Cormorants in roost-trees, Delta region, Mississippi.

An evaluation of winter roost harassment for dispersing double-crested cormorants away from catfish production areas in Mississippi

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Abstract We evaluated the effectiveness of harassing wintering double-crested cormorants (*Phalacrocorax auritus*) at their night roost sites over a 3-winter period as a means of reducing their impact on the catfish industry in the Delta region of Mississippi. Cormorants were dispersed from night roost sites by persons firing pyrotechnics at the birds in the roost and at those flying towards the roost for a 2-hour period before sunset. Numbers of cormorants at intensely harassed roost sites were greatly reduced in comparison with numbers at roosts that were not harassed or less intensely harassed. Numbers of cormorants surveyed on or near catfish ponds in March also were reduced by ≥70% during years of extensive harassment compared with numbers surveyed the year before harassment. Catfish producers within an area of intensive roost harassment perceived a reduction in problems with cormorant predation during the years of harassment as compared to previous years. Producers within this roost harassment area also reported spending less money on cormorant control on their farms. Those outside the roost-harassment area reported spending more.

Key words catfish, double-crested cormorant, frightening, *Ictalurus punctatus, Phalacrocorax auritus,* roosting

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Production of channel catfish (*Ictalurus punctatus*) in Mississippi has increased from its first commercial pond in 1965 to 37,000 ha of ponds and is the primary aquaculture industry within the state (U.S. Dep. Agric. 1994). In the Delta region of Mississippi, catfish are raised in rectangular ponds averaging 8 ha each. Ponds are shallow, ranging from 1 to 2 m deep. Concentrations of these shallow fish ponds, averaging approximately 20 per farm, are stocked with fish at densities ranging from 12,000 to 24,000 per ha. These fish concentrations provide attractive foraging areas for piscivorous birds. Increasing numbers of wintering double-crested cormorants (*Phalacrocorax auritus*) in this region have come into serious conflict with this expanding fish-farming industry. These birds are estimated to annually consume catfish fingerlings valued at $2 million (Glahn and Brugger 1995).

Attempts to reduce cormorant predation at catfish farms primarily involve the use of scaring devices (Littauer 1990, Mott and Boyd 1995). These efforts usually have only a short-term effect because the birds frequently habituate to the devices.

Frightening cormorants from night-time roost sites is a possible alternative for reducing predation at catfish ponds. In Mississippi, cormorants typically roost in bald cypress trees (*Taxodium distichum*) in oxbow lakes or swamps. Mott et al. (1992) demonstrated that cormorants at selected roost sites could be easily displaced by the use of pyrotechnic devices, and that cormorant activity in the area immediately surrounding the roost was also reduced. Mott et al. (1992) did not evaluate the simultaneous harassment of multiple roost sites over a large geographic area, but cautioned that such a program might be difficult to implement because of personnel and equipment required to harass all roosts concurrently for extended periods. Such a program, if successful, would help alleviate problems of catfish predation by displacing large numbers of cormorants away from areas of intensive catfish production.

In this study, we measured the effectiveness of harassing cormorants in multiple roost-site areas over 3 winter periods. To evaluate the effects of harrassment we tested the hypotheses that (1) the number of cormorants roosting in treated areas should differ from those in areas and years with no or limited harassment; (2) within areas of roost harassment, the number of cormorants on or near catfish ponds should differ from the number on or near ponds before extensive harassment; (3) perception of cormorant predation problems and costs of control by producers should differ between areas of minimal and extensive harassment, both before and during harassment programs.

Methods

Study area

We conducted this study in an area of northwestern Mississippi referred to as the Delta region, comprising the 16,000-km^2 alluvial plain of the Mississippi River (Fig. 1). Catfish production is interspersed with cotton and soybean production throughout this intensively farmed region, but approximately 80% of catfish production in the Delta is concentrated in the east-central Delta, consisting of Humphreys, Sunflower, LeFlore, and parts of Holmes and Yazoo counties (Fig. 1). Although much of the Delta has been drained for farm crops, approximately 10% of the original wetland areas remain. These areas, consisting of oxbow lakes, cypress swamps, and bayous, provide roosting habitat for double-crested cormorants. Cormorants roost in these areas during the wintering period of November–April (Aderman and Hill 1995). Harassment efforts during the winters of 1993–1994 and 1994–1995 primarily occurred in the east-central Delta (Fig. 1), because of the

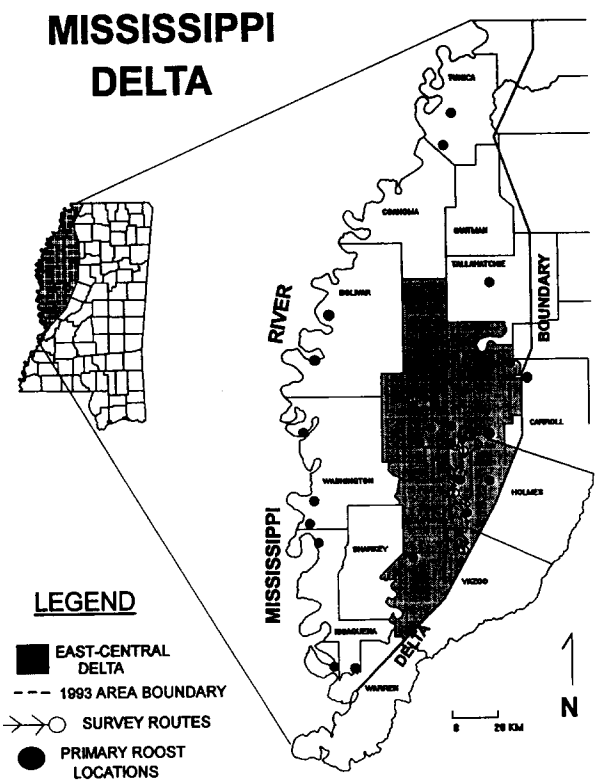

Fig.1. Location of the Delta region and counties comprising the east-central Delta within Mississippi, as well as locations of primary roosting sites and survey routes during 3 years of cormorant harassment, winters of 1992–1993, 1993–1994, and 1994–1995.

high density of catfish producers. In the winter of 1992-1993, the harassment effort was further restricted to a treated area defined by LeFlore and Sunflower counties, and the southern half of the east-central Delta served as an untreated control area (Fig. 1).

Harassment efforts

Harassment efforts took place at previously identified roost sites (Glahn et al. 1996) and new sites subsequently identified in aerial surveys. Seven study participants harassed all known roost sites within the treated area 9-17 times between 28 January and 25 March 1993. Prior to March a series of individual roosts were harassed (Hess 1994). During the month of March, we simultaneously harassed all roosts weekly in the treated area. No harassment efforts took place in the untreated control area during this period.

During the winters of 1993-1994 and 1994-1995 we attempted to harass all roosts identified within the Delta region of Mississippi. Harassment efforts were initiated in November and continued through April of each winter. However, the only sustained harassment effort took place in the east-central Delta. During these years, 40-58 catfish producers and their employees were responsible for the actual harassment effort. U.S. Department of Agriculture (USDA) Wildlife Services, formerly Animal Damage Control (ADC), personnel organized, participated in, and monitored the results of this harassment program. Pyrotechnics and pistol launchers were provided by the USDA to all personnel participating in the harassment effort.

Personnel harassed cormorants by firing pyrotechnics at birds in the roost and at birds flying into the roost during a period approximately 2 hours before sunset until 0.5 hour after sunset. Personnel positioned themselves along the perimeter of the roost site or in boats within the roost. They fired pyrotechnics consisting of screamer-sirens, which make a loud whistling noise, or bird bombs and shell crackers, which contain a large firecracker. Screamer-sirens and bird bombs were fired from a single-shot, 15-mm pistol launcher (Reed-Joseph Int. Co., Greenville, Miss.). Shell crackers were fired from a shotgun. The start and end times of the harassment effort, number of personnel, and number of devices used at each site were recorded. Personnel harassed each roost on consecutive evenings until the roost site was abandoned by ≥90% of the birds. Once a site was abandoned, we observed it ≥1 time per week for use by cormorants, and we harassed these birds again if their numbers exceeded abandonment levels.

Cormorant roost surveys

We estimated numbers of roosting cormorants in the entire Delta region during the winters of 1993-1994 and 1994-1995 using procedures described by Glahn et al. (1996). We conducted surveys each winter in mid-December, mid-February, and either the last week of March or the first week of April. We used data previously collected for the winters of 1991-1992 and 1992-1993 (Glahn et al. 1996) to compare the numbers of cormorants in the region before and after roost harassment programs. We surveyed previously identified roost sites (Aderman and Hill 1995, Glahn et al. 1996), as well as new sites identified from aerial surveys and ground observations. Usually starting the week before the scheduled census, we conducted aerial surveys during late afternoon and evening over the Mississippi, Sunflower, Tallahatchie, and Yazoo Rivers. During these surveys, we looked for cormorants roosting in cypress swamp habitat of bayous and oxbow lakes along these river systems (Glahn et al. 1996). During the winter of 1992-1993, we surveyed cormorants at roosts in the treated and control areas within 2 days before initiating harassment efforts and then at least weekly in both areas during the 8-week study period.

Double-crested cormorant.

We analyzed data from the winter of 1992-1993 with a paired *t*-test (PROC TTEST; SAS Inst. Inc. 1990), comparing differences in maximum numbers of cormorants before and after harassment in the treated and control area. We used a nonparametric analysis of variance (PROC ANOVA; SAS Inst. Inc. 1990) to separate differences of Delta-wide surveys among years before and during harassment programs in 1993-1994 and 1994-1995 and areas with different levels of harassment. To examine effects of consistent versus inconsistent harassment efforts on subsequent numbers of cormorants counted, we used a nonparametric ANOVA to compare numbers from sites harassed within 5 days of the roost surveys with sites less recently harassed.

Cormorant–catfish pond surveys

We conducted surveys of cormorants along prescribed routes to provide an index of cormorants foraging at catfish ponds within selected roosting areas of the east-central Delta. In March 1993 we established 3 16-km survey routes in the vicinity of 3 cormorant roosts (Little Mossy, Snake Creek, and Bee Lake). Each route started at the catfish farm nearest to the roost was oriented in the direction cormorants left the roost and surveyed between 264 and 645 ha of catfish ponds. Other roost sites in the vicinity (Fig. 1) probably also contributed to cormorants counted on these routes. In 1993 1 route was in the harassed area, and 2 of the routes were in the area not harassed (Fig. 1). However, in 1994 and 1995 all routes were in the intensively harassed area (Fig. 1). We collected survey data in March of each year by conducting surveys 3 days per week in 1993 and once per week in 1994 and 1995. The same observer conducted surveys between 0830 and 1130 hours each time. All cormorants seen on catfish ponds, in flight, or loafing in trees along the route were counted. We used a nonparametric ANOVA to compare cormorants seen on routes in the harassed and non-harassed areas in 1993 and to compare differences between counts of cormorants among years.

Perceptions of catfish producers

Within 2 months after the completion of Delta-wide harassment programs in 1993-1994 and 1994-1995, we solicited the perceptions of catfish producers and managers concerning problems with cormorant predation. In May 1994, we developed a mail-in questionnaire in cooperation with the Mississippi Cooperative Extension Service and sent it out under their auspices to approximately 300 catfish owners and managers on their statewide mailing list. Because few producers within the study area returned the questionnaire, we conducted telephone interviews with 29 Delta-region producers in 1994 and exclusively used telephone interviews with 100 Delta-region producers in 1995. Questions were designed to evaluate the effectiveness of the harassment program by having producers rate changes, if any, in problems with cormorant predation and costs of deterring cormorants at their farms during the harassment-program years compared to previous years. Because producers cannot directly measure cormorant predation, their perception of the problem is based largely on numbers of cormorants seen on their ponds. We partitioned responses from producers in the east-central Delta from those of producers in the western and northern Delta and compared frequencies of responses concerning changes in cormorant problems between areas with chi-square contingency table analysis (PROC FREQ; SAS Inst. Inc. 1990). We used a *t*-test to compare cost differences between areas. We conducted this research following study protocol QA-284, which was approved by the National Wildlife Research Center Animal Care and Use Committee.

Results

Harassment effort

From late January through March 1993, 6 roosts within the 2-county treated area were harassed an average of 12.6 (SE = 1.5) days. Except for 2 sites initially harassed in late January and mid-February, all harassment took place during the month of March. This harassment effort involved 1-7 people per site and averaged 41 (SE = 12.6) man-hours per site. During this effort an average of 1,110 (SE = 592, range = 89-3,582) pyrotechnic devices were fired per roost, or approximately 27 devices per man-hour of harassment. Costs of pyrotechnics averaged approximately $444 (SE = 289, range = $36-$1,720) per roost.

During the winter of 1993-1994, participants harassed 31 of 48 known roost sites within the Delta region of Mississippi, including all 22 known roosts in the east-central Delta. These 22 roosts averaged 22.5 (SE = 4.6) days of harassment per site compared to only 9.5 (SE = 6.4) days per site outside this area. Man-hours of effort involving 1-8 people per site averaged 50 (SE = 9.7) hours between areas combined. Overall, an average of 530 (SE = 86, range = 3-1,418) pyrotechnic devices were used per roost, or approximately 10.6 devices per man-hour of harassment.

Based on an average price of $27.20 per 100 rounds for pyrotechnics and $8.00 per hour for labor, costs of pyrotechnic devices and labor to conduct harassment averaged $544 (SE = 100, range = $7-$1,996) per roost. If producers had paid for pyrotechnics the average cost per participating producer would have been approximately $419.

During the winter of 1994-1995, 40 of 57 known roost sites in the Delta region were harassed, including all 27 roosts in the east-central Delta. Although these 27 sites were intensely harassed, averaging 35 (SE = 7.5) days of harassment, the 13 other sites averaged only 6.2 (SE = 1.2) days of harassment. Overall, harassment effort averaged 69 (SE = 15.5) man-hours per roost and involved 1-12 people per site. During this effort, an average of 891 (SE = 206, range = 17-5,071) pyrotechnic devices were used per roost, or 12.9 devices per man-hour of harassment. Due to increased effort and number of devices used, costs of pyrotechnics and

labor to conduct harassment increased to $794 (SE = 171, range = $14–$4,101) per roost. The average cost among the 58 producers would have been $557.

Cormorant roosting activity

Cormorants consistently abandoned roost sites after 1–2 evenings of roost harassment, but could return to abandoned sites <1 week later. For example, 1,118 cormorants harassed from 1 site on 17 March 1993 returned to pretreatment levels within 5 days. Due to weekly harassment efforts in March 1993, maximum numbers of cormorants in all harassed roosts were reduced from 18,554 birds to 640 birds during the course of the study. Concurrently, maximum numbers of cormorants counted in all roosts in the adjacent, untreated 3-county area increased from 3,759 to 28,966. These changes in numbers of cormorants between areas differed significantly (t = 2.95, P = 0.0342), suggesting a shift in cormorant roosting activity due to harassment.

Similar to the 1993 data, cormorants during the subsequent 2 winters shifted their roosting activity away from intensely harassed sites to sites not harassed or sites less intensely harassed, including new locations. Cormorant numbers differed (F = 5.77; 1, 21 df; P = 0.0257) between sites harassed within 5 days and sites with less recent harassment efforts. During the winter of 1993–1994, a mean of 2,484 (SE = 1,953) cormorants were counted at sites harassed within 5 days before a census compared to a mean of 12,600 (SE = 3,394) cormorants counted in roost sites not harassed in this manner. This included 11 new roosting locations not identified before the harassment effort. During the winter of 1994–1995, an average of 3,521 (SE = 978) cormorants roosted at sites that were harassed within 5 days before a census, compared to an average of 21,115 (SE = 4,163) in roosts that were not harassed in this manner. This included 9 new roosting locations not previously identified before this winter's harassment effort.

Overall, Delta-wide numbers of cormorants were not different (F = 0.05; 1, 22 df; P = 0.8332) between 2 baseline years (1991–1992, 1992–1993) and the 2 harassment program years (1993–1994, 1994–1995) (Table 1). However, numbers of cormorants were smaller (F = 28.62; 1, 10 df; P = 0.0003) in the east-central Delta than in the remaining Delta during harassment years, where no difference (F = 1.04; 1, 10 df; P = 0.3316) was found in previous baseline years (Table 1). Considering locations inside and outside the east-central Delta, a significant (F = 6.70; 3, 20 df; P = 0.0026) interaction between location and years suggested a shift in cormorant roosting numbers between locations and years before and during harassment.

Cormorant–catfish pond surveys

Although only a few hundred cormorants roosted within the treated area during March 1993, counts of cormorants on the Mossy Lake route were not different (F = 0.14; 2, 32 df; P = 0.8740) from survey counts on the Snake Creek and Bee Lake routes in the untreated area (Table 2).

Average numbers of cormorants counted on each of the 3 survey routes were different (F = 4.40; 4, 58 df; P = 0.0036) among years. Numbers of cormorants on survey routes were reduced (Tukey's, P < 0.05) by 70 and 71% during the expanded roost harassment programs in 1993–1994 and 1994–1995, respectively, from the previous winter when limited harassment occurred (Table 2).

Surveys of catfish producers

In 1994, 61.5% of 83 producers in the east-central Delta reported experiencing fewer problems with cormorant predation than in previous years compared to only 37.8% outside of this area (Table 3). Perceptions of producers differed between areas (χ^2 = 7.442; 2 df; P = 0.024) with respect to changes in cormorant problems experienced in 1994 compared

Table 1. Number of winter-roosting cormorants counted in the east-central Delta and other areas of the Delta region of Mississippi from December 1991 to April 1995.

	East-central Delta				Outside east-central Delta			
	1991–1992[a]	1992–1993[a]	1993–1994[b]	1994–1995[b]	1991–1992[a]	1992–1993[a]	1993–1994[b]	1994–1995[b]
Dec	7,246	5,363	3,284	2,034	5,314	6,078	9,377	13,039
Feb	14,666	21,108	5,753	7,932	12,686	10,798	8,145	23,820
Mar–Apr	8,194	10,114	3,653	7,185	5,296	9,353	15,042	19,891

[a] The winters of 1991–1992 and 1992–1993 were considered baseline years before intensive roost harassment in the east-central Delta.

[b] The winters of 1993–1994 and 1994–1995 were years of intensive roost harassment in the east-central Delta.

Table 2. Average number of double-crested cormorants counted in the vicinity of catfish ponds along 3 survey routes centered on cormorant roosting sites in the east-central Delta region of Mississippi during March in 1993, 1994, and 1995.

	Cormorants counted by survey route								
	Mossy Lake[a]			Snake Creek[b]			Bee Lake[b]		
Year	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
1993	11	831	315.6	12	582	120.8	12	1,311	418.0
1994	5	131	22.6	5	333	94.0	5	209	66.0
1995	5	272	82.0	4	284	14.0	4	80	26.5

[a] Cormorant roosts in this area were harassed in 1993, 1994, and 1995.
[b] Cormorant roosts in these areas were not harassed in 1993, but they were harassed in 1994 and 1995.

to previous years. A similar difference (χ^2 = 12.835; 2 df; P = 0.002) in perceived changes of problems with cormorants occurred in 1995, with 74.7% of 71 producers in the east-central Delta viewing problems with cormorant predation as decreasing. In other areas of the Delta, 62.5% of producers in 1995 viewed cormorant problems as either increasing or remaining about the same (Table 3).

In the east-central Delta, producers reported annually spending an average of $9,119 (SE = 1,757) and $11,641 (SE = 2,950) in 1993-1994 and 1994-1995, respectively, for deterring cormorants from their farms during the 3 years preceding these harassment programs (Table 3). Based on lower figures reported for 1993-1994 and 1994-1995, we calculated average cost reductions at $1,406 (SE = 491) and $3,217 (SE = 1,520) for these years, respectively (Table 3). In contrast to these cost reductions, producers outside the east-central Delta reported average increases in costs of $845 (SE = 776) and $741 (SE = 733) during 1994 and 1995, respectively (Table 3). Reported cost savings differed between areas in 1994 (t = -2.5816; 70 df, P = 0.011), and in 1995 (t = -2.3459; 87.9 df; P = 0.0212).

Discussion

Although cormorants readily abandoned roost sites after 1 or 2 evenings of harassment, continued harassment on a weekly basis appeared to be needed to prevent cormorants from returning.

In spite of large numbers of catfish producers participating in the harassment program within the region, areas outside the east-central Delta lacked a sufficient number of participants to harass all sites simultaneously or to harass sites on a regular basis. This lack of participants was exacerbated by the numerous alternative roosting sites available to cormorants along the Mississippi River where most of the newly identified sites were located. Thus, roosts in this area were not harassed or were only harassed periodically. Even within the east-central Delta, harassment efforts were not always sustained on a regular basis. At a few sites, harassment was curtailed during the waterfowl hunting season from mid-December to mid-January, because it was felt that cormorant harassment might also disperse waterfowl from these sites.

With weekly simultaneous harassment of 6 sites in the 2-county treated area during March 1993, most dispersed cormorants appeared to move to roost sites in the adjacent untreated counties. This was also noted by King (1996) who followed radio-instrumented cormorants during the same time period within this study. In response to harassment efforts focused primarily in the east-central Delta during the

Table 3. Perceptions of catfish farm owners and managers concerning problems with cormorant predation and costs of deterring cormorants in and outside the east-central Delta of Mississippi during and before the winter of 1993–1994 and 1994–1995 cormorant roost-harassment programs.

Producer perceptions compared to years before programs	East-central Delta region				Outside east-central Delta			
	1993–1994		1994–1995		1993–1994		1994–1995	
	n	%	*n*	%	*n*	%	*n*	%
Cormorant predation								
Increasing	18	21.7	7	9.9	17	32.1	9	37.5
Decreasing	51	61.5	53	74.7	20	37.8	9	37.5
About the same	14	16.9	11	15.5	16	30.2	6	25.0

	East-central Delta region		Outside east-central Delta	
	1993–1994	1994–1995	1993–1994	1994–1995
Average costs of deterring cormorants from farms ($)				
Before-roost programs	9,119	11,641	8,637	9,085
During-roost programs	7,713	8,424	9,482	9,826
Cost reduction	1,406	3,217	–845	–741

winters of 1993-1994 and 1994-1995, cormorants, in part, shifted their roosting activity to sites outside this area, primarily along the Mississippi River. Although there may be some potential negative impacts from moving cormorants to the roosts along the Mississippi River, Glahn et al. (1995) showed that the diet of cormorants roosting along the Mississippi River is predominately gizzard shad (*Dorosoma cepedianum*). Therefore, they may pose less of a problem to the catfish industry. The establishment of 20 new cormorant roosting locations within the Delta in 1993-1994 and 1994-1995 appeared to be a consequence of harassment efforts. Prior to the start of roost harassment in March 1993, few new roost sites had been located in 1991-1992 or 1992-1993 (Glahn et al. 1996).

Surveys of cormorants on or near catfish ponds in the treated area during March 1993 indicated similar numbers of cormorants foraged in the treated area compared to the untreated area. This suggests that harassing roosting cormorants over a limited area may not be effective in reducing cormorant predation within that area. This is not surprising since cormorants are known to travel ≤60 km from their night-roost location to their first foraging location (King et al. 1995). However, similar survey data from the east-central Delta in March 1994 and March 1995 indicated reductions in numbers of cormorants in the vicinity of catfish ponds compared to 1993. This decrease in the numbers of cormorants observed near ponds is indicative of reduced cormorant predation in the east-central Delta and appears to be associated with intensive roost harassment efforts over this larger area. Mott et al. (1992) reported similar reductions in cormorants in the vicinity of catfish ponds after harassing 1 or 2 roost sites in 3 selected study areas of the Mississippi Delta. Although these possible reductions in cormorant predation in March of this study are probably not indicative of predation on catfish occurring throughout the winter, Glahn and Brugger (1995) suggested that March is a month of most intense cormorant predation.

The observed reductions in the numbers of cormorants in the east-central Delta substantiate the perceived decrease in cormorant problems reported by catfish producers in this area. In contrast, most producers in the western Delta perceived cormorant problems to be increasing or remaining the same. Another indication of the effectiveness of these harassment programs in the east-central Delta was the reported reductions in the costs of deterring cormorants from catfish farms. Although a large number of producers may have benefitted from these harassment programs, the actual cost-benefit ratios of these programs remains difficult to ascertain. However, costs for pyrotechnics and manpower to implement the Delta-wide harassment programs during the winters of 1993-1994 and 1994-1995 were only a fraction of costs reported by catfish producers to maintain harassment patrols for cormorants on their ponds. In 1988 catfish producers reported spending an average of $4,700 per farm harrassing cormorants from ponds during the 6-month period they are present (Stickley and Andrews 1989). Assuming all producers spend the average for harrassment patrols, this amounts to roughly $1.3 million for all producers in the Mississippi Delta. Based on our study, this figure may have doubled in recent years for producers in the central Delta. In contrast, the costs of harassment programs were $16,757 during the first winter and $32,302 the second winter.

Management implications

Large-scale harassment of cormorants at their roost sites can be effective in shifting cormorant roosting and foraging activity away from catfish production areas and presumably reducing fish-predation losses caused by these birds. However, the effectiveness of such programs will likely vary with the amount of effort expended in implementing these programs. To be most effective, all roost sites within a large geographic area need to be harassed simultaneously, or at least harassed on a weekly basis, to prevent cormorants from moving from site to site or reoccupying previously abandoned sites. Other suitable roost habitat within that area also needs to be monitored to prevent cormorants from establishing roosts at alternative locations. An initial assessment of the extent of alternative roosting habitat may also be helpful in determining whether roost-harassment programs may be practical to implement. Coordination of the harassment effort and an adequate number of participants to carry out this effort is paramount. From a practical standpoint, the number of personnel needed should greatly exceed the number of roost sites to be harassed so that the burden of weekly harassment efforts over the winter can be shared by a number of individuals.

Although harassment of cormorant roosts does not eliminate the predation problems caused by cormorants at catfish farms, it can reduce the numbers of cormorants on or near catfish ponds and therefore the amount of effort needed to harass cormorants, especially on those farms near roost sites.

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