hoover, U.S. Geol. Surv., unpubl. data
South Carolina	1990	1994	115 ^a	515(8) ^a	45.5	1994	2,539(88) ^a	1994	6,980(57) ^a	S.C. Dep. Nat. Resour., (1996)
Texas	1990	1996	6 ^a	? ³		1991-92	1,809(60) ^a	1991-92	4,404(53) ^a	W. Roach, U.S. Fish Wildl. Serv., pers. comm. (DCCO); Tex. Park and Wildl. Dep. (1991-92) (GTBH, GREG)
Virginia	1992	1993	50 ^a	398(5) ^a	696.0	1991	4,597(52) ^a	1991	253(14) ^a	G. Costanzo (DCCO) and D. Schwab (GTBH, GREG) Va. Dep. Game and Inland Fish, unpubl. data
Subtotal	~1991	~1994	12,594	≥13,604(≥15)	2.6	1994	≥18,613(≥301)	1994	≥26,424(≥238)	

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	GTBH		GREG		Source
			estimated # nesting pairs (# colonies) ¹			Year	estimated # nesting pairs (# colonies) ¹	Year	estimated # nesting pairs (# colonies) ¹	
			Year 1 ²	Year 2						
4. <u>West coast and Alaska</u>										
Alaska	1975-92	1996	2,924 ^c	2,935(120) ^c		1996	? ³	1996	0	S. Stephensen, U.S. Fish Wildl. Serv., unpubl. data (DCCO); D. Groves (GTBH) and K. Wohl (GREG), U.S. Fish Wildl. Serv., pers. comm.
Arizona ⁸	1992	1996	750 ^c	(<15-20)		1996	(>50)	1996	(<5)	T. Corman, Ariz. Game and Fish Dep., pers. comm.
British Columbia	1987-89	1988	1,753 ^b	2,032(15) ^c		1980-87	>1,181(84) ^b	1996	0	Campbell et al. (1990)
California	1989-91	1993-95	5,592 ^{a,c}	2,394(17) ^c		1995	369(59) ^{c,9}	1995	628(21) ^{c,9}	Carter et al. (1996), S. Tappen, Audubon Canyon Ranch, pers. comm. (DCCO); J. Kelly, Audubon Canyon Ranch, unpubl. data (GTBH, GREG)
Idaho	1984	1993	850 ^b	~1,288(11) ^c	4.7	1994	≥341(50) ^c	1993	~21(~5) ^c	Trost et al. (1994)
Nevada	1992	1994	1,500 ^c	≥80(≥3) ^c	-76.9	1994	≥64(≥7) ^c	1994	≥83(≥4) ^c	Herron (1994)
Oregon	1988-92	1992	7,167 ^{a,c}	6,987(24) ^a		1994	2,500	1994	≥376(≥7) ^c	H. Carter et al. (1995) (DCCO); Gilligan et al. (1994) (GTBH); Marshall et al. (1996) (GREG)
Utah	1987-92	1987-96	1,200 ^b	482(15) ^d		1988-96	668(32) ^d	1996	0	F. Howe, Utah Div. Wildl. Resour., unpubl. data

Appendix 1 (continued)

Region	Year 1 ²	Year 2	DCCO		mean percent annual change	Year	GTBH	Year	GREG	Source
			estimated # nesting pairs (# colonies) ¹	Year 2			estimated # nesting pairs (# colonies) ¹		estimated # nesting pairs (# colonies) ¹	
Washington	1992	1995	2,018 ^{a,c}	886(21) ^c	-24.0	1996	>1,200(295) ^{d,10}	1996	≥45(4) ^d	U. Wilson, U.S. Fish Wildl. Serv., unpubl. data (DCCO); T. Owens, Wash. Dep. Fish and Wildl., pers. comm. (GTBH, GREG)
Subtotal	~1989	~1993	23,754	≥17,084(243)	-7.9	1993	>6,323(≥577)	1995	≥1,153(≥46)	
Total	~1990	~1994	336,790	>356,051(>824)	1.4	1993	>133,034(>3,345)	1995	>35,908(>421)	

¹ Classifications for various population estimates: a = recent complete count; b = extrapolated older count or other informed estimate; c = estimate, often based on knowledge of most colonies but few counts of individuals; d = guess: only old, indirect, or incomplete recent knowledge available.

² From Hatch (1995).

³ Species known to breed, recent data unavailable.

⁴ Counts from Boulder area only.

⁵ Total spring population count (adults and subadults).

⁶ Number represents only 1 colony.

⁷ Number represents counts from only 1 county in the state.

⁸ Data provided for number of colonies only.

⁹ Count from northern San Francisco Bay area only.

¹⁰ Colony size estimates ranged from 4 - 400 nests. A conservative estimate of 4 was used to calculate number of nests.



Fig. 1. Geographic boundaries for regional populations of Double-crested Cormorants, Great Blue Herons, and Great Egrets in the United States and Canada (after Hatch 1995).