Evaluation of Control Techniques for Avian Predators of Pond-reared Fishes[1]

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Abstract: Research and development studies involving red drum and hybrid striped bass culture in coastal ponds have been seriously impacted by avian predators, especially when overwintering was required. Studies were conducted at the Waddell Mariculture Center to document the effect of predation by birds and also to test various non-lethal control techniques. Use of pyrotechnics, flash tape, "evil-eye" balloons, aerial balloons, and various wire grid patterns over a pond offered only short term protection. Mortality of fish in ponds protected by these devices ranged from 42.0% to 99.7% depending primarily on duration of the studies. Phase II red drum reared in unprotected "control" ponds exhibited mortalities of 79.5% to 83.1% after 1 month and 99.8% after 8 months. Double-crested cormorants were by far the most destructive predator and they quickly learned how to ignore or avoid the various discouragement devices tested. Total pond covers with plastic meshes did control bird predation but were expensive.

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During the past 20 years, expansion of the aquaculture industry in the southeastern U.S. has been accompanied by increased losses due to birds consuming fish. This problem is exemplified by the catfish industry in Mississippi where a

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1988 survey of 281 catfish growers showed that 87% of the farmers felt that their farms were sufficiently impacted by bird predators to warrant harassment efforts (Stickley and Andrews 1989). Consumption rates of up to 28 catfish fingerlings/cormorant/hour were documented and losses to cormorants alone were estimated at $3.3 million (Stickley et al. 1992). The cost of control techniques was estimated to be an additional $2.1 million. Problems in other areas have occurred as farmers in Florida reported potential losses of up to $75/hour in catfish ponds (Schramm et al. 1984); while in Texas, birds were feeding on the pond-reared shrimp as well as competing for their shrimp feed (Beynon et al. 1981).

The first substantial problem with avian predators at the S.C. Wildlife and Marine Resources Department's (SCWMRD) Waddell Mariculture Center (WMC) occurred during the unusually cold winter of 1989. Since then, bird predation has become a major problem affecting pond culture of red drum (*Sciaenops ocellatus*) and hybrid striped bass (*Morone saxatilis x M. chrysops*). Research efforts to intensify production levels of these fishes have been confounded by increased predation by birds especially when fish must be held in ponds during winter months.

At least 9 species of piscivorous birds have been observed feeding on fish in production ponds. These included: double-crested cormorant (*Phalacrocorax auritius*), osprey (*Pandion haliaetus*), laughing gull (*Larus atricilla*), Bonaparte's gull (*L. philadelphia*), great blue heron (*Ardea herodias*), common egret (*Casmerodius albus*), snowy egret (*Leucophoyx thula*), brown pelican (*Pelicanus occidentalis*), and hooded merganser (*Lophodytes cucullatus*). These species are all common winter residents in South Carolina. To date, the most serious predator in our coastal research ponds has been the double-crested cormorant. This species' range has spread southward and the first breeding colony was documented in South Carolina in 1985 (Post 1988). In only 4 years (1986–1989) the size of the South Carolina population increased by 310% (Post and Seals 1991).

The research reported herein was undertaken to document the impact of avian predation on fish reared in coastal ponds as well as to test various recommended non-lethal control techniques. The information obtained should be of interest to both private and public fish production facilities and be useful in management decisions related to requests for bird depredation permits. This manuscript documents: 1) the effect of avian predators on survival of red drum and hybrid striped bass reared in ponds; and, 2) provides results from studies testing the effectiveness of various non-destructive avian discouragement techniques.

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Methods

Research on non-lethal avian control methods was conducted during 1989–1992 at WMC, Bluffton, S.C. Ponds at this facility range in size from 0.1 to 0.5 ha and are lined with 40 mil high-density polyethylene. Pond bottoms are covered

with 25 cm of native soil and sloped towards the drain to facilitate water removal and harvesting. The hybrid striped bass and red drum used in the studies were produced by SCWMRD. Stocking and harvest population numbers were determined by actual count. At stocking, fish size designations for the various phases were: Phase II - 7.6 cm (3") to 20.3 cm (8"); and Phase III - >20.3 cm (8"). At harvest, samples of 50–150 fish were randomly taken and individuals measured to the nearest 1 mm and weighted to 0.1 g. On occasion, either length or weight data was not obtained at harvest. In such cases, the missing data were estimated from length/weight linear regression models generated from >1,000 observations of similar sized fish (resulting R^2 value = 0.8851) using SAS computer software (SAS Inst. 1988).

Results reported from pond studies include only trials during which rearing conditions were normal other than the presence of birds. No protective techniques were applied to control ponds and no attempts were made to discourage bird predation of fish in these ponds. Disturbance due to routine pond maintenance and personnel movement was similar for all ponds.

In some cases, different scare techniques were simultaneously tested in separate ponds. At other times, efforts were focused on a specific technique. For purposes of this manuscript, data obtained from various trials are presented by type of control technique tested. Type and size of fish, pond size, and duration of pond rearing varied among different techniques tested. This was intended to allow testing of techniques under a wide variety of conditions and also to document temporal impacts. No studies were conducted for a time period greater than nine months. The above conditions and constraints precluded rigorous statistical analyses.

Bird control efforts consisted of 2 types of non-lethal methods: frightening devices and exclusion techniques. The frightening devices included airborne explosive shells or pyrotechnics, "evil-eye" balloons, silver mylar aerial balloons, reflective flash tape, and plastic wire grid patterns. The exclusion approach utilized plastic mesh netting to cover the ponds. Most testing was conducted during winter months since this was the period of greatest avian predator problems.

Frightening Devices

Two types of airborne explosive shells were employed in combination: screamer sirens which produce a siren-like screeching sound and bird bangers which fly for a distance and then explode with a loud bang. Both were shot into the air by a single or double shot pistol launcher propelled by a .22 caliber blank.

Two different types of balloons were tested. The multi-colored "evil-eye" balloons were approximately 51 cm in diameter with distinctive large eye spots on various background colors. These balloons were filled with air and suspended over the midline of a pond. The second type was a reflective silver mylar balloon approximately 81 cm in diameter. These were inflated with helium and tethered in random locations around the pond. Both types of balloons had reflective tape suspended from them to flutter in the wind. Four eyed balloons and 6 reflective mylar balloons were utilized together in a 0.25-ha pond.

Another approach was to install 10–12 rolls of silver and red reflective mylar flash tape (11 mm wide x 90 m in length) across a 0.5-ha pond in a random criss-cross pattern. This tape which has a high tensile strength, was tied to metal stakes driven into the ground around the perimeter of the pond. When moved by even a slight wind, the tape reflected sunlight in bright flashes.

Heavy duty, black plastic wire was strung in a 9.1 m × 9.1 m grid pattern over a 0.25-ha pond. The wire was stretched tight and connected to metal stakes flush with the top of the pond berm approximately 1 m above the water surface. The design of the grid system was intended to hinder cormorants from entering and exiting the pond. Due to our pond design, the height of the grid above the water surface was double that suggested by Littauer (1990).

Total Exclusion

Two types of plastic mesh netting were tested in order to totally exclude all birds. The first netting utilized was a light weight extruded black plastic with a 3.8 cm square mesh. It was used to cover a 0.25-ha pond and was supported 1.7 m above the water along the center line by plastic wire attached to 2 wooden end posts. Additional lower supporting wires were stretched the length of the pond with the netting secured around the pond perimeter by metal stakes. The completed cover resembled a "pup tent."

The second type of exclusion devise was a heavy weight, UV-resistant, multi-woven, polypropylene 2.5-cm square mesh netting which had a 5- to 7-year life expectancy. A wooden support frame was built around the perimeter of a 0.25 ha pond and used to secure the tightened mesh. Additional support consisted of 10 mm steel cables anchored 1 m above the pond berm and stretched across the width of the pond in five locations. This arrangement allowed paddlewheel aerators to be placed under the mesh cover.

Results

Frightening Devices

Pyrotechnics were the first frightening technique used to discourage birds. Initially cormorants were scared away but within 2 to 3 weeks the bird abundance increased and many simply submerged when pyrotechnics were fired. On 1 occasion, 100 rounds were fired over 15 actively feeding cormorants and 4 of the birds remained. Pyrotechnics were also utilized in an attempt to frighten various gulls from eating feed pellets which were distributed by blower into ponds. However, within a few days the birds actually cued in on the noise of the exploding shells and greater numbers flocked in from the nearby Colleton River to feed.

Survival of Phase II hybrid striped bass and red drum was very low when pyrotechnics were used as the only protection method (Table 1). The use of pyrotechnics was sporadic, 6 patrols per day, since no personnel was stationed on the ponds at all times. Survival of hybrid bass was 30.5% in one 9-month trial and 4.2% in the second. Only 18.6% of the larger Phase III hybrid bass survived a

Table 1. Survival of pond-reared fishes using different avian discouragement techniques.

Technique	Species	Rearing phase	Stocking density (*N*/ha)	Time (months)	Harvest size T.L. (mm)	Harvest size Wt (g)	Survival (%)
Pyrotechnics	Hybrid bass	II	60,628	9	240	180	30.5
"	Hybrid bass	II	60,632	9	190	115	4.2
"	Hybrid bass	III	10,000	2	245	190	18.5
"	Red drum	II	61,894	4	142	29	0.3
Flash tape	Red drum	II	107,982	4	126	17	39.4
Plastic wire	Red drum	II	61,220	4	180	43	58.0
"	Red drum	II	64,504	4	153	32	24.8
Mesh netting	Red drum	II	60,200	4	153	32	74.0[a]
"	Red drum	II	174,670	5	201	85	79.6[a]
"	Red drum	II	33,632	4	157	33	100.0[b]
None[c]	Red drum	II	60,236	8	210	109	0.2
"	Red drum	II	19,000	1	164	39	16.9
"	Red drum	II	18,004	1	162	38	20.5
"	Hybrid bass	III	32,060	1	271	227	68.0

[a] Lightweight extruded mesh covered ponds for 65% of growing season.
[b] Heavy-duty multi-woven mesh covered pond entire season. Population estimated gravimetrically at stocking and harvesting.
[c] None = control ponds where no discouragement techniques were used.

2-month trial. The poorest survival recorded was from small red drum which exhibited a survival of only 0.3% after 4 months (Table 1).

The "evil-eye" and mylar balloons did little to discourage either swimming or diving birds and were discontinued after several weeks. It was also difficult to keep the helium balloons filled for more than a few days at a time.

The silver and red reflective tape also proved relatively inefficient at discouraging birds and problems were encountered with the tape stretching and sagging. The tape had to be retightened every few days to keep it out of the water and from becoming entangled in the paddlewheel aerators. Cormorants were frightened for a couple of days and then became proficient at flying in and out of the ponds, navigating through openings in the intricate grid pattern. Adding additional flash tape did not deter cormorants once they learned that fish were in the ponds. Using flash tape, Phase II red drum stocked at a density of 107,982 fish/ha had a survival of 39.4% after 4 months (Table 1).

Use of plastic wire grid patterns over the ponds also did little to discourage the birds. Within a few days the cormorants became adept at maneuvering through the wire grid. Additional wire was strung to form "x"s but these did not prevent the birds from entering and leaving the ponds. Two trials using Phase II red drum stocked at about 61,000–64,000/ha resulted in survival rates of 24.8% and 58.0% after 4 months (Table 1). The difference in survival is suspected to be related to the level of human activity in the general pond area. The pond with the higher survival was located close to the main laboratory building while the pond with lower survival was located at the perimeter of the property.

Total Exclusion

The light weight plastic mesh cover excluded all birds from the ponds, but installation costs were high as small panels had to be sewed together to form a piece large enough to cover the pond. This mesh was not very durable as it stretched and sagged and became tangled in the aerators. It also became brittle within several weeks and eventually was torn off during a windstorm. In contrast, the heavy-duty multifilament mesh provided excellent protection with minimal maintenance even after 1.5 years of use. Despite the problems with the light-weight material, survival rates for Phase II red drum ranged from 74.0% to 79.6% over a 4–5 month period (Table 1). In the case of the heavy-duty mesh, survival of Phase II red drum stocked at a density of 33,622 fish/ha was estimated to be nearly 100% after 4 months of use (Table 1).

Control Ponds

During the various studies, 4 ponds were stocked with fish and no avian deterrent methods implemented (Table 1). Cormorants proved to be the most destructive species by far and in 1 pond consumed 32% of the hybrid bass (mean weight 227 g) in only 1 month. At the documented consumption rate of 454 g/day/cormorant (Stickley 1990), it would only require 17 birds to cause this magnitude of loss. On occasion, as many as 52 cormorants were observed actively feeding in a 0.5-ha pond. In 2 Phase II red drum ponds, cormorants consumed nearly 80% of the fish in only 1 month (Table 1). During a longer trial with red drum, survival was 0.2% after 8 months of culture (Table 1).

Economic Considerations

Labor required to implement the various techniques was not considered during the trial periods; however, most techniques evaluated demanded considerable time to set up and maintain. For example, approximately 60 hours were needed to construct the frame and assemble the heavy-duty netting. In addition, stretching the mesh over the pond frame required 10–15 people and took about 1 hour.

Single and double shot pyrotechnic pistols ranged in price from $22–$28 while the .22 blanks, 15 mm screamer siren, and bird banger shells cost $40/100. "Evil-eye" and reflective mylar balloons cost between $6–$9/each. Cost per roll of reflective flash tape was $1.00. Expense for metal stakes and plastic wire used for the grid patterns over a .25-ha pond was about $90. Posts, metal stakes, turnbuckles, and light-weight mesh netting for application on a .25-ha pond was $860. The actual costs for framing material and heavy-weight mesh netting to cover a .25-ha pond was $3,534. Material costs ranged from $24/ha for the flash tape to approximately $14,000/ha for the heavy duty mesh pond covers (Table 2). However, of the techniques evaluated, only the pond covers offered any substantial relief from avian predators.

Discussion

With increased time in operation, WMC has experienced increased problems due to predation on cultured fishes by birds (Table 3). When the facility began

Table 2. Estimated cost for materials (not including labor) used in studies to attempt to discourage bird predation of pond-reared fishes.

Method	Cost/ha ($)
Flash tape	24
Balloons	315
Plastic wire grid	360
Pyrotechnics	100–3,000
Light-weight mesh	3,440[a]
Heavy-duty mesh	14,136[a]

[a] May not accurately represent costs due to possible need for additional structural materials since estimate was expanded from 0.25-ha application.

operations in 1984, there was essentially no predation from birds. By 1989, however, avian predators had become a problem. Studies conducted from 1984 to 1989 had a documented mean survival of 75.6% for red drum and 79.2% for hybrid striped bass. In contrast, from 1989 to 1992, survival of red drum decreased to a mean of 22.9% while survival of hybrid bass declined to a mean of 17.8% (Table 3). At present, the double-crested cormorant is the primary predator causing substantial damage to all phases of production. Even though cormorants have been documented consuming fish 40 cm in length (Campo 1991), Phase II fish (7.6 cm–20.3 cm) are the most preferred size. Unfortunately, Phase II fish are the size typically over-wintered in ponds at WMC. Cormorants are proficient and persistent and will feed until essentially all pond-held fish are consumed.

Birds are highly opportunistic feeders capable of altering normal feeding patterns to accommodate new feeding opportunities. Gulls and cormorants quickly became conditioned to fish feeding techniques, equipment, and times, and required only a short time to learn to ignore various non-destructive control techniques. Gulls were observed primarily as competitors for feed but have also been documented to feed on fish near the water surface in ponds.

Of the techniques evaluated, only total pond covers were successful in pre-

Table 3. Survival of Phase II red drum and hybrid striped bass in uncovered ponds at WMC prior to serious bird predation (1984–1989) and after birds became prevalent (1989–1992).

		1984–1989 Survival (%)			1989–1992 Survival (%)	
Species	*N* Obs.	Mean	Range	*N* Obs.	Mean	Range
Red drum	11	75.6	56-99	7	22.9	0.2–58.0
Hybrid bass	13	79.2	52-99	3	17.8	4.2–30.5

venting predation by birds. The other techniques offered limited short-term control and then only if they were aggressively utilized when birds first appeared on the premises. In the long term, these non-lethal techniques were expensive and did not offer satisfactory bird control. Unfortunately, the cost to totally cover ponds is even greater and may not be economically justifiable for many facilities. Limiting production cycles to certain times of the year would be helpful but may not be practical.

Results of this study clearly support the need for intensification of production levels in smaller units which can be fully covered and the need for additional research to identify more effective bird control approaches.

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