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Effects of lethal control at aquaculture facilities on populations of piscivorous birds

Jerrold L. Belant, Laura A. Tyson, and Philip A. Mastrangelo

Abstract We used depredation permit records to document the extent of lethal control at aquaculture facilities in a 9-state region of the southeastern United States from 1987 to 1995, and used Christmas Bird Count (CBC) data (1987–1995) to evaluate the effects of this program on winter populations of piscivorous birds. During these 9 years, 904 depredation permits (including ≥ 1 species) were issued, primarily for double-crested cormorants (*Phalacrocorax auritus*) (94% of permits issued), great blue herons (*Ardea herodias*) (80%), and great egrets (*Ardea alba*) (60%). For all species and years, 108,701 birds were authorized to be taken; of these, 64,011 (59%) were reported taken, primarily double-crested cormorants (55%), great blue herons (21%), and great egrets (13%). Most (74–78%) of these species were taken in Arkansas. Overall, actual take did not exceed 65% of the authorized take for any species. For states where double-crested cormorants, great blue herons, or great egrets were taken, there was no negative association ($r \geq -0.42$, $P \geq 0.26$) between number of birds taken annually and the respective mean number of birds observed/CBC that same year. Also, number of these species taken annually represented $< 3\%$ of the respective continental breeding populations. We conclude that number of double-crested cormorants, great blue herons, and great egrets taken with depredation permits at aquaculture facilities in the southeastern United States did not adversely affect regional winter or continental breeding populations of these species.

Key words *Ardea alba*, *Ardea herodias*, aquaculture, double-crested cormorant, great blue heron, lethal control, *Phalacrocorax auritus*, southeastern United States, wildlife damage management

Aquaculture production has increased dramatically in the southeastern United States in recent years. For example, number of hectares of catfish ponds in Mississippi has increased from 0 to $> 40,000$ since 1965 (Brunson 1991). In 1993, the value of aquaculture in the United States was estimated at \$875 million (Price and Nickum 1995). This expansion of the aquaculture industry has resulted in increased conflicts between aquaculture facility operators and wildlife, particularly piscivorous birds such as double-crested cormorants

(*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and great egrets (*Ardea alba*). These species are federally protected in the United States by the Migratory Bird Treaty Act.

Numerous nonlethal techniques are available to alleviate depredations by piscivorous birds (Mott and Boyd 1995); however, few (e.g., winter roost dispersal [Mott et al. 1992]) are considered cost-effective (Trapp et al. 1995). Currently, the United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS)

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program has the responsibility to address migratory bird depredations (Acord 1995). From requested on-site evaluations of aquaculture facilities, WS personnel determine the type of resource affected and the number and species of birds involved, estimate economic loss, and document control methods that have been used to reduce damage (Mastrangelo et al. 1996). From these evaluations, integrated damage management plans that emphasize nonlethal control techniques are developed. If nonlethal control is deemed ineffective to adequately reduce damage, management plans may then be amended to include recommendations to the United States Fish and Wildlife Service (USFWS) to issue depredation permits (Mastrangelo et al. 1996).

Trapp et al. (1995) stated the need to evaluate the impact of issuing bird depredation permits on local, regional, and national populations of piscivorous birds. Two recent studies (Coon et al. 1996, Mastrangelo et al. 1996) described integrating depredation permits into damage management plans at aquaculture facilities and the number of double-crested cormorants, great blue herons, and great egrets taken with depredation permits in the Mississippi Delta region. However, these studies did not fully evaluate effects of lethal control on piscivorous bird populations. Our objectives were to determine: 1) number and distribution of piscivorous birds taken with depredation permits at aquaculture facilities in the southeastern United States; and 2) effects of this lethal control program on regional winter populations of the species most frequently taken: double-crested cormorants, great blue herons, and great egrets.

Methods

We obtained data on depredation permits for a 9-state region (Ala., Ark., Ga., Flor., La., Miss., N. C., S. C., and Tenn.) of the southeastern United States for 1987-1995 (C. Simonton, United States Fish and Wildlife Service, unpublished data). Information on depredation permits included number of permits issued, number of birds authorized to be taken, and number of birds reported taken for each state by species (or group of species; e.g., gulls [*Larus* spp.], other herons) each year. We obtained winter population data for double-crested cormorants, great blue herons, and great egrets from 1987 to 1995 Audubon Christmas Bird Counts for these same states (National Audubon Society 1988-1996).

To determine the effect of depredation permits on

winter populations of cormorants, herons, and egrets, we first determined the total number of these species taken annually under depredation permits by state from 1987 to 1995. We then determined the mean number of each species observed/CBC by state and year. Number of CBCs conducted varied among states and years ($n=10-53$). For each state where cormorants, herons, or egrets were taken during ≥ 1 year, we used simple correlation analyses (SAS Institute 1988) to determine the association between number of birds taken annually and mean number of birds observed/CBC initiated during December of that same year. We established statistical significance at $P < 0.10$. Although we recognize the potential limitations of using CBC data for inferential comparisons, it is currently the only systematically collected regional data available for winter populations of these species.

Results

From 1987 to 1995, 904 depredation permits were issued for ≥ 1 species, primarily double-crested cormorants (94%), great blue herons (80%), and great egrets (60%). For all species and years, 108,701 birds were authorized to be taken, of which 64,011 (59% of authorized take) were taken (Table 1). Species composition of birds taken included 55% double-crested cormorants, 21% great blue herons, 13% great egrets, and 11% other. No other species or group of species represented $>5\%$ of the total take. Actual take did not exceed 65% of the authorized take for any species.

For all species, number of depredation permits issued increased from 7 in 1987 to 199 in 1995 (45.1% mean annual increase [a.i.]) (Table 2). Similarly, number of birds authorized to be taken and number of birds taken increased at annual rates of 37.7% and 47.3%, respectively.

Number of depredation permits issued that included cormorants increased from 6 in 1987 to 186 in 1995 (46.5% a.i.). Number of depredation permits issued for herons and egrets increased similarly, 43.9% (6 in 1987, 159 in 1995) and 46.5% (4 in 1987, 124 in 1995) a.i., respectively. In contrast, number of cormorants authorized to be taken and number of cormorants taken increased at greater rates (57.1% [210 in 1987, 12,264 in 1995] and 69.5% [67 in 1987, 7,756 in 1995] a.i., respectively) than did the authorized and actual take for herons (34.4% [285 in 1987, 4,073 in 1995] and 38.9% [145 in 1987, 2,798 in 1995] a.i.) and egrets (35.5% [210

in 1987, 3,203 in 1995] and 47.4% [60 in 1987, 1,975 in 1995] a.i.).

Arkansas had the greatest number of depredation permits issued (396, 44% of total) and the greatest number of birds taken (48,762 birds, 76% of total), followed by Mississippi (360 permits, 40.0%; 8,980 birds, 14%), Louisiana (40 permits, 4%; 2,495 birds, 4%), North Carolina (86 permits, 10%; 1,385 birds, 2%), Alabama (32 permits, 4%; 1,128 birds, 2%), and Georgia (19 permits, 2%; 682 birds, 1%) (Table 3). Florida, South Carolina, and Tennessee each comprised $\leq 1\%$ of the total number of depredation permits issued and number of birds taken.

For the three states (Ark., Miss., and La.) with the greatest combined take of cormorants, herons, and egrets, the mean number of these species observed/CBC generally increased or was approximately stable during 1987–1995 (Figure 1). An exception was dramatic fluctuations in the mean number of cormorants observed annually in Mississippi, a consequence of 17,000–20,000 birds observed on a single CBC in 1987 and 1991.

Table 1. Number of depredation permits issued, number of birds authorized to be taken, and number of birds taken at aquaculture facilities in the southeastern United States, 1987–1995.

Species	No. of times permits issued	No. of birds authorized to be taken	No. of birds taken	% of authorized take
Double-crested cormorant	847	54,912	35,332	64
Great blue heron	719	20,497	13,364	65
Great egret	538	14,985	8,187	55
Other herons ^a	224	7,696	3,040	40
Grebes ^b	51	2,453	986	40
American white pelican	70	1,221	571	47
Snowy egret	192	3,878	901	23
Gulls ^c	50	1,612	805	50
Anhinga	12	172	42	24
Other ^d	35	1,275	783	61
Total permits issued	904 ^e	108,701	64,011	59

^a Primarily little blue herons (*Egretta caerulea*); also green-backed (*Butorides virescens*), tri-colored (*E. tricolor*), black-crowned night (*Nycticorax nycticorax*), and yellow-crowned night (*N. violacea*) herons.

^b Primarily pied-billed grebes (*Podilymbus podiceps*); also horned grebes (*Podiceps auritus*).

^c Primarily ring-billed gulls (*Larus delawarensis*); also includes Franklin's gulls (*L. pipixcan*).

^d Includes kingfishers.

^e Total number of permits is less than sum of column as ≥ 1 species can occur on a depredation permit.

Throughout the Southeast, the total number of each species observed during CBCs also appeared stable or increased slightly (Figure 2). The high total number of cormorants observed in 1988 and 1990 was a consequence of >100,000 birds being reported for 2 CBCs in each year. The annual maximum number of cormorants, herons, and egrets observed from 1987 to 1995 during CBCs was 381,836; 17,944; and 20,428; respectively.

For states where ≥ 1 double-crested cormorant, great blue heron, or great egret was taken, there were no negative associations ($r \geq -0.42$, $P \geq 0.26$) between the number of birds taken in that state and the respective mean number of birds observed/CBC in that same state (Table 4). Eight comparisons resulted in positive associations ($r \geq 0.60$, $P < 0.10$).

Discussion

Most birds were taken at aquaculture facilities in the Mississippi River Delta region, the area of the southeastern United States with the greatest number of hectares in aquaculture production and the greatest biomass of fish produced. However, the total number of depredation permits issued and the number of birds reported taken in each state may not accurately reflect the magnitude of the problem or the extent of loss. For example, in 1995, Mississippi had approximately twice as much production area (40,000 ha) for aquaculture as did Arkansas (23,000 ha) (Andrews et al. 1997), yet about 5.5 times more birds were taken in Arkansas (48,762) than in Mississippi (8,980). This inverse relationship may be the result of Arkansas' approximately 12,000

Table 2. Number of depredation permits issued annually for avian species at aquaculture facilities in the southeastern United States, 1987–1995.

Year	No. of permits issued	No. of birds authorized to be taken	No. of birds taken	% of authorized take
1987	7	1,260	429	34
1988	9	1,907	516	27
1989	53	7,401	3,601	49
1990	93	12,024	6,731	56
1991	120	15,610	7,777	50
1992	125	14,001	8,502	61
1993	145	15,464	9,980	65
1994	153	18,569	12,498	67
1995	199	22,465	13,977	62
All years	904	108,701	64,011	59

Table 3. Number of birds taken (depredation permits issued) by state at aquaculture facilities, southeastern United States, 1987-1995.

Species	Ala.	Ark.	Fla.	Ga.	La.	Miss.	N.C.	S.C.	Tenn.	All states
Double-crested cormorant	325(19)	26,309(368)	149(8)	284(17)	1,948(40)	5,301(353)	636(33)	380(9)		35,332(847)
Great blue heron	411(30)	9,881(323)		247(11)	213(14)	2,404(307)	178(29)		30(5)	13,364(719)
Great egret	277(9)	6,384(249)		116(6)	218(13)	1,167(257)	5(2)		20(2)	8,187(538)
Other herons ^a	17(4)	2,921(211)		15(2)	0(3)		87(4)			3,040(224)
Grebes ^b		986(51)								986(51)
American white pelican		479(56)			82(3)	10(11)				571(70)
Snowy egret	90(5)	731(165)		2(1)	33(4)	45(17)				901(192)
Gulls ^c		299(19)				47(14)	459(17)			805(50)
Anhinga		42(12)								42(12)
Other ^d	8(2)	730(25)		18(3)	1(1)	6(3)	20(1)			783(35)
All species ^e	1,128(32)	48,762(396)	149(8)	682(19)	2,495(40)	8,980(360)	1,385(86)	380(9)	50(5)	64,011(904)

^a Primarily little blue herons; also includes green-backed, tri-colored, black-crowned night, and yellow-crowned night herons.

^b Primarily pied-billed grebes; also includes horned grebes.

^c Primarily ring-billed gulls; also includes Franklin's gulls.

^d Includes kingfishers.

^e Combined values for number of depredation permits issued are less than sum of columns as ≥ 1 species can occur on a depredation permit.

ha of ponds in baitfish production, which attract large numbers of herons and egrets (Hoy 1994). The number of herons and egrets taken in Arkansas was about 4 and 6 times greater, respectively, than the numbers taken in Mississippi. Also, dispersal of cormorants at roosts in the Mississippi Delta area of Mississippi (Mott et al. 1992) may have caused these birds to relocate to areas where they are not considered a problem, thus reducing the number of cormorants taken in that state.

For all species, the actual take was substantially less than the take authorized under depredation permits, probably because producers were unable to take the number of birds permitted. In Mississippi, producers took only about 12% of the cormorants authorized to be taken (Hess 1994).

The overall stability of winter population trends for cormorants, herons, and egrets in the southeastern United States from 1987 to 1995 and the lack of negative association between these population trends and the number of individuals taken for each species suggest that lethal control at aquaculture facilities did not adversely affect state or regional winter populations. The fact that there were 8 significant positive associations between the number of birds taken and the mean number of birds observed during CBCs indicates that as bird populations increased, more depredation problems developed, resulting in more birds being taken.

The annual rate of increase in the number of depredation permits issued or birds taken probably does not reflect an identical increase in depredation. It is likely that additional factors were involved, including increased awareness by aquaculture producers of the availability of permits and an increased number of WS personnel available to assist aquaculture producers with management plans for their facilities.

Table 4. Associations (r) between the number of birds taken annually at aquaculture facilities and mean number of birds observed/Christmas Bird Count in that same year for a 9-state region of the southeastern United States, 1987-1995 ($n=9$ for each comparison).

State	Species					
	Double-crested cormorant		Great blue heron		Great egret	
	r	P	r	P	r	P
Ala.	0.64	0.06	0.48	0.19	0.01	0.97
Ark.	0.87	<0.01	0.76	0.02	0.42	0.26
Fla.	-0.36	0.34	—	—	—	—
Ga.	0.30	0.44	0.65	0.06	0.95	<0.01
La.	0.46	0.21	0.03	0.94	0.60	0.09
Miss.	-0.01	0.98	0.69	0.04	0.28	0.46
N.C.	-0.42	0.26	-0.26	0.50	-0.21	0.60
S.C.	0.58	0.10	—	—	—	—
Tenn.	—	—	-0.10	0.79	0.75	0.02

Dashed lines indicate no individuals of a species were taken in that state.

Breeding populations of double-crested cormorants, particularly the Interior population, have increased dramatically in recent years (Hatch 1995). For example, the Atlantic population increased from about 25,000 pairs in 1972 to 96,000 pairs in 1992 (Hatch 1995). Also, the Great Lakes population has increased 29% annually since the early 1970s to 38,000 occupied nests in 1992 (Weseloh et al. 1995). These increases were likely caused in part by reduced human persecution and declining levels of organochlorine contaminants at breeding colonies (Weseloh et al. 1995). However, recent exploitation of catfish at aquaculture facilities in winter also may have enhanced overwinter survival of cormorants and other piscivorous birds (Erwin 1995).

Combined Canadian and United States populations of double-crested cormorants were estimated

recently at >350,000 breeding pairs (Belant and Tyson 1997). Most birds that winter in the southeastern United States are from the Interior and Atlantic populations (Dolbeer 1991), which represented $\geq 320,000$ breeding pairs (Belant and Tyson 1997). For several populations, 0.6–4 nonbreeding cormorants per breeding pair have been estimated (McLeod and Bondar 1953, Price and Weseloh 1986, Watson et al. 1991). Thus, we estimate a minimum continental population of 1 million cormorants, with the actual population probably >2 million. The number of cormorants taken annually at aquaculture facilities in the southeastern United States conservatively represented $\leq 0.5\%$ of the estimated continental population.

Population estimates for great blue herons and great egrets are less complete than are those for cormorants. Conservative estimates for breeding pairs of great blue herons and great egrets in the United States and Canada are $\geq 133,000$ and $\geq 36,000$, respectively (Belant and Tyson 1997). Thus, we estimate that the number of herons and egrets taken annually in the southeastern United States represented $\leq 1\%$ and $< 3\%$ of the respective nesting populations. These estimates do not include immature or nonbreeding adult herons or egrets; thus, the percentage of the total population taken for each species annually is less.

We conclude that number of double-crested cormorants, great blue herons, and great egrets taken at aquaculture facilities in the southeastern United States from 1987 to 1995 did not adversely affect regional winter or continental breeding populations of these species. We recommend continued monitoring of lethal control via depredation

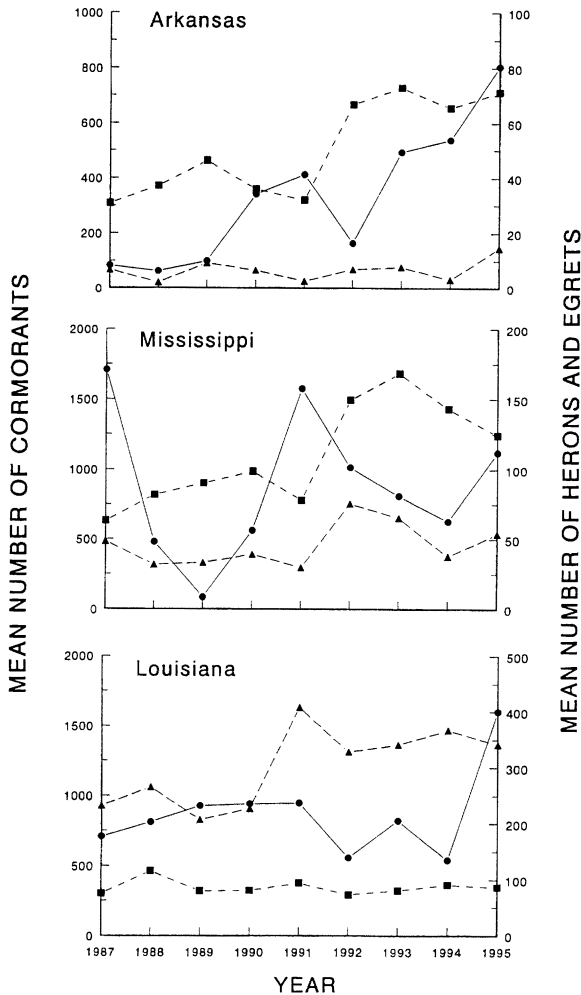


Figure 1. Mean number of double-crested cormorants (circles), great blue herons (squares), and great egrets (triangles) observed/Christmas Bird Count in Arkansas, Mississippi, and Louisiana, 1987–1995.

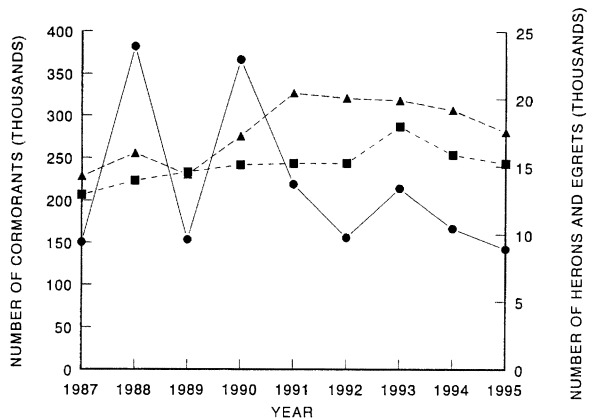


Figure 2. Total number of double-crested cormorants (circles), great blue herons (squares), and great egrets (triangles) observed during Christmas Bird Counts in the southeastern United States, 1987–1995.

permits at aquaculture facilities and winter and breeding populations of piscivorous birds to ensure that populations are not adversely affected.

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