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[Article]

The Economic Impact of Restricting Use of Black Carp for Snail Control on Hybrid Striped Bass Farms

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Abstract.—Black carp *Mylopharyngodon piceus* have been used in the U.S. for several decades for snail control in fish ponds. Recent concerns over the potential environmental effects of escaped fish have resulted in proposals to list black carp as an injurious species. A mixed-integer programming model was extended to evaluate the farm-level economic effects of restricting access to black carp for those farming hybrid striped bass (white bass *Morone chrysops* × striped bass *M. saxatilis*). The alternatives evaluated included (1) no snail control, (2) chemical control with hydrated lime, (3) chemical control with copper sulfate, and (4) biological control with redear sunfish *Lepomis microlophus*. Lack of access to black carp to control snail populations will reduce the marketability of food-size hybrid striped bass and will reduce the supply of hybrid striped bass fingerlings. Each 10% decrease in the marketability of hybrid striped bass food fish decreased net returns above variable costs by US$2,987/ha. Each 10% reduction in the supply of fingerlings further reduced net returns above variable costs by $1,107 to $1,855/ha. Net returns were lower as fingerling price increased with fingerling shortages after the first year. The industry standard of using black carp was the most cost-effective strategy. In the long run, based on the projections of our model, even with adoption of the alternative treatments analyzed in this study, small farms would go out of business, medium farms would suffer losses of 47% to 59%, and large farm would incur losses ranging from 33% to 41%. The total annual fish sales lost as a result of restrictions on the use of black carp were estimated to be $4.7–$11.96 million/year; with multiplier effects, total economic losses would be $16.45–$72.9 million/year.

Concerns over potential negative environmental effects from the introduction of nonnative species have increased in recent years. At least 185 nonindigenous species of fish have been introduced into the U.S. from other countries and 139 of these have become established (Fuller et al. 1999). Black carp *Mylopharyngodon piceus* are molluscivores and eat snails that serve as intermediate hosts for several fish parasites (Mitchell 1995; Rothbard et al. 1996; Rothbard and Rubenstein 1999). Slootweg et al. (1994), Shelton et al. (1995), and Huckins (1997) documented the effectiveness of black carp as a biological control agent for snails. Black carp were reported to have been brought into the U.S. as a contaminant in grass carp *Ctenopharyngodon idella* stocks from Asia in 1973 (Nico et al. 2001). Subsequent introductions were made with the assistance of the U.S. Fish and Wildlife Service (USFWS) to provide a potential biological control of snails that serve as intermediate hosts for fish pathogens.

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Farmers of hybrid striped bass (white bass *Morone chrysops* × striped bass *M. saxatilis*) and fathead minnow *Pimephales promelas* farmers began to stock black carp in fingerling and food fish ponds in the early 1980s for control of the yellow grub *Clinostomum complanatum*. The life cycle of the yellow grub includes the great blue heron *Ardea herodias* and snails common in fish ponds (Lane and Morris 2000). The yellow grub causes mortality in hybrid striped bass fingerlings and renders food-size bass unmarketable (Lane and Morris 2000; Lo et al. 1985). Mortalities in fathead minnow ponds resulting from yellow grub infestations can be as high as 80% (Nico et al. 2005). Thomforde (1990) showed that stocking 25 black carp per water hectare eliminated the presence of up to 100% of snails in fathead minnow ponds. In more recent years, catfish farmers in Mississippi and Arkansas have stocked black carp in catfish ponds to control infestations of an exotic trematode *Bolbophorus* spp. The trematode has resulted in severe economic losses in the catfish industry (Venable et al. 2000; Terhune et al. 2003). Its life cycle includes the white pelican *Pelicanus erythrorhynchos* (a protected migratory species) and the rams-horn snail *Planorbella trivolvis* (Avery et al. 2002).

There is no effective, approved therapeutic treatment for fish infested with yellow grubs and other trematodes. Since eliminating the presence of birds on fish farms is unlikely, the only practical approach to control infestations is to break the life cycle of the parasite by eliminating the presence of the intermediate hosts.

The USFWS has proposed adding black carp to the list of injurious fishes, mollusks, and crustaceans (USFWS 2004). Listing black carp as an injurious species would prohibit the interstate transportation of live black carp and viable eggs. The proposal grew out of concern over the potential impact on native freshwater mussels and snails in aquatic ecosystems of the United States should black carp escape. The Mississippi Interstate Cooperative Resource Association (MICRA) initiated a petition to list fertile diploid black carp as an injurious species to protect native freshwater mussels and snails in the Mississippi River basin. However, Nico and Williams (1996) indicated that, if diploid black carp can be contained in ponds, establishment of black carp in open waters is unlikely. Inducing triploidy in fish is an effective method to prevent reproduction (Nico et al. 2001). Histological analyses demonstrated that the gonads of triploid fish are abnormal, resulting in functionally sterile fish. Therefore, use of sterile triploid black carp minimizes potential negative effects to the environment because escaped fish would not be capable of reproducing.

Listing black carp as an injurious species would probably affect hybrid striped bass, fathead minnow, and catfish farms. However, no economic analyses have been published in the scientific literature on the impacts of the proposed rule on fish businesses. The USFWS estimated losses of less than US$100 million to aquaculture if black carp are restricted but provided little supportive evidence for this estimate and ignored impacts on major catfish-producing states such as Alabama, Arkansas, and Mississippi. The report (USFWS 2004) further stated that "this report underestimates this impact of the proposed rulemaking . . . due to limited data availability for the impact of black carp on baitfish and hybrid striped bass." Given the substantial differences in commercial farming practices for the different species, separate analyses would be required for each. While the overall impacts of this rule may be greater for the catfish industry owing to its larger size, the impact on individual hybrid striped bass farms also may be considerable. The hybrid striped bass industry grew rapidly from 1991 to 2000 (Engle and Quagrainie 2005; Figure 1). However, the industry reported a decline in sales in 2001 and 2002 and attributed this to effects from the September 11, 2001, terrorist attack in New York City. Although

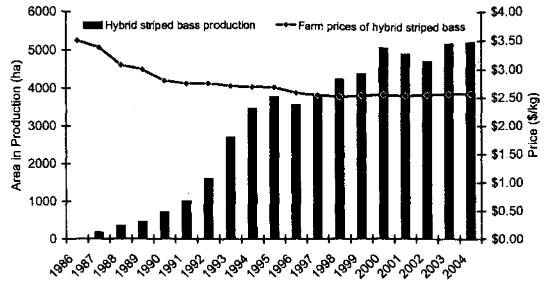

FIGURE 1.—U.S. farm production of hybrid striped bass and farm prices, 1986–2004.

this industry is continuing to grow, a lack of effective control of yellow grubs could prevent it from reaching its full potential.

Little research has been done on the economics of hybrid striped bass farming. Enterprise budgets have been developed for a 13-ha food fish farm in North Carolina (Dunning 2001; Dunning and Daniels 2001) and fingerling production in Maryland (Lipton and Harrell 1990). A simulation analysis was used by Gempesaw et al. (1991) to compare pond and tank production economics of hybrid striped bass. Net returns for the pond system were higher than for the tank system and were higher at medium stocking densities. Moreover, the analysis showed that net returns were more sensitive to price decreases than to price increases, particularly at prices less than $1.36/kg. Gempesaw et al. (1992) used a dynamic whole farm Monte Carlo capital budgeting simulation model to determine that optimal pond size was 1–4 ha for hybrid striped bass production in the mid-Atlantic region. D'Abramo et al. (2002) compared two- and three-phase hybrid striped bass production and determined that net returns were similar for two-phase low-density, high density, and three-phase production. Wui and Engle (2004) used survey data from hybrid striped bass growers to build a mixed-integer programming model. This model was used to compare alternative effluent treatment options.

The primary objective of this paper was to evaluate the economic effects of the proposal to list black carp as an injurious species on hybrid striped bass farms. Farm-level effects of proposed regulations were analyzed for different farm sizes, and alternative snail control treatments were considered.

Experimental Alternatives to the Use of Black Carp for Snail Control in Fish Ponds

Several alternatives to the use of black carp for snail control in ponds have been studied. These include (1) chemical control with hydrated lime, (2) chemical control with copper sulfate, and (3) biological control with redear sunfish *Lepomis microlophus* and blue catfish *Ictalurus furcatus*.

Mitchell (1995) reported results of trials of a shoreline application of copper sulfate and citric acid to production ponds. This treatment consisted of a solution made from 589 g of copper sulfate and 58.9 g of citric acid with 48.5 L water spread over a 2-m wide swath per 10 linear meters along the pond shoreline at temperatures of 26.5–28°C. The treatment was limited to the water along the edge of the pond. The treatment killed snails in the area, and did not harm fish because it became diluted as it dispersed throughout the pond. This treatment would not be suitable for fingerling and fry ponds because fry tend to congregate along the shoreline and that concentration would be lethal to small fish. Fish would be more vulnerable in small ponds (<3 ha) due to the greater shoreline : water surface area ratio and in waters with low total alkalinity less than 100 mg/L, at which copper is more toxic to fish (Boyd 1990). Additional work demonstrated that copper sulfate alone produced similar results (Mitchell and Hobbs 2003).

Application of hydrated lime at 22.7 kg per 25–30 m of pond bank has been proposed as an alternative treatment to prevent access of snails to ponds (Terhune et al. 2002). However, this treatment is also limited to the pond bank and to waters with total alkalinity above 30 mg/L.

Redear sunfish were tested for potential as a biological control method for snails (Ledford 2003). Redear sunfish use rounded, molar-like teeth to crush snails for consumption as a natural food source (Cook and Spurlock 1998). Redear sunfish are known to eat snails, but given their small mouth gape questions arise as to how effective they are in controlling snail populations. French and Morgan (1995) reported that redear sunfish ingested zebra mussels *Dreissena polymorpha* larger than 20 mm and rams-horn snails *Planorbella trivolvis* < 15 mm. Redear sunfish have been reported to avoid snails with hard shells (Kelly 2000). Ledford (2003) and Mitchell (A. Mitchell, H.K. Dupree Stuttgart National Aquaculture Research Center, personal communication) reported that redear sunfish prefer *Physella* to *Planorbella* snails. In the Ledford (2003) studies, black carp consumed 98% of available snails, redear sunfish 37% of available snails, and blue catfish only 14% of snails. Black carp consumed snails from all size ranges provided (6–16 mm) while redear sunfish and blue catfish did not consume the larger, 14–16-mm snails. Black carp was determined to be the most efficient consumer of the rams-horn snail. Redear sunfish have been reported to prey on juvenile fish and would not be effective in ponds stocked with fry. Moreover, redear sunfish reproduction in commercial ponds could become problematic. The low control by blue catfish in the Ledford (2003) studies did not warrant inclusion in this analysis. While freshwater drum *Aplodinotus grunniens* have also been suggested for biological control, preliminary work has not been promising (A. Mitchell, H. K. Dupree Stuttgart National Aquaculture Research Center, personal communication).

Methods

Model development.—A mixed integer-programming (MIP) model was used to model a hybrid striped bass farm under current conditions (which include using black carp for snail control) and then to evaluate the effects of adopting various alternative treatment methods. Mixed-integer programming models are commonly used to identify profit-maximizing management strategies for agricultural production, particularly in situations that involve discrete production units (Dantzig 1963). The Wui and Engle (2004) analytical model for hybrid striped bass farming was developed focusing on maximizing net returns above variable costs derived from hybrid striped bass production subject to the imposition of several different snail infestation treatment options. The original analysis assumed that black carp were used for snail control, based on survey data from hybrid striped bass farms. The model yielded multiple products of grow-out and fingerling fish, sold market-size fish at fixed prices, and used fingerlings as the inputs for grow-out fish production. The model used the following fixed market prices for inputs: fingerlings, feed for grow out and fingerlings, labor, chemicals, electricity, fuel, harvest and marketing costs, other variable costs, and interest charges for financing. The model also used land resources that are available in fixed quantities for the different farm sizes. Nonnegativity and supply and demand balance equations are included. The Wui and Engle (2004) model was extended to examine scenarios that included lack of access to black carp for snail control and effects of alternative snail control treatment options.

The set of produced products (intermediate and final) was designated as p, inputs as i, and resources as r. Decision variables were defined as the set of produced products, H_p; the set of production processes of grow-out-size fish, HG; the set of production processes of fingerling-size fish, HF; and the set of purchased inputs i, Z_i.

Additional parameters were developed that describe the relationships among production variables. These parameters are the quantity of output p (market-size hybrid striped bass) produced by one unit of HG, a_p;

TABLE 1.—Hybrid striped bass production characteristics by farm size from hybrid striped bass producer survey, 2001 data (see Wui and Engle 2004).

Production characteristic	Farm size[a]		
	Small	Medium	Large
Water area (ha)	5.5	27.9	157.2
Food fish area (%)	80	80	76
Food fish price ($/kg)	5.35	5.69	5.51
Food fish feed conversion ratio	1.5–1.5	2	1.6–2.8
Food fish survival rate (%)	95–100	85–95	85–95
Food fish stocking density (fish/ha)	11,120	11,120	7,413–9,884
Harvest weight per fish (kg)	0.73	0.68	0.70
Food fish yield (kg/ha)	6,369	4,847	3,912
Marketability[b]	99	87	64

[a] Farm sizes are as follows: small, 8.1 ha; medium, 28.3 ha; and large, 121.4 ha.
[b] Percent of food crop sold.

the amount of intermediate product p required to produce one unit of HG, b_p; the amount of intermediate product p produced by one unit of HF, c_p; the amount of input i required to produce one unit of HG, g_i; the amount of input i required to produce one unit of HF, h_i; the amount of fixed resource r required to produce one unit of HG, k_r; the amount of fixed resource r required to produce one unit of HF, l_r; and the endowment amount of r resource, m_r.

The objective of the base model was to maximize net returns above variable costs from hybrid striped bass production using the current industry practice of stocking black carp for snail control. To do so, additional parameters, including the sales price, input purchase costs, and other operating costs are needed. These parameters are defined as the sales price of output p, n_p; the variable cost to produce HG, q; the variable cost to produce HF, s; and the purchase cost of input Z_i, u_i.

The objective of the hybrid striped bass production model is to maximize the net returns above variable costs of multiple products, that is,

$$\text{Maximize} \sum_p n_p H_p - q\text{HG} - s\text{HF} - \sum_i u_i Z_i. \quad (1)$$

There are four constraints. The first set of constraints are the demand and supply balances of grow-out-size and fingerling-size products, for which the quantity sold is less than or equal to the quantity yielded through production:

$$H_p - a_p\text{HG} \leq 0, \quad \text{for grow-out-size product } p \quad (2)$$

$$H_p - b_p\text{HG} - c_p\text{HF} \leq 0, \quad \text{for fingerling-size product } p. \quad (3)$$

Given the above constraints, grow-out-size fish are only used for sales, but fingerling-sized fish can be sold in markets and used as intermediate inputs to produce food-size fish. The term b_pHG represents the inputs used to produce HG.

The second set of constraints includes demand and supply balances for purchased inputs whose quantity is greater than or equal to the quantity used in the production process. Input constraints are as follows:

$$g_i\text{HG} + h_i\text{HF} - Z_i \leq 0 \quad \text{for all } i. \quad (4)$$

The third constraint type is a resource availability constraint that insures that the quantity used of each fixed quantity of input does not exceed the resource endowments:

$$k_r\text{HG} + l_r\text{HF} \leq m_r \quad \text{for all } r. \quad (5)$$

The fourth constraint type is the nonnegativity condition for all decision variables:

$$\text{HG, HF, } Z_i \geq 0 \quad \text{for all } p, i. \quad (6)$$

The base scenario consists of fingerling and grow-out production activities that include the industry standard for snail control, stocking black carp. Optimal production solutions were obtained for each farm size for the base scenario. Sensitivity analyses were then developed with GAMS software by looping the first program with varying marketability rates (percent of food-size bass produced that was sold), reductions in fingerling supplies, and the subsequent increased fingerling input prices ($u_{\text{fingerling}}$) that would be expected to occur if black carp were prohibited. All levels used in the initial sensitivity runs were analyzed with each alternative snail control treatment by incorporating the increased costs from each treatment option as well as the reduced costs from the elimination of black carp.

Data and scenarios.—Survey data were collected in 2001 from hybrid striped bass farmers across the United States and are presented in detail in Wui and Engle (2004). Survey data, including the market price of hybrid striped bass, stocking densities, yields, feed conversion ratios (FCR), and rates of marketable yields, were used to characterize three farm-size scenarios: small (8.1 ha), medium (28.3 ha), and large (121.4 ha), as in Wui and Engle (2004) (Table 1). The survey data collected in 2001 showed decreasing profits as farm size increased. This was due largely to marketing problems associated with the September 11, 2001, terrorist attack in New York City, as the city's restaurants are the primary market for the larger hybrid striped bass farms. The decrease in restaurant sales following that event directly affected hybrid striped bass sales on the larger farms in that year.

The base scenario was developed assuming average values of FCR, stocking density, survival rate,

TABLE 2.—Values of variables used in the base scenario evaluated with the hybrid striped bass production model.

Variable	Food-size fish	Fingerlings
Feed conversion ratio	1.86	1.5
Stocking density (fish/ha)	11,120	50,500
Survival rate (%)	90	86
Harvest size (kg)	0.68	0.11
Yield (kg/ha)	6,808	4,924
Marketability rate (%)	100	n.a.
Output price ($/kg)	5.51	n.a.

[a] The same values were used for small, medium, and large farms; n.a. = not applicable.

harvesting size for food fish and fingerlings, and output prices for all farms surveyed (Table 2). The base scenario assumed that 100% of the hybrid striped bass produced from the small, medium and large farms were sold. In reality, the market for hybrid striped bass is volatile with fluctuating quantities demanded. Sensitivity analyses in Wui and Engle (2004) showed that increased marketability rates (percentage of the food-size fish produced that were sold) of 1% increased net revenue by $298.70 per ha. Demand for hybrid striped bass was assumed to be elastic. No estimates of price elasticity for hybrid striped bass were found in the literature, but demand for other major farm-raised finfish (e.g., channel catfish *Ictalurus punctatus* and Atlantic salmon *Salmo salar*) is elastic (Zidack and Hatch 1991; Zidack et al. 1992; Bjorndal et al. 1994; Hanson et al. 2001; Kinnucan and Myrland 2003). Given the degree of substitutability among finfish species in many markets (Roheim et al. 2003), it is reasonable to assume that demand for hybrid striped bass likewise would be elastic.

Survey data revealed that the only type of treatment practiced on commercial farms was that of stocking black carp; hence this is the reason for the selection of black carp for the base scenario in this analysis. Black carp were assumed to be stocked at 25/ha at an annual cost of $41/water ha (M. Rapert, Nature's Catch, personal communication). Black carp are replaced typically about once every 3 years (L. Dorman, Arkansas Cooperative Extension Program, personal communication). Thus, the costs of using black carp estimated in this paper are conservative. While these estimates over-estimate the cost to one farm, they do represent the cost to a farm starting out in hybrid striped bass production.

The primary treatment options considered in this paper were (1) the base scenario of black carp treatment, (2) no-snail-control treatments, (3) stocking redear sunfish instead of black carp as an alternative biological control treatment, (4) treating pond shorelines with copper sulfate, and (5) applying hydrated lime on pond shorelines (Table 3). Data on the relative efficacy of each option were obtained from (1) M. Rapert (Nature's Catch, personal communication), (2) M. Freeze (Keo Fish Farm, personal communication), (3) Ledford (2003), (4) Mitchell (2002) and Mitchell and Hobbs (2003), and (5) Terhune et al. (2003). Snail control treatment alternatives were added individually to the MIP model to evaluate the effect of each treatment alternative on net returns above variable costs/ha.

The base scenario that uses black carp as the snail control treatment option represented a hybrid striped bass farm that produces primarily food fish. The basic production cycle followed by many hybrid striped bass growers is based on a two- or three-phased system. In a three-phased production system (the traditional system), farmers stock fry into ponds fertilized to produce a zooplankton bloom for approximately 30 d. Juveniles are size-graded and stocked into phase-2 ponds for approximately 150 d before harvesting and grading. Phase-2 fish are stocked into phase-3 ponds for growth to market size. In a two-phased production system, fry are raised to a larger size in phase 1 and the larger juveniles restocked into food fish grow-out ponds.

The scenario of no treatment for snail control represents the immediate effect likely to result from listing black carp as injurious. The injurious species listing would prohibit interstate shipment of live black carp and would deny access to black carp by hybrid striped bass farms in states without hatcheries capable of rearing black carp. Given that there is only one state with hatcheries that produce black carp, the injurious species listing would restrict access to black carp to that state. Moreover, the no-snail-control scenario represents the maximum damage on farms due to the proposed regulation. Without black carp, hybrid striped bass food fish growers would save $41 per water ha; the cost incurred to stock black carp, but would also suffer a 20% reduction in marketability (Table 3). Since hybrid striped bass are sold as whole fish on ice (skin on), yellow grub parasites (visible on the fish's skin) render the fish unmarketable. Sensitivity analyses were conducted on reductions in marketability of from 5% to 30%. Growers reported average reductions in marketability of 20%, with no snail control treatment. While it is possible that marketability rates could be reduced even below the 30% selected as the endpoint for the analysis, this paper focused more attention on the relative improvements from the various snail control treatments. Thus, more emphasis was placed on the effects of marketability rate reductions below the 20% average reported by growers.

Hybrid striped bass fingerling production would probably be affected to a greater degree than would

TABLE 3.—Effects on snail populations, marketability of food fish, fingerling supplies, fingerling prices, and variable costs per hectare in hybrid striped bass production with different snail control treatments.

Effect	Treatment				
	Black carp	No treatment	Redear sunfish	Copper sulfate	Hydrated lime
Snail population (%)	0	100	60	10	40
Marketability (%)	100	80	88[a]	98[a]	92[a]
Fingerling					
Supply (%)	100	25	55	25[b]	50[b]
Price increase (%)	0	300[c]	100[c]	300[c]	100[c]
Variable costs ($/ha)	41	0	82	163[d]	169[d]
Data sources	Nature's Catch	Keo Fish Farm	Ledford (2003)	Mitchell (2002); Mitchell and Hobbs (2003)	Terhune et al. (2003)

[a] Based on the proportion of snails controlled as compared with the black carp and no-treatment options.
[b] Reduced owing to the toxicity of the chemical to small fish.
[c] Inversely proportional to the reduction in fingerling supply.
[d] Assumes two annual treatments.

food fish production (M. Freeze, personal communication). Yellow grubs can result in up to 75% mortality in hybrid striped bass fingerling ponds. Restricted supplies of hybrid striped bass fingerlings might cause food fish growers to reduce the total water area stocked either due to lack of access to fingerlings or to increased fingerling prices resulting from tightened supplies. In the first year, fingerling price would probably remain constant because of long-term contracts between hatchery and food fish producers. However, price would be expected to increase in subsequent years due to the higher mortalities and shortages of fingerlings. The increased fingerling input prices in subsequent years were assumed to increase in proportion to the inverse ratio of the reduced fingerling supply. For example, a 25% reduction in the fingerling supply would increase fingerling prices by 33% (i.e., by multiplying the base input prices by 1.33 [100% ÷ 75%]). The effects of restrictions in fingerling supplies up to a 75% reduced supply on net returns were analyzed in increments of 25%.

Snail control options.—Data on the relative efficacy of alternative treatment options have been reported in terms of the percent of snails remaining after treatment (Mitchell 2002; Ledford 2003; Mitchell and Hobbs 2003;; Terhune et al. 2003). Snail population levels used in the model were 0% for the control by black carp (Thomforde 1990), 100% for no treatment, 60% for control by redear sunfish (Ledford 2003), 10% for copper sulfate treatments (Mitchell 2002; Mitchell and Hobbs 2003), and 40% for the hydrated lime treatment (Terhune et al. 2003) (Table 3).

Stocking redear sunfish at 50 fish/ha costs $82/ha annually (Table 3). However, farms would save $41/ha from not stocking black carp. This is a conservative estimate because, in practice, these fish would not have to be replaced annually on fish farms. In the absence of farm-level data on annual mortality of redear sunfish in commercial ponds, the more conservative estimate was used. The cost of stocking black carp likewise was estimated based on the conservative estimate of annual re-stocking.

Stocking redear sunfish eliminated 40% of the snails (Ledford 2003). Effects on marketability and fingerling supply were assumed to be proportionate to the ratio of marketability under the base scenario (100% control with black carp) and that of no treatment (80% marketability). Thus, given the 20% decrease in marketability with no treatment, the 40% reduction in snails in the redear sunfish treatment would increase marketability by 8% (to 88%; Table 3). Similarly, fingerling supply would increase from 25% to 55% with the control provided by redear sunfish. These estimates are considered to be conservative because snails mature at early ages (a few months). As *r*-selected species, snails have high fertility rates (Eversole 1978) of approximately 20–40 eggs per week (van der Schalle and Berry 1973). The higher water temperatures and pH of commercial fish ponds during the growing season result in conditions shown to increase fecundity in *Planorbella* snails (Hunter 1990). Shedding rates have been measured at 330 cercaria/mL (Terhune et al. 2002). Thus, even if a few infected snails escape treatments, the likelihood of re-infecting the pond is high (Venable 1998). Moreover, the herons that serve as the other vector of infection are present on fish ponds throughout the year. There is no direct experimental evidence to quantify the relationship between snail populations and either marketability of hybrid striped bass or fingerling supply. Thus, we conducted a series of sensitivities ranging from effects

TABLE 4.—Net returns above variable costs per hectare ($) with various combinations of fingerling supply and marketability during the first year of restrictions on the use of black carp for snail control, by farm size, (no change in fingerling price is assumed).

Fingerling supply (%)	Marketability (%)	Farm size		
		Small	Medium	Large
100	100	11,065	14,648	18,543
75	95	7,209	9,897	12,818
	90	6,089	8,777	11,698
	85	4,969	7,657	10,578
	80	3,849	6,537	9,458
	75	2,729	5,417	8,338
	70	1,609	4,297	7,218
50	95	4,806	6,598	8,545
	90	4,059	5,851	7,799
	85	3,313	5,104	7,052
	80	2,566	4,358	6,305
	75	1,819	3,611	5,559
	70	1,073	2,864	4,812
25	95	2,403	3,299	4,273
	90	2,030	2,926	3,899
	85	1,656	2,552	3,526
	80	1,283	2,179	3,153
	75	910	1,806	2,779
	70	536	1,432	2,406

of food fish marketabilities from 70% to 100% and fingerling survivals from 25% to 100%.

Copper sulfate treatments cost $81.50/ha per treatment. Two annual treatments were assumed, for a cost of $163/ha per year (Table 3). However, some farms treat up to four times a year and, when problems persist, may add a whole-pond treatment (L. Dorman, Arkansas Cooperative Extension Program, personal communication). Nevertheless, this analysis used the more conservative cost of two annual applications. The copper sulfate treatment would reduce marketability of grow-out fish by only 2% (by eliminating 90% of the snails in the pond within 4 d; Mitchell 2002). However copper sulfate applied to fingerling ponds could adversely affect fingerlings and result in a potential decrease in the fingerling supply of up to 75%. Such a reduction in fingerling supply would increase fingerling prices in the long run.

The hydrated lime treatment costs $84.50/ha each, or $169/ha for the two annual applications assumed in this analysis. As with copper sulfate treatments, some farms may treat more frequently, but the more conservative rate of two annual applications was used. Hydrated lime would be expected to eliminate 60% of the snails in the pond and result in an 8% reduction in the marketability of grow-out fish and a 50% reduction in fingerling supply, increasing fingerling input prices in the long run.

Results were calculated based on net returns above variable costs. However, fixed costs must be considered in determining profits. For a farm to stay in business, returns must be high enough to cover all fixed costs (Kay and Edwards 1999). Annual fixed costs for the large (121 ha) farm size were taken from D'Abramo et al. (2002) who estimated annual fixed costs at $1,924/ha for a 121-ha hybrid striped bass farm. The Dunning (2001) estimates of $4,383/ha for annual fixed costs for a 13-ha hybrid striped bass farm were used for the smallest (8 ha) farm size in this analysis. An average of the two estimates of annual fixed costs were used for the medium farm size ($3,154/ha). These estimates of increased fixed costs reflect the economies of scale in hybrid striped bass farms reported by Wui and Engle (2004).

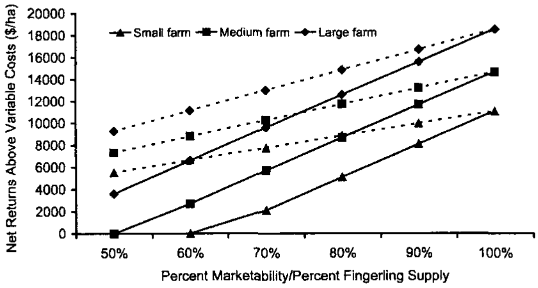

FIGURE 2.—Comparative effects of decreased marketability and fingerling supply for small (8.1 ha), medium (28.3 ha), and large (121.4 ha) hybrid striped bass farms. The solid lines represent the effects of decreased marketability with 100% fingerling supply; the dotted lines represent the effects of decreased fingerling supply with 100% marketability.

Results

Net returns above variable costs per water hectare in the base scenario were $11,065, $14,648, and $18,543 on the small, medium, and large farms, respectively (Table 4). Under the assumption that farms can sell 100% of their product, the large farms generated the greatest net returns above variable costs. Net returns above variable costs is not a true measure of profit because fixed costs that include depreciation and interest on investment have not been included. Thus "profits" in hybrid striped bass farms are lower than the net returns above variable costs in Table 4. Fixed costs present analytical difficulties in linear programming (McCarl and Spreen 1996). Since the alternative treatment costs consist primarily of variable costs, the conventional modeling form of maximizing net returns above variable costs was used in the MIP model. Fixed costs are taken into account later in the analysis.

Figure 2 compares the effects of restricted marketability and restricted fingerling supplies. Lack of access to black carp will reduce marketability of food-size hybrid striped bass because consumers will not

TABLE 5.—Net returns above variable costs per hectare ($) during subsequent years, by farm size, with various combinations of fingerling supply and marketability (assumes increased fingerling prices after the first year).

Fingerling supply (%)	Marketability (%)	Farm size		
		Small	Medium	Large
100	100	11,065	14,648	18,543
75	95	6,493	9,441	12,443
	90	5,373	8,321	11,323
	85	4,253	7,201	10,203
	80	3,133	6,081	9,083
	75	2,013	4,961	7,963
	70	893	3,841	6,843
50	95	3,374	5,687	7,796
	90	2,627	4,940	7,049
	85	1,880	4,193	6,302
	80	1,134	3,447	5,556
	75	387	2,700	4,809
	70		1,953	4,062
25	95		1,932	3,148
	90		1,559	2,775
	85		1,186	2,401
	80		812	2,028
	75		439	1,655
	70		66	1,281

TABLE 6.—Water area stocked (ha) with various combinations of reductions in fingerling supply and marketability, assuming no reduction in stocking rate.

Reduction in fingerling supply (%)	Marketability (%)	Farm size		
		Small	Medium	Large
100	100	8.1	28.3	121.4
75	95	6.1	21.2	91.1
	90	6.1	21.2	91.1
	85	6.1	21.2	91.1
	80	6.1	21.2	91.1
	75	6.1	21.2	91.1
	70	6.1	21.2	91.1
50	95	4.0	14.2	60.7
	90	4.0	14.2	60.7
	85	4.0	14.2	60.7
	80	4.0	14.2	60.7
	75	4.0	14.2	60.7
	70		14.2	60.7
25	95		7.1	30.4
	90		7.1	30.4
	85		7.1	30.4
	80		7.1	30.4
	75		7.1	30.4
	70		7.1	30.4

purchase hybrid striped bass infested with grub parasites. Each 10% decrease in the marketability of hybrid striped bass food fish decreased net returns above variable costs by $2,987/ha, irrespective of farm size, under the assumption that fingerling supplies were not affected by yellow grubs. The effects of decreased marketability impacts on net returns above variable costs were constant across farm sizes because market impacts are independent from production processes. When marketability was held constant, each 10% reduction in fingerling supply reduced net returns by $1,107 to $1,855/ha. Thus, decreased marketability resulted in larger decreases in net returns than similar percent decreases in fingerling supplies. Larger farms were affected to a greater extent by the restricted fingerling supplies than were the smaller farm sizes.

Table 4 presents results from varying combinations of decreased fingerling supplies and decreased marketability in the first year following restrictions with no change in fingerling price. Each 10% decrease in marketability decreased net returns by $2,240, $1,493, and $747/ha for the 75, 50, and 25% levels of fingerling supplies, respectively (Table 4). This was true both for the case of no change in fingerling price (first year following restrictions; Table 4) and in subsequent years with increased fingerling prices (Table 5) regardless of the change in fingerling input price. In subsequent years, net returns were reduced further ($375 to $2,403/ha lower) as the losses generated cumulative effects (Table 5). The greater the restriction in fingerling supply became, the greater the cumulative effect was. Thus, policy makers should evaluate effects of proposed restrictions on black carp over a period of several years, not just the first year of restrictions.

The effect of reduced fingerling supplies on net returns above variable costs is greater at higher marketability rates since the higher marketability is more restricted by the reduced fingerling supplies (Table 5). For example, for the medium farm, at a marketability rate of 90% and a fingerling supply of 75%, net returns above variable costs were $8,321/ha. A 25% reduction in the supply of fingerlings (to 50% fingerling supply) with 90% marketability, resulted in a decrease of $3,381/ha (to $4,940). In contrast, this same decrease in fingerling supply (from 75% to 50%) with a 70% marketability rate caused net returns above variable costs to decrease from $3,841 to $1,953, or only $1,888. Nevertheless, the combined effects of reductions in marketability and reduced fingerling supplies resulted in substantially lower levels of net returns above variable costs. On small farms, there were no net returns above variable costs with fingerling supplies at 25% of current levels and at 50% of current levels with a 70% marketability rate.

The model results showed that fewer hectares would be stocked if fingerling supplies were reduced (Table 6). With a 50% reduction in fingerling supply, the model projected that hybrid striped bass farmers would decrease surface area in production proportionately, by up to 50%. Net returns above variable costs decreased at a rate consistent with the percentage decrease in

TABLE 7.—Net returns above variable costs per hectare ($) under alternative snail control scenarios in the first year of restrictions on the use of black carp (no change in fingerling price) and in subsequent years (increased fingerling prices, by farm size). Results with black carp are shown for comparison.

Treatment	Fingerling supply (%)	Marketability (%)	Farm size		
			Small	Medium	Large
First year					
Black carp	100	100	11,065	14,648	18,543
Hydrated lime	50	92	8,547	12,130	16,026
Redear sunfish	55	88	7,311	10,895	14,790
Copper sulfate	25	98	10,176	13,759	17,655
No treatment	25	80	1,242	2,220	3,194
Subsequent years					
Black carp	100	100	11,065	14,648	18,543
Hydrated lime	50	92	2,695	9,216	13,096
Redear sunfish	55	88	2,572	8,019	11,679
Copper sulfate	25	98	322	7,842	12,607
No treatment	25	80	[a]	853	2,069

[a] Model solution not feasible because costs exceed revenues.

fingerling supply and hectareage. Sensitivity analyses showed that food fish farm net returns above variable costs would decrease by $1,094–$1,102, $1,452–$1,463, and $1,842–$1,853/ha for each 10% reduction in fingerling supply on the small, medium and large farms, respectively (assuming 100% marketability in the first year of restrictions with no changes in fingerling input price; losses would be greater with lower levels of marketability). Thus, decreased profits were due to the reduced water area in production. Net returns decreased more on the larger farms because the large farms lost more production area than did the small farms. The loss in production area was directly related to shortages in fingerling supplies. It was more profitable to stock fewer hectares at the more profitable, higher stocking rate and remove the other ponds from production.

In the years following implementation of restrictions, hatcheries would probably raise fingerling supply price to compensate for the increased fingerling mortality from yellow grubs, reducing net returns above variable costs even more. Sensitivity analyses with increased fingerling prices resulted in decreases in net returns above variable costs of $1,381–$1,389, $1,635–$1,646, and $1,992–$2,003/ha for each 10% reduction in fingerling supply (assuming 100% marketability) for the small, medium, and large farms, respectively.

The effects on net returns above variable costs of switching to alternative treatments for snail control will include various combinations of the above-described reductions in fingerling supply and marketability. Table 7 presents results showing the specific combinations of effects on fingerling supplies and marketability estimated from the literature for each treatment alternative.

Without snail control, net returns above variable costs declined by $9,823 to $15,349/ha in the first year (with no increase in fingerling price) and by $11,065 to $16,474/ha in subsequent years (with higher fingerling prices) (Table 7). Without snail control (reductions of 20% of marketability of food fish and 75% in fingerling supply), small-scale farmers would not be able to cover even their variable costs of production in the years subsequent to imposing restrictions. Compared with the black carp control method, hydrated lime treatments resulted in reduced returns of $2,518/ha in the first year of restrictions with no change in fingerling price and $8,370, $5,432, and $5,447/ha in subsequent years, for the small, medium, and large farms, respectively. Control by redear sunfish was estimated to reduce marketability by 12% and fingerling supply by 45%. These effects resulted in reducing net returns by $3,754/ha in the first year of restrictions with no change in fingerling price and $8,493, $6,629 and $6,864/ha in subsequent years for the small, medium and large farms, respectively. Copper sulfate treatments instead of black carp treatments resulted in reduced returns of $889/ha in the first year of restrictions (no change in fingerling price) and $10,743, $6,806, and $5,936/ha in subsequent years. Net returns per hectare remained constant across farm sizes in the first year following restrictions because the treatment costs per hectare are the same regardless of farm size and fingerling prices are assumed to be constant in the first year following restrictions due to long-term contracts. However, the increased fingerling prices in subsequent years due to decreased fingerling supplies have differing effects due to farm size.

Figure 3 presents net returns above total costs and shows that the most cost-effective treatment is that of black carp. In subsequent years, with increased fingerling prices, the small farms probably would be put out of business altogether without black carp (Figure 3A). Copper sulfate treatments were the best alternative to black carp in the first year of restrictions (with no change in fingerling price), but did not provide sufficient control for small farms to survive beyond one year. Medium and large farms would not be anticipated to survive without snail control (Figure 3B, 3C). Copper sulfate treatments were preferable to the other treatment alternatives in the first year of restrictions, but hydrated lime resulted in economic returns similar to copper sulfate treatments in subsequent years. The hydrated lime costs estimated in this study were based on the use of powdered hydrated lime. Slurried hydrated lime is applied at higher rates

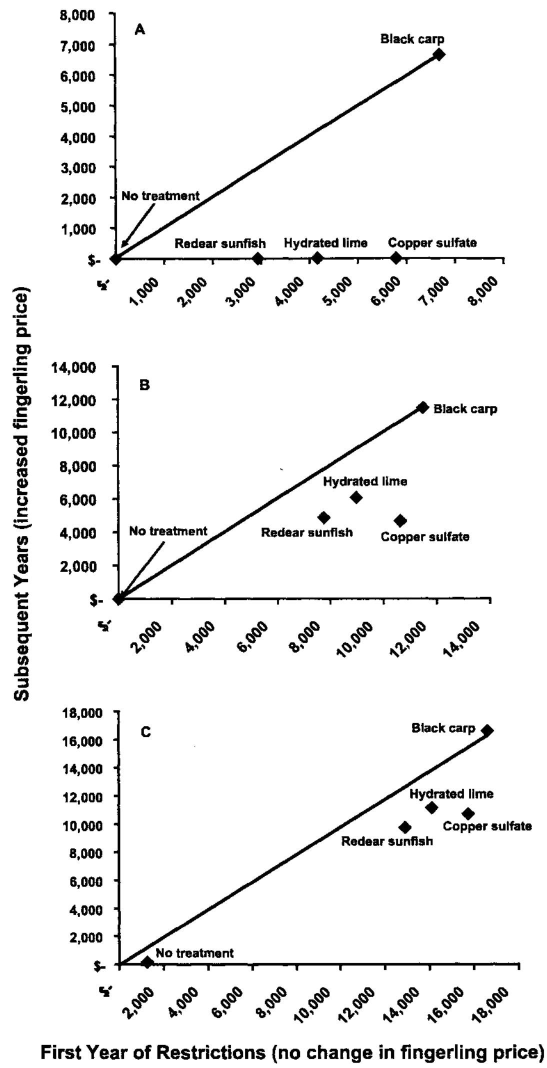

FIGURE 3.—Per-hectare net returns above total costs by snail control scenario (no treatment and treatment with redear sunfish, hydrated lime, or copper sulfate) for (A) small, (B) medium, and (C) large hybrid striped bass farms. The net returns that would occur if black carp were used for snail control are shown by way of reference.

and would be at least as expensive as copper sulfate. Moreover, high pH in ponds treated with hydrated lime may also kill or harm hybrid striped bass fry. Thus, it is possible for hydrated lime to result in economic returns less than those of copper sulfate.

Discussion

Stocking black carp for snail control is the most economically efficient treatment for control of yellow grubs in hybrid striped bass ponds. Based on our model, only medium and large farms would survive without black carp when total costs, including increased fingerling prices are considered. Losses on large farms would range from 33% to 41% and those on medium-size farms from 47% to 59%, based on adoption of one of the alternative treatment control methods considered in this analysis. Moreover, this analysis did not account for the fact that copper sulfate treatments are limited to ponds greater than 3 ha and cannot be used in waters with low alkalinity or in fingerling ponds (Mitchell 2002).

TABLE 8.—Losses in revenue (i.e., reduction in annual net returns above variable costs [million $]) owing to the elimination of black carp from hybrid striped bass farms in the USA, by alternative snail control treatment and farm size. Values are based on 2001 statistics.

Treatment	Farm size: Small	Medium	Large	Total
	First year			
No treatment	1.299	1.137	8.603	11.039
Copper sulfate	0.117	0.081	0.498	0.697
Hydrated lime	0.333	0.230	1.411	1.974
Redear sunfish	0.496	0.343	2.104	2.943
	Subsequent years			
No treatment	1.463	1.262	9.234	11.959
Copper sulfate	1.420	0.623	3.327	5.370
Hydrated lime	1.106	0.497	3.053	4.657
Redear sunfish	1.123	0.607	3.847	5.577

These cost estimates are based on the assumption that there is a direct relationship between the size of the snail population and percent marketability and fingerling mortality. Given the fertility rates of snails and the shedding rates of cercariae, it is likely that relatively small percentages of snails could quickly repopulate and reinfect ponds. This would mean that control measures that provide less than 100% control may result in greater losses than those reported in this study.

The aggregate maximum costs of no snail control on food-size hybrid striped bass farms in the USA were estimated as $11.0 million/year in the first year following restrictions (with no change in fingerling prices) and $11.96 million/year in subsequent years (with increased fingerling prices due to shortages) (Table 8). With adoption of one of the alternative control methods analyzed in this study, losses would range from $0.7 to $2.94 million/year in the first year (with no change in fingerling price) and from $4.7 to $5.6 million/year in subsequent years (with increased fingerling prices). These values are based on the 2001 value and pond water areas of 132.2, 91.5, and 560.5 ha for small, medium, and large farms, respectively. However, total economic impacts would include multiplier effects. If multipliers estimated for catfish production on the local economy are used (Kaliba and Engle 2004), the total annual economic losses would be from $28.4 to $72.9 million/year, depending on the alternative adopted. The Kaliba and Engle (2004) multipliers were developed from an IMPLAN-based analysis with primary data collected from one county. Multipliers estimated on a local scale frequently are higher than those estimated on a national basis. Using a nationally estimated multiplier for aquaculture of 3.5 (Dicks et al. 1996), economic impacts would range from $16.45 to $41.86 million/year. These estimates do not account for (1) the effects on new farms that might enter the business or (2) lost future revenue if restrictions on black carp prevent additional industry growth.

Elimination of black carp would probably force many farms out of business due to the magnitude of the economic effects. Considering that about 75% of hybrid striped bass farmers are small scale, the economic costs of eliminating black carp would be very high. Use of sterile triploid black carp could reduce environmental risks associated with the possibility of escape from ponds because sterile triploid black carp cannot reproduce. In the absence of other economically feasible alternatives for hybrid striped bass growers, the use of sterile triploid black carp would allow the hybrid striped bass industry to remain viable while minimizing risks to the environment. Comprehensive analyses of all benefits and costs associated with the public debate related to use of black carp for snail control are needed.

Acknowledgments

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During 2003 and 2004, Schramm and Basler (2005) employed AC electrofishing gear to sample selected waterways "in proximity to open-pond aquaculture facilities known or expected to use black carp" in Arkansas, Louisiana, and Mississippi. No black carp were caught. The researchers concluded that the absence of black carp in their samples "suggests black carp are absent or present in low densities" in these waterways.

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August 1, 2007

To: Office of Management and Budget

RE: RIN 1018–A670, Addition of Black Carp to the List of Injurious Wildlife

FROM: Harry V. Daniels, Ph.D., Professor of Zoology and Aquaculture Extension Specialist North Carolina State University and North Carolina Cooperative Extension Service

I appreciate the opportunity to comment on RIN 1018–A670, Addition of Black Carp to the List of Injurious Wildlife. As the Warmwater Aquaculture Specialist for the North Carolina Cooperative Extension Service, my comments will be restricted to the Hybrid Striped Bass (HSB) industry.

The HSB industry is a significant economic contributor to the North Carolina aquaculture industry, representing approximately 32% of the total revenue from food fish production. The HSB industry has struggled over the past decade with infestations of the yellow grub and with methods to control the grub's intermediate host, the Ram's Horn Snail. Triploid black carp have become a crucial tool to control the digenetic trematode and the associated diseases caused by this parasite. If the NC HSB industry could not use this means of infestation control, the financial impact would be greater than $1,000,000 annually due to the loss of fingerlings and food fish from both yellow and white grub. This level of impact represents about 14% of the current farm-gate value of the industry.

Current management practices and challenges:
Copper sulfate – Periodic high doses of copper sulfate sometimes mixed with hydrated lime can be used to kill snails along the margin of ponds. It is not yet clear whether this application is an extra-label use of copper sulfate. If it is determined that the HSB producers can no longer use copper in this manner, then this option will no longer be available as a means of controlling snails

Annual pond draining – Since the snails in the middle of the ponds are unaffected by copper sulfate treatment, draining of the ponds after harvest, and between stocking, is another effective means of drying out the pond bottoms and reducing snail populations. The Regional NC Division of Water Quality currently frowns upon this practice as it generates significant amounts of effluents. Within the next 1-2 years, it is likely that the HSB producers will no longer be allowed to annually drain their ponds, which will remove another means of controlling snails.

Triploid Black Carp - Currently, this is the most effective method option to manage snail populations. No other biological control is as effective at controlling these parasites. In the event that one or both of the above management options (copper sulfate and pond draining) are no longer available to HSB producers, the use of triploid black carp will be the only means currently available to control snails. If the use of black carp is prohibited then the producers will have no other viable means of managing snail populations and grub infestations.

Screening and monitoring system - In 2001, Mike Frinsko, a NC Cooperative Extension Service Area Aquaculture Agent (NCCES AAA), developed a strict protocol, the NC Triploid Black Carp Importation Program, for importing triploid black carp into eastern NC. Working with Kent Nelson with the NC Wildlife Resources Commission (NCWRC), Mr. Frinsko established a permitting and triploid verification process for all of the NC HSB farmers that use black carp. Using this importation procedure for triploid black carp has provided a specialized control and management process for HSB producers and the NCWRC.

Following the NC Triploid Black Carp Importation Program, Mr. Frinsko has worked with the six largest fingerling producers to purchase and import in all triploid black carp stocked in NC. Fewer than 4,100 were introduced into HSB ponds. These fish ranged in size from six to nine inches and were stocked at densities of 2 to 10 animals per acre, based on available literature, input from the NCWRC and other state agencies as well as ongoing communication from HSB farmers.

Summary - In North Carolina, an established and strict system is currently in place that would allow the rigorous screening and tracking of triploid black carp that are used for control of Ram's horn snails in HSB ponds. We feel that this system provides the oversight and control of that is required for responsible monitoring of triploid black carp use in HSB ponds.

Triploid black carp are a useful means of controlling snails. Given that the current snail control options (copper sulfate and pond draining) also face possible elimination, the removal of triploid black carp would put an end to one of the remaining practical and effective means of controlling yellow and white grubs.

If you have any questions regarding this critical issue, please contact me.

Sincerely,

Harry V. Daniels
Professor of Zoology

Over-Estimation of Risk to Environment of Triploid Black Carp

1. Calculations that show 10,000 or 20,000 lb of mussels to be eaten by a single triploid black carp cannot be justified based on realistic parameter values.

   a. This is equivalent to saying that, since one human being can live to 130 years, can eat 10 lb of food a day, every day, that, over the lifetime of a human being, that the expected food intake is 474,500 lb of food.

   b. Another equivalent example would be that, since one mussel can spawn 500,000 spat a year and can live for up to 70 years, that each mussel would contribute 35 million new mussels to the mussel population over its lifetime.

   c. The clear fallacies in the black carp example are:

      1. The maximum possible years of lifespan are assumed in the calculation instead of an average lifespan appropriate for conditions in the wild.
      2. There is no mortality rate assumed.
      3. A perfect and infinite supply of food is assumed such that an unlimited amount of food is available for each black carp that allows it to consume its maximum amount each day without expending energy and time seeking out food.
      4. The only source of food assumed for the black carp is endangered mussels. Ignored are the large quantities of zebra mussels, other mollusks, insect larvae, and other types of food that black carp are known to eat.
      5. The calculation of mollusk consumption by black carp ignores the fact that very young fish do not consume the same quantities as large fish and that sexually mature fish do not consume the same quantities of food as young, immature fish that are in a rapidly growing phase.
      6. The calculation of mollusk consumption by black carp ignores the biological fact that fish are poikilotherms (cold-blooded), and they do not eat when water temperatures are outside their optimal range. There are many days throughout the year, including the winter months, when water temperatures are sub-optimal and black carp will not eat much, if at all. Unlike other types of animals, fish do not need to eat every day.

2. Likelihood that black carp will cross paths with endangered mussel populations in the U.S. The endangered mussel populations tend to be found in more shallow waters in the upper reaches of tributaries of the Mississippi River. The habitat of black carp is in the deeper portions of larger rivers.

"Nikolsky (1948) stated that the major habitat of the black carp includes lowland rivers, river channels, and major lakes."

"Welcomme (1988) noted that the black carp is a freshwater fish that inhabits lakes and lower reaches of rivers. Major rivers within its native range are all characterized by extensive lowland floodplains in their lower reaches."

"Ding (1994) described black carp as a bottom-dwelling fish that prefers areas with slow current."

"Moteki (2002) commented that large individuals hide in deep water areas with cover (i.e., among submerged posts and stones). Sokolov (1983) also noted that black carp keep to channels and floodplain reservoirs and that they winter along the river bottom. Sokolov (2002), in apparent reference to Amur River populations, commented that black carp usually remain in more backwater areas during the summer, entering the main channel to spend the winter."

The following is taken from Nico et al. (2005) book on black carp:

"Unlike other Chinese carps, black carp are bottom dwellers, typically remaining in the middle and lower portions of the water column (IHAS 1976; Chu 1984; Chu et al. 1989), rarely coming to the surface (Wu et al. 1964b; IHAS 1976).

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COOPERATIVE EXTENSION PROGRAM

University of Arkansas at Pine Bluff

Arkansas Aquafarming

University of Arkansas at Pine Bluff, United States Department of Agriculture, and County Governments Cooperating

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Aquaculture/Fisheries Field Day to be Held October 5

The Aquaculture/Fisheries Center Field Day will be Thursday, October 5, 8:30 a.m. to noon, at the Aquaculture Research ponds at the University of Arkansas at Pine Bluff. The Field Day features tractor and walking tours, a poster display and a sponsored trap shoot. Demonstrations include the following:

- **The Seinitizer: Only You Can Prevent Disease Transmission** (techniques and equipment that can prevent the spread of disease; cheap, easy and safe disinfectants, cleaning seines)
- **Channel Catfish vs. Hybrids: A Growout Challenge** (preliminary results of ongoing growth studies comparing the channel catfish and channel catfish/blue catfish cross)
- **Why Chemical Treatments Fail: Are You Getting Dead Spots?** (efficient chemical application methods)
- **Statewide Distribution and Impact of the Catfish Trematodes** (the distribution of this parasite and its control)
- **Baitfish Certification Program** (what it is, how it works and benefits farmers)
- **Producing Hybrid Catfish Fry** (specialized techniques, equipment and the costs)
- **Judging Potassium Dose Effectiveness in Muddy Water and Thick Algae Blooms** (obtaining the correct dosage)
- **Cool Season Feeding of Catfish: Time to Change Your Oil?** (catfish nutrition with growth and changing water temperatures)
- **Handheld Computers: The Farm at Your Fingertips** (Using Personal Data Assistants to have farm info at your fingertips)
- **Electrical Safety Demonstration** (safety around power lines)
- **Understanding Electrical Costs** (reducing costs by managing electric fees)

The Field Day is cohosted by the United States Department of Agriculture-Agriculture Research Service (USDA-ARS) Aquaculture Systems Research Unit (ASRU). The fall meeting of the Catfish Farmers of Arkansas will be held at the end of the field day. To get to the Field Day, take Hwy 79 to Oliver Road (turn at the new UAPB football stadium) and follow the signs to the Agriculture Research Station. For more information, contact Nathan Stone at (870) 575-8138 or email nstone@uaex.edu.

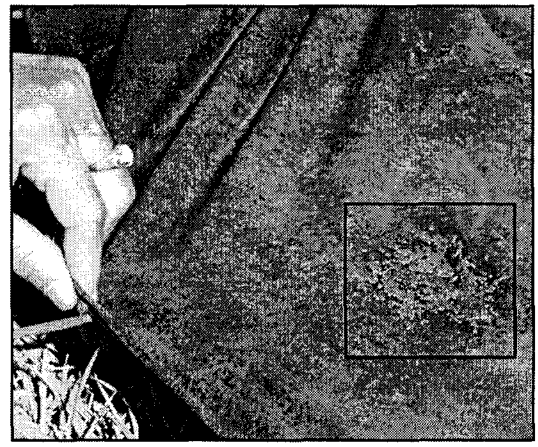
Spawning Fathead Minnows

Nathan Stone, Extension Fisheries Specialist, and Ignacio Masson, Graduate Student

Plastic irrigation tubing (*gut* pipe or poly pipe) is often used as a spawning substrate by fathead minnow producers because used pipe is available for free. However, recent research (Masson et al. 2006) has confirmed that fathead minnow eggs do not stick well to smooth surfaces. While rough or textured surfaces retained 72 to 77 % of eggs, only 41% of eggs stuck to poly pipe. Eggs that do not stick in the nest are not likely to survive. Benoit and Carlson (1977) first found that fathead minnow eggs do not adhere well to smooth surfaces when they tested a variety of substrates including cement-asbestos tile, glass, stainless steel screen, and sand-coated, shot-peened and unaltered stainless steel. This is an important consideration for fathead minnow farmers who practice fry transfer and seek to maximize the number of young minnows produced in brood ponds. For those farmers that raise minnows in spawning-rearing ponds, it's likely that there will be sufficient reproduction even when smooth substrates are used.

Rough wood and unfinished fiberglass are two substrates that appear to provide decent egg adhesion. Recent studies at UAPB have been conducted using landscape fabric as a spawning substrate. Landscape fabrics are sold as barriers to prevent the growth of terrestrial weeds and are readily available. Such fabrics typically are woven or perforated, providing a roughened surface, and are UV stabilized. Based on preliminary testing, thin fabrics are unlikely to last in ponds and are easily torn. However, the heavier fabrics have held up well.

Fathead minnows are amazingly fecund and produce lots of eggs over time. Gale and Buynak (1982) found that over the spawning season, female fathead minnows spawned an average of every 3.9 days and produced a volume of eggs that was 3.8 to 6.8 times the volume of their own body! Clemment and Stone (2004) determined that one pound of fathead minnows (4 females: 1 male) would produce an average of 2,700 eggs per day. Production ranged from 8 – 28 eggs/female/day. A review of controls for various toxicity studies found that fathead minnow egg production in aquaria typically averaged between 10 and 66 eggs/female/day (typically 20 – 30 eggs/female/day). Unfortunately, current production systems, using spawning-rearing ponds and fry transfer, do not allow us to take full advantage of all these eggs.



Fathead minnow nest on landscape fabric (outlined by a black box).

Is there potential for a hatchery system for fathead minnows, similar to what currently exists for golden shiners and goldfish? There are several obstacles, the first of which is that fathead minnow nests are spread out over substrates, so that collecting eggs requires significant labor. An efficient egg collection system is essential. We know that eggs can be removed from substrates using a 1.5% sodium sulfite solution. Eggs can be left in the sulfite solution for up to 30 minutes without apparent harm, although the solution contains no oxygen. Unfortunately loose fathead minnow eggs, even when rolled in hatchery jars, appear exceedingly susceptible to fungus. A hatching system incorporating a fungus control protocol is required. The ultimate obstacle, however, may be the cost of such a system. Currently, production of farm-raised fathead minnows has been constrained by the availability of cheap, wild-caught minnows. Furthermore, concerns over wild baitfish as potential carriers of exotic diseases or aquatic nuisance species will lead to new restrictions on harvesting minnows from the wild and could provide increased opportunities for producers of farm-raised fathead minnows.

For additional information, see:

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Costs of Trematode Treatments

Carole Engle, Professor, Department Head, and Larry Dorman, Extension Fisheries Specialist

The catfish trematode (*Bolbophorus*) has become widespread in the catfish industry. Recent research has shown that even low numbers of catfish trematodes have a significant effect on catfish and may be a common reason for poor feeding and growth (Hanson and Wise, 2005). This parasite has a complex life cycle involving white pelicans, fish, and rams-horn snails. Pelicans often visit ponds at night. They often leave before dawn so their stopovers may go unnoticed. You are at high risk for trematode problems if pelicans visit your ponds, and if rams-horn snails are also present. If trematode infection occurs, you have four options: (1) do nothing, (2) stock triploid black carp, (3) treat with copper sulfate, or (4) treat with hydrated lime. This article reviews costs associated with each of these options.

Option 1: Do Nothing

When the trematode was first found in catfish ponds, attention focused on the extent of mortalities. A recent study has showed decreased yields in ponds with even light infestations of trematodes (Hanson and Wise 2005). The decrease in yields resulted from decreased consumption of feed by fish infected with trematodes. There were 40 ponds sampled in the study. Of these, 17 had no trematodes, 7 had light infestations, 5 moderate, and 11 had severe infestations. The study showed that feed consumption averaged 72 lb/acre/day in ponds not infected with trematodes. Ponds with light infestations consumed 62 lb/acre/day of feed and those with moderate and severe infestations 47 lb/acre/day. On average, feed consumption decreased by 10-25 lb/acre/day in ponds infected with trematodes. If fish are converting feed at 2.5:1 this decrease in feed consumption results in a loss of 4-10 lb/acre/day of production. Hanson and Wise (2005) estimated that light infestations of trematodes result in an 81% decrease in profits (net returns). Losses occur with moderate or severe infestations. The decrease in net returns was $950/acre and $1,073/acre for the moderate and severe infestations, respectively.

Option 2: Stock Black Carp

Black carp (*Mylopharyngodon piceus*) belong to a group of fish commonly called Chinese carp. Black carp have a strong appetite for snails, and have been used worldwide to control snails that serve as intermediate hosts for a variety of parasites. They are also effective at controlling the rams-horn snail that hosts the catfish trematode.

There has been controversy in recent years regarding the culture of Chinese carps. There is common agreement that black carp and other non-native species must not become established in the wild. In Arkansas, only sterile (triploid) black carp are available and legal for use. Prices of fingerling triploid black carp are approximately as follows: $1.50 each for 4-inch fish, $2.50 each for 6-inch fish, and $3.50 each for 10-inch fish. At the recommended stocking rate of 10/acre, it would cost about $250 to stock one 10-acre pond with 6-inch triploid black carp. Additional black carp must be stocked about every 3 years. Thus, the annual cost of the use of triploid black carp would be about $83/year for one 10-acre pond, or $8.30/acre/year.

Option 3: Treat with Copper Sulfate

Copper sulfate has also been recommended to kill the snails that host the trematode. The most common treatment recommended is to apply copper sulfate along the shoreline. For very heavy infestations, it is necessary to treat the entire pond. Typically this is recommended only if the shoreline treatments have not provided adequate control. Table 1 shows the costs associated with one shoreline treatment for one 10-acre pond, for three applications throughout the year, and for one additional whole-pond treatment.

The cost of a single shoreline treatment of copper sulfate on one 10-acre pond at 2005 prices is $250. This is not a task for unskilled workers. It takes two men about 2 hours to treat the pond. At $20/hr for each worker, that comes to $80 for the job. The tractor cost adds another $40, at $20/hr. Thus the total operating costs are $370 for one treatment of a 10-acre pond. The amortized fixed cost of the spray rig needed for the shoreline treatment is $450. Thus the total cost of one shoreline treatment one a 10-acre pond is $820. Three treatments per year would cost $1,560. Whole-pond treatments would cost $770/year more, for a total annual cost of $2,330/year for the 10-acre pond, or $233/acre/year.

The price of copper sulfate doubled in 2006. On the typical 10-acre pond costs increased to $1,070 for a shoreline treatment, $2,310 for three applications a year, and $3,580/year or $358/acre/year if a whole-pond treatment is needed in addition to the three shoreline treatments.

continued on page 4

Continued from page 3

Option 4: Treat with Hydrated Lime

Table 1 presents the costs of a single shoreline treatment and three treatments per year. The hydrated lime costs $380 and the labor, tractor, and spray rig costs are the same as those for copper sulfate treatments. The total cost of one shoreline treatment is $950 for the 10-acre pond and $1,950 for three applications per year ($195/acre/year).

Limitations: Copper Sulfate and Hydrated Lime

There are limitations to the use of both copper sulfate and hydrated lime. Both are toxic to fish in waters with low alkalinity. It is imperative to check alkalinity prior to treating with either chemical to ensure that it is safe. One farm lost 4,000 lb of broodstock following an application of copper sulfate because they did not first check the alkalinity.

Chemical treatments, especially the shoreline treatments, do not provide 100% control. Some ponds are re-infested quickly by snails not killed by the shoreline treatment or by snails that migrate in from elsewhere. It only takes a few snails and a few visits from pelicans to re-infect a pond. If chemical treatments are used ponds must be treated multiple times.

Stocking triploid black carp is the most cost-effective way to prevent decreased yields that can result from trematode infestations. It takes more time at harvest to manually remove the carp, but black carp provide long-term control at a modest cost. In the event of severe infestations of trematodes, it may be necessary to first treat with chemicals and then stock black carp for longer-term control.

Triploid black carp are an approved aquaculture species in Arkansas, but farms must first establish necessary precautions to prevent escape of the fish to the wild, and obtain a special permit from the Arkansas Game and Fish Commission. Screening both ends of pond drains is recommended, using a mesh size smaller than the smallest black carp. The discovery of black carp, even triploid fish, in natural waters may result in increased regulation, and perhaps prohibition of black carp for any purpose, effectively crippling the catfish industry with trematode infestations.

Hanson, T.R. and D.J. Wise. 2005. Economic analysis projects 10% loss to *Bolbophorus* trematodes in U.S. catfish industry. Global Aquaculture Advocate, December: 64-65.

Table 1. Costs of Treating Ponds with Copper Sulfate and Hydrated Lime (at 2005 prices)

Item	Copper sulfate					Hydrated lime		
	One time	Three applications	Whole pond	Yearly	Costs/acre/ year[d]	One time	Three applications	Costs/acre/ year
Chemical	$250	$750	$500	$1,250		$380	$1,140	
Labor[a]	$80	$240	$120	$360		$80	$240	
Tractor[b]	$40	$120	0	$120		$40	$120	
Boat	0	0	$150	$150		0	0	
Total variable costs	$370	$1,110	$770	$1,880		$500	$1,500	
Fixed costs[c]	$450	$450	0	$450		$450	$450	
TOTAL COST	$820	$1,560	$770	$2,330	$156	$950	$1,950	$195

[a]2 men for 2 hours at $20/hour. [b]2 hours at $20/hour. [c]Annual fixed cost of spray rig. [d]For 3 shoreline applications a year.

Table 2. Summary of Costs of Options for Treating Trematode Infestations

	Costs	
Option	10-acre pond per year	Per acre per year
Do nothing	$3,630 - $10,732	$363- $1,073
Stock black carp	$83	$8.30
Treat with copper sulfate[a]		
2005 prices	$1,560	$156
2006 prices	$2,310	$231
Treat with hydrated lime	$1,950	$195

[a]3 shoreline applications per year

Who is Watching Out for Your Aquaculture Business?

Andy Goodwin, Assistant Director, and Carole Engle, Director, UAPB Aquaculture/Fisheries Center

In the last five years, the aquaculture industry has been faced with one regulatory challenge after another. These have included the EPA and effluent regulations, the U.S. Fish and Wildlife Service and Asian carps, the USDA National Animal Identification System, the OIE guidelines for the shipping and slaughter of aquatic animals, APHIS efforts to control Spring Viremia of Carp Virus, and the new national Aquatic Animal Health Plan. In addition, well-organized environmental and animal rights groups have targeted aquaculture and have managed to impact public opinion. While these groups have primarily focused on Atlantic salmon, the scare tactics used are causing consumers to fear many aquaculture products. At the state and international levels, trade protectionism is a major force influencing exotic species and fish health regulations, and can severely limit your ability to ship fish. All of these initiatives have the potential to put significant new regulatory and financial burdens on fish farmers. Fortunately, there is a way to protect your business.

Federal agencies are legally bound to listen to their stakeholders and to address their concerns. New regulations must be scientifically justified and their economic impact weighed against their potential benefit. Thus, when agencies begin the planning for new regulations, they must include representatives of stakeholder groups in the process. For the aquaculture industry, the stakeholder groups involved are the National Aquaculture Association (NAA), species-specific national groups like the Catfish Farmers of America (CFA), the US Shellfish Association, the National Ornamental Goldfish Association, and the U.S. Trout Growers Association, and state and regional associations like the Arkansas Bait and Ornamental Fish Grower's Association (ABOFGA) and the Catfish Farmers of Arkansas (CFAR). By having a seat at the table, these organizations have a major influence on federal regulations and are able to insist that proposed regulations are rational, scientific, and not financially burdensome. They serve as the counterbalance to the influence of other groups also invited to the table – groups that would not be upset if commercial aquaculture ceased to exist. You probably owe the very existence of your business to the successful efforts of these industry associations.

The power and influence of aquaculture trade associations is directly related to the size of their membership. The bigger the association, the more stakeholders it represents and the more influence it has to negotiate. Equally important, larger numbers of dues-paying members are needed to support lobbying efforts and travel costs for representatives that must attend national meetings. To protect your industry and your business it is vital to join these organizations, pay your dues, and to participate in their efforts to respond to regulatory initiatives. As a baitfish or goldfish producer in Arkansas, you should belong to both the ABOFGA and the NAA. As a catfish farmer, the CFAR and CFA are most critical, but the NAA is also very important. Farmers producing other aquaculture products should belong to the NAA and a national species-specific association. Contact information for membership to these organizations is below. Join and make sure that your voice is heard, and respected during the next regulatory initiative.

Catfish Farmers of Arkansas
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Arkansas Bait and Ornamental
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Upcoming Events

Aquatic Sciences Day
Fifth annual event promoting aquaculture and fisheries. High schools: please send students!
9:00 to noon, Thursday, September 21, 2006. Aquaculture and Fisheries Center, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas. Cassandra Hawkins-Byrd (870) 575-8123

Aquaculture/Fisheries Field Day
Semi-annual event for commercial fish farmers. Keep up to date on Arkansas aquaculture.
8:30 to noon, Thursday, October 5, 2006. Aquaculture and Fisheries Center, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas. Nathan Stone (870) 575-8138

Florida Aquaculture Association
Annual fall conference.
November 17-18, 2006. Hillsborough Community College, Brandon Campus (near Tampa), Florida. (863) 293-5710

U.S. Freshwater Prawn and Shrimp Growers Association
Annual meeting.
December 8-9, 2006, Radisson Hotel Opryland, Nashville, Tennessee. Dolores Fratesi (662) 390-3528

American Heartland Aquaculture Conference
Regional trade show and conference. January 19-20, 2007. Jointly sponsored by Illinois, Indiana, Kentucky, and Missouri aquaculture associations. Rend Lake Resort, Whittington, Illinois. Bart Hawcroft (573) 526-6666

Arkansas Aquaculture 2007
Annual educational meeting
January 25-27, 2007. Sponsored by the Catfish Farmers of Arkansas. Embassy Suites Hotel, Hot Springs, Arkansas. Bo Collins (870) 672-1716 or (479) 437-3081

Arkansas Bait and Ornamental Fish Producers
Annual educational meetings. February 8, 2007. Sponsored by Arkansas Bait and Ornamental Fish Growers Association. Lonoke Community Center, Lonoke, Arkansas. Hugh Thomforde (501) 676-3124

Fish Farming Trade Show and Catfish Farmers of America
Annual convention and trade show. February 15-17, 2007. First time joint event. Perdido Beach Resort, Orange Beach, Alabama. Sponsored by Catfish Farmers of Arkansas, Catfish Farmers of Mississippi, Alabama Catfish Producers and Louisiana Catfish Farmers Association. Mike McCall (601) 206-1600

Aquaculture America 2007
February 26-March 2, 2007. San Antonio, Texas. Early registration ends January 5, 2006. Sponsored by the U.S. Aquaculture Society and the National Aquaculture Association. (760) 751-5005

Farm Pond Website

Wes Neal, Assistant Professor, Small Impoundments

It takes careful planning and wise management to maintain high-quality fishing in a pond year after year. For about two years, the Cooperative Extension Program at UAPB has maintained a website that provides easy access to pond management expertise for anyone who has access to the internet. At this website you can find information on all aspects of pond management including construction, permits, stocking, management, species selection, fish identification, habitat, and vegetation control. You can also download publications and management resources and find information on fish suppliers near you. New information is added frequently. Recent additions include a farm pond management calendar, a guide to water analysis, and an online survey.

To access the website, follow the links on www.uaex.edu/aqfi or go directly to www.uaex.edu/wneal/pond_management. Then, use the menus to navigate to topics of interest. If you cannot find answers using the standard menu links, check the link entitled *Specific Topics* for additional links. If you still cannot find the information you need, send us an e-mail. Contact information is located at the bottom of the site's homepage. You will receive a quick response to your question, and the site will be updated for future users with similar questions.

Preparing for Electric Power Outages

Steeve Pomerleau, Extension Aquaculture Specialist

Adequate maintenance of electric boxes and aeration units can minimize the risk of power disruption caused by fire ant damage or faulty electric wiring. Although power outages are often outside farmers' control, there are things fish farmers can do to assist their electricity provider to restore service promptly following a power outage.

Verify and update the service location and contact information of your electric accounts. Electrical service on fish farms is often supplied through several different accounts, each supplying a different part of the farm. Each account should have a detailed description of the meter location. The service location is normally printed on the electric bill. Accounts providing power to fish ponds or hatcheries should have a service location such as *Fish Ponds* or *Fish Hatchery* followed by a description of the access roads. Here is an example: *Catfish Ponds 22-23-24-25, Hwy 7, two miles south of Hwy 9, Lake Village, AR 71653*. Such detailed information will help the power company locate the meter and restore service promptly. Verify the service location on your bills and contact the customer service department to offer more details.

It's wise to verify the contact name and phone number in the electric company files. Insist that they keep your account records up to date. You may need to report a power outage by that name and number, or the electric company may try to call you for additional information following the report of a power outage.

Keep a list of all your accounts in your vehicles. Farm managers, night employees on catfish farms, and other key individuals should keep a list of all the electrical account numbers, account names, service locations, and location numbers, along with the emergency phone number to report outages. Keep a laminated sheet with this information in all farm vehicles. With easy and fast access to the information, farmers can rapidly report power outages through the automated company phone system rather than through a representative. Precious time is lost searching for your account information on their computer.

Most information can be found on your electric bills. Note the location number. It may not be printed on the bills. The ten digit location number (*Map Location Number* or *Distribution Location Number*) may be found on a braded or white tab at the meter base or on the pole close to the meter. The location number helps service personnel locate the electric meter with GPS (Global Positioning System).

Report outages through the automated outage phone system. The fastest and easiest way to report a power outage and get it restored is to call the outage number and to use the automated phone system. The automated phone system will answer and give you instructions for reporting your outage. In most cases, you will be asked to dial or speak the account number. It is important to report *all* accounts that are out of service. As soon as the system registers your account numbers, central computers process the information, target the source of the outage, and automatically alert the closest repair technicians.

Reporting power outages through any other means often slows the whole service restoration process. Reporting a power outage by calling the local customer service office or the local repair technician at his house to explain everything does not speed up the process. Restoration will only begin after the account numbers are received by the computerized central processing unit.

Make a separate call for each account out of service (Customers of Entergy Arkansas). Depending on the source of the power outage, you may have more than one account on your farm out of service. Customers of Entergy Arkansas must make separate calls to the outage hotline for each account out of service. If you have ten accounts out of service, call 1-800-9OUTAGE ten times, entering each time a different account number. This allows Entergy's computers to pinpoint the source of the power outage and direct repair technicians to the critical locations.

Complete the *Critical Account Identification Process* form (Customers of Entergy Arkansas). Entergy Arkansas understands the severe implications of power outages on fish farms. They have developed a process to earmark commercial aquaculture accounts, and give them priority in service restoration. To identify critical fish farm accounts, fish farmers must complete the *Critical Account Identification Process* form. The form is available from the Catfish Farmers of Arkansas or UAPB fish disease diagnostic labs.

Column 1: Enter the name of the account as it appears on your bill.

Column 2: Enter the account number as it appears on your bill.

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COOPERATIVE EXTENSION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
UNIVERSITY OF ARKANSAS
P.O. BOX 391
LITTLE ROCK, ARKANSAS 72203

OFFICIAL BUSINESS

NON-PROFIT ORGANIZATION
US POSTAGE PAID
LITTLE ROCK, AR 72203
PERMIT NO. 502

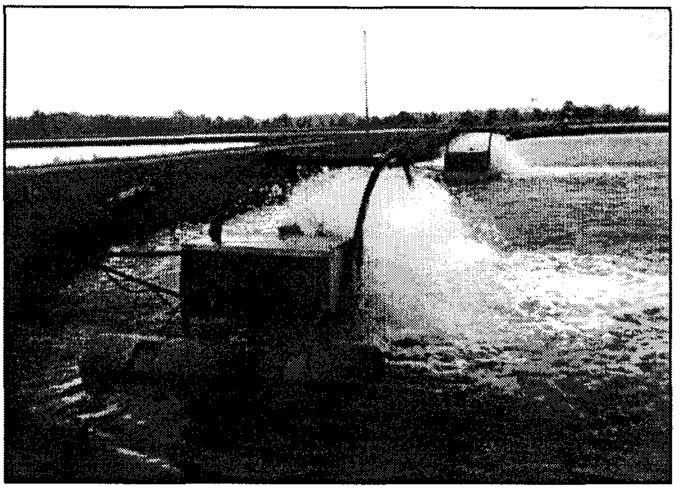
Continued from page 7

Column 3: Enter the service location of the meter as it appears on your bill. The location of the meter should be as precise as possible to help Entergy personnel locate the meter in case of emergency.

Column 4: Enter the distribution location number. This is a ten digit number on a yellow or white tag on the pole close to the meter. This number helps Entergy personnel locate the meter with GPS (Global Positioning System).

Mail the completed form to Entergy Arkansas at the address specified. Keep copies of the completed form in the vehicles of farm managers and night employees.

Thanks to Entergy Arkansas and Craighead Electric Cooperative for comments and suggestions.



Every catfish farm depends on electricity.

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The purpose is to advance aquaculture production in Arkansas by providing reliable, practical, timely information.

Comparison of our Cost Estimates with those in the Draft Economic Analysis Conducted by the U.S. Fish and Wildlife Service

	Our 2007 Annual Cost Estimates[a]		U.S. Fish & Wildlife Service Estimates[b]	
	Farm-gate sales	Total economic losses	Farm-gate sales	Total economic losses
Catfish	$45,400,000[c]	$281,500,000	$49,000	$0
Hybrid striped bass	$11,959,000	$50,650,000[d]	$0	$0
Largemouth bass	$2,800,000	$17,100,000	$0	$0
Baitfish	$2,500,000	$15,200,000	$0	$0
TOTAL	$62,659,000	$364,450,000	$49,000	$0

[a]These estimates do not include effects on new farms that might enter the business or lost future revenue if restrictions on black carp prevent additional industry growth.

[b]Draft Economic Analysis stated that 3 to 6% of revenue will be lost, on average on baitfish and hybrid striped bass farms. This would result in $1,797,975 annual losses on baitfish farms and $1,351,395 in annual losses on hybrid striped bass farms. These were not included in their tables of estimates of economic losses, in spite of discussing this in the text.

[c]These estimates are based on only the main catfish-producing region and do not take into account the rapid spread of the trematode and future infections.

[d]Range of $28,400,000 to $72,900,000 per year, depending on the alternative adopted.

Under-estimation of Costs of Listing all Black Carp as Injurious

1. The assumption to not include costs associated with Arkansas, Mississippi, and Missouri are not correct.

   a. Arkansas: a very high percentage (likely >90%) of the catfish produced in Arkansas are transported live across the Mississippi River into Mississippi for processing because there is no major processing plant in Arkansas. If one triploid black carp were to be included in a load of 40,000 lb of catfish (they are all killed by electrocution upon arrival at the plant), that producer could be prosecuted under the Lacey Act, if all black carp were to be listed.
   b. Mississippi: one farmer has a few (5-6 diploid black carp). However, this farmer has never spawned black carp, nor has he made triploid black carp. Black carp are difficult to spawn and Mississippi continues to depend entirely on Arkansas for its supply of triploid black carp.
   c. Missouri: Missouri farmers were required to give up all diploid black carp. There currently are no diploid black carp in Missouri. All triploid black carp in Missouri are bought from Arkansas each year.

2. Following statement from the U.S. Fish & Wildlife Service draft economic analysis for black carp is incorrect: "Arkansas – Requires a permit for the use of triploid black carp for aquaculture use and a permit for diploid black carp as a broodstock for production of triploids. As of 2001, there were about 11 black carp permits." This is incorrect because triploid black carp are an approved aquaculture species and no special permit is required. There are far more than 11 farms with black carp in Arkansas, and the number is growing. There is a waiting list for black carp to be stocked in catfish ponds in Arkansas.
3. The cost estimates do not include the losses of farms that have already gone out of business due to trematode infestations. Much of the lost acreage in Louisiana was due to trematodes, on farms that did not have access to black carp.
4. The estimates of losses do not account for the rapidly expanding range of the trematodes.
5. The multiplier effects of industry losses have not been accounted for. These are real losses to the communities that depend on aquaculture industries. Most of these are in rural areas.
6. The economic analysis ignores information submitted previously during comment periods on the economic effects on the hybrid striped bass industry of listing all black carp as injurious.
7. The average price used to estimate catfish losses was an unusually low price. The 10-year average price of catfish is $0.70/lb. The U.S. Fish & Wildlife Service used $0.57/lb, dramatically underestimating the value of losses that would be incurred over time.

Incidence of the catfish trematode (*Bulbophorus sp.)* in Arkansas

The University of Arkansas at Pine Bluff conducted a statewide survey of trematode incidence and prevalence during the summer of 2006 and we are in the process of repeating that survey in 2007. In 2006, 346 ponds on 54 farms were sampled. This included 34 ponds on 6 farms in Northeast Arkansas, 15 ponds on 5 farms in Southwest Arkansas, and 276 ponds on 46 farms in Southeast Arkansas. Results of the survey revealed that the trematode was present in 67 of the 346 ponds sampled, or approximately 19.4 percent of the surveyed ponds statewide. Within the critical Southeastern region of Arkansas, the location of most of the State's production, 50% of the farms surveyed had trematode problems.

The infestation of the trematode causes the catfish to stop or reduce feeding and this harms farm profitability. Fish do not reach a size suitable for the processing plants in a timely manner. Studies by Mississippi State University personnel (David Wise) revealed that even a light infestation rate of the catfish trematode reduces catfish feed intake by 16 percent. Heavy infestations were reported to reduce catfish feeding rates by 82 percent.

Chemical treatments include copper sulfate and hydrate lime. Copper sulfate is very expensive and, in low alkalinity water, very toxic to fish. Hydrated lime is caustic to fish and humans and triggers ammonia toxicity in fish. Both chemical treatments may be useful in acute outbreaks, but neither has more than a temporary effect and to control the parasite they must be used repeatedly over the growing season. Black carp are the only effective and economical treatment for trematodes.

A major Arkansas catfish farm using copper sulfate treatments prior to our 2006 survey had trematodes in 7 of 12 ponds. They were rated as "heavy" in 3 of those ponds (keeping in mind that even mild infections have serious economic impacts). That farm stocked black carp after the 2006 survey. The same 12 ponds were sampled during the same period in 2007. After just one year, incidence dropped to 3 of 12 ponds with the infestations in all three positive ponds rated as "light". The farm manager reports greatly increased feed consumption and fish growth in the 2007 season.

Economic Analysis Pr… To *Bolbophorus* Tr… In U.S. Channel Catfish Indu…

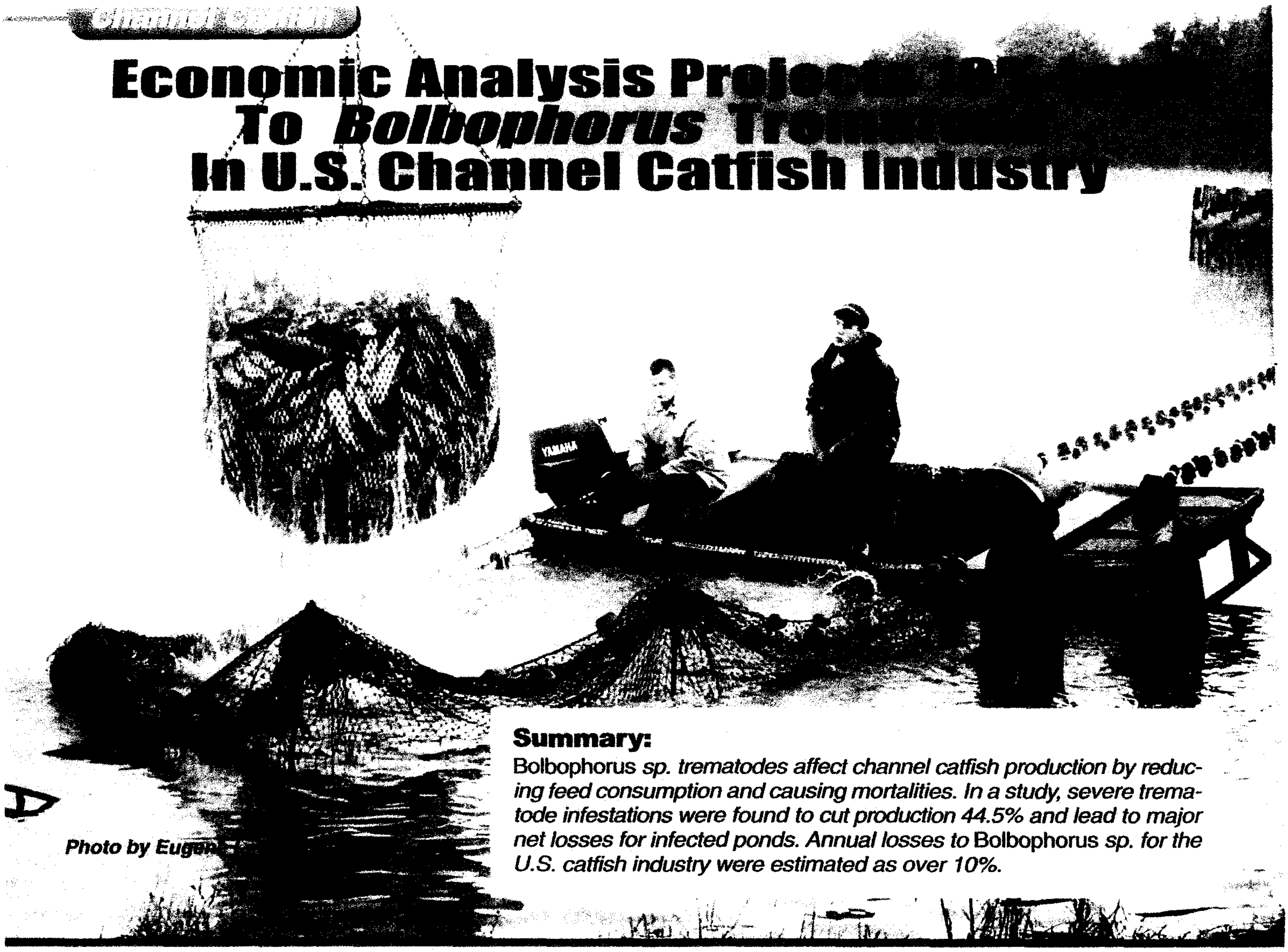

Photo by Eu…

Summary:

Bolbophorus *sp. trematodes affect channel catfish production by reducing feed consumption and causing mortalities. In a study, severe trematode infestations were found to cut production 44.5% and lead to major net losses for infected ponds. Annual losses to* Bolbophorus *sp. for the U.S. catfish industry were estimated as over 10%.*

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The trematode identified as *Bolbophorus* sp. can cause significant production losses in commercially raised channel catfish. The encysted trematode, which appears as small bumps under the skin, has been associated with high mortality rates, decreased feed consumption, and poor production efficiency.

To assess its economic impact, a disease-monitoring and production efficiency study was conducted by the authors at a commercial catfish operation with reported trematode infestations in the United States.

Farm Study

The farm contained approximately 183 ha in 40 ponds for food fish production. Prior to sampling, only a limited number of ponds were identified by the producers as having problems associated with trematode infections.

About 20-30 fish/pond were examined for the presence of nodules containing the encysted trematode. Ponds with infected catfish were placed into categories of light, moderate, or severe infection when the percentage of trematode-infected fish in the samples ranged 1-33%, 34-66%, or 67-100%, respectively. Ponds that did not contain trematode-infected fish were categorized as negative.

Infection Levels

Of the 40 ponds sampled, 17 were categorized as negative, seven as light, five as moderate, and 11 as severe. Fish from the trematode-positive ponds consumed significantly less feed compared to fish from the trematode-negative ponds. Trematode-negative fish consumed on average 82.2 kg/ha/day, and those from ponds categorized as light, moderate, and severe consumed 69.7, 53.2, and 52.9 kg/ha/day, respectively.

Similarly, production decreased as the severity of infection increased. Compared to the negative ponds, those in the light, moderate, and severe categories produced 13.8, 36.0, and 40.5% less fish weight per hectare, respectively.

Enterprise Budget

The level of catfish produced and quantity of feed fed were put into a generalized enterprise budget format (Table 1). The catfish production was estimated based on the amount of feed applied, assuming a 2.25:1 feed-conversion ratio. Estimated revenue was based on a selling price of U.S. $1.54/kg. Variable and fixed costs of production were estimated from previous work by the first author to develop enterprise budgets for catfish farms in Mississippi.

Representing 50% of the total variable cost, feed was the major cost factor that varied in each category. All other costs were applied equally to each category. Net returns to land were calculated by subtracting the total of variable plus fixed costs from the revenue. While errors in these estimations are likely, this analysis is a conservative estimate, since the actual costs and feed conversions would likely be higher for populations of fish infested with trematodes.

Production was naturally greatest in the ponds found negative for the trematode infection. In this model, the negative ponds produced 6,759 kg/ha, resulting in fish sales of U.S. $10,408/ha and net returns of $1,123/ha.

Table 1. Net returns (U.S. $) to catfish operations with trematode infestations.

Value	Negative	Degree of Trematode Infestation: Light	Moderate	Severe
Number of ponds	17	7	5	11
Pond area (ha)	74	30	24	55
Revenue				
Fish produced (kg/ha)	6,759	5,824	4,323	4,019
Selling price/kg	$1.54	$1.54	$1.54	$1.54
Fish sales/ha	$10,408	$8,969	$6,658	$6,189
Variable Costs				
Feed fed (mt/ha)	15.21	13.10	9.73	9.04
Feed price/mt	$253	$253	$253	$253
Feed cost/ha	$3,847	$3,315	$2,461	$2,288
Trematode treatment/ha	$355	$356	$365	$378
Other variable costs/ha*	$3,847	$3,847	$3,847	$3,847
Total variable costs	$8,050	$7,518	$6,673	$6,513
Income Above Variable Costs/ha	**$2,359**	**$1,451**	**-$16**	**-$324**
Fixed Costs/ha	**$1,236**	**$1,236**	**$1,236**	**$1,236**
Net Return/ha	**$1,123**	**$215**	**-$1,251**	**-$1,560**

* Other variable costs are estimated as 50% of the total variable costs of the negative ponds.

Compared to the trematode-negative ponds, those in the light, moderate, and severe categories produced 13.8, 36.0, and 40.5% less fish weight per area, respectively. Net returns for ponds in the light category were reduced by 80.8%, and production from ponds in the moderate and severe categories did not cover the costs of production. Severly infected ponds produced a net loss of $1,560/ha.

Industry Effect

The industrywide effect of trematode infestations on producers' net returns was estimated using results from Terhune, Wise, and Khoo (2002) research combined with data from this study. Pond acreage data for the concentrated U.S. catfish industry region came from United States Department of Agriculture National Agricultural Statistics Service reports.

Terhune et al. found that 262 ponds (32%) of the 821 ponds surveyed on 32 farms contained fish positive for trematode infection. The 32% figure was applied to the catfish growing acreage as a measure of the industry-wide infestation. This prevalence rate was differentiated into light (28%), moderate (22%), and severe (50%) categories based on the prevalence and severity data collected from the farm study described above.

Under these assumptions, the loss from *Bolbophorus* trematodes to producers in the main U.S. catfish-producing region was estimated as U.S. $45.4 million annually. With 2004 catfish farm sales at $450 million, this represents a loss of over 10%.

Monitoring Required

While heavy infestations are usually recognized, low-grade and even moderate trematode infections can remain undetected for years, slowly decreasing production and profitability. In some ways, low-grade infections represent a greater risk to production in the long run because they usually do not cause obvious production problems.

On any given day, feeding activity may appear normal, and low-level infestations may not cause unusually high death rates. Close attention to year-end feed and production records should be made to identify poor-producing ponds. At the very least, ponds with lower feed and production rates should be intensively sampled to rule out trematodes as a cause for poor production.

Note: The cited reference is available from the first author.