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Catfish 2010

Part III: Changes in Catfish Health and Production Practices in the United States, 2002–09

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Items of Note

In general, it appeared that two factors might have had an overarching influence on many of the differences between Catfish 2003 and Catfish 2010, and these two factors are likely related to each other. The first factor is changes in the demographics of catfish operations; the total number of catfish operations decreased from 1,161 on January 1, 2003, to 994 on January 1, 2010 (source: NASS Catfish Production reports). Additionally, the water surface acres used for production decreased from 187,200 for the period January 1 through June 30, 2003, to 115,100 for the same 6-month time frame in 2010. Based on these numbers, the calculated average surface acres per operation decreased from 161.2 acres in 2003 to 115.8 acres in 2010, which might indicate that a number of smaller operations joined the industry, a number of larger operations left the industry, and/or some operations decreased in size. The second factor that appears to have had a global effect on production practices is the business climate for the catfish industry, including the weak economy, which has made it more difficult for producers to obtain credit, and increased competition from foreign producers. Data suggest that some producers made changes in production practices to save costs for their operations, while other producers chose or were forced to to leave the industry.

Catfish Production Phases

From Catfish 2003 to Catfish 2010, the percentage of operations in production declined for three of the four production phases (p 7). The percentages of operations that bred catfish, operated a hatchery, or raised fry to fingerlings declined, while the percentage of operations that grew out foodsize fish did not change. For Catfish 2010, less than 13 percent of operations bred catfish, operated a hatchery, or raised fry to fingerlings, while more than 94 percent of operations grew out foodsize fish.

Breeding

As noted, the percentage of operations that bred catfish declined, from 14.2 percent of operations for Catfish 2003 to 8.8 percent of operations for Catfish 2010 (p 10). Part of this decline might result from a change in the definition of a breeding operation; for Catfish 2003, a breeding operation was one that bred catfish for egg production, whereas for Catfish 2010, a breeding operation was one that bred catfish for egg collection. Some operations that bred catfish but did not collect the eggs might not have been counted as breeding operations for Catfish 2010. The percentages of operations with broodfish lines of blue catfish and pond-run catfish increased between studies, while the percentages of operations with most other broodfish lines decreased. The increase in blue catfish is likely related to increased production of channel x blue hybrid catfish (p 11). Other trends for breeding operations include the following.

- The percentage of operations that stocked broodfish at a density of 1,200 lb/acre or higher increased from 26.9 percent to 35.1 percent, and the percentage of broodfish stocked at this rate increased from 41.6 percent to 67.0 percent. Maximum recommended broodfish stocking densities are about 1,200 lb/acre; the large percentage of fish stocked at this density or higher might be related to the increase in fighting.

Hatchery

As noted, the percentage of operations that operated a hatchery declined between studies. From Catfish 2003 to Catfish 2010, the percentage of operations that had more than 75 percent of eggs survive until hatching declined from 76.0 percent of operations for Catfish 2003 to 55.2 percent for Catfish 2010. Accordingly, the percentage of operations that had less than 75 percent of eggs survive until hatching increased from 24.0 percent to 44.8 percent, and, while no Catfish 2003 operations lost more than 50 percent of eggs, 10.3 percent of Catfish 2010 operations lost more than 50 percent of eggs. The decrease in the percentage of eggs surviving until hatching might reflect increased production of channel x blue hybrids or changes in management factors, such as reduced treatment of eggs for fungal or bacterial diseases (p 28) and reduced turning of egg masses (page 34).

Fry/Fingerling

As noted, the percentage of operations that raised fry to fingerlings declined by more than half, from 29.9 percent of operations for Catfish 2003 to 12.8 percent for Catfish 2010. Trend data suggest that smaller operations stopped raising fry/fingerlings or expanded their operations to achieve economies of scale. Between studies, the average number of fry/fingerling ponds on operations increased (from 10.3 to 15.6), the average pond size increased (from 7.6 to 8.7 surface acres), and the average total surface acres increased (from 77.0 to 136.5). Additionally, the percentage of operations with 1 to 2 ponds decreased from 28.2 percent of operations to 21.1 percent of operations, while the percentage of operations with 11 or more fry/fingerling ponds increased from 23.3 percent 34.7 percent of operations. Other trends for fry/fingerling operations include the following.

- The percentage of ponds with a stocking rate of 200,000 or more fry per acre increased from 12.7 percent of ponds for Catfish 2003 to 27.5 percent of ponds for Catfish 2010 (p 60).

- Overall, the protein level of floating feed primarily fed to fry decreased between studies. The percentage of operations primarily providing feed with 35 percent protein declined, while the percentage of operations primarily feeding 28 or 32 percent protein increased (p 65).

- The percentage of operations vaccinating any fry against ESC declined between the two studies, from 11.4 percent of operations to 3.9 percent (p 71).

- The percentage of operations feeding medicated feed to fry/fingerlings was similar for the two studies, but there was a shift in the medicated feed used. Aquaflor®, which was not yet on the market during the Catfish 2003 study, was used by a higher percentage of Catfish 2010 operations than Terramycin® or Romet® (p 80).

- The percentage of operations that had a snail problem in any fry/fingerling ponds in the year prior to the study increased from about 11.6 percent of operations to 23.1 percent. The percentage of operations using any measures to control snails decreased from 26.8 percent to 19.2 percent (p 82).

Foodsize Fish

The percentage of operations that had some channel x blue hybrid catfish present on January 1 of the study year increased from 2.1 percent of operations for Catfish 2003 to 21.2 percent for Catfish 2010. Unspecified channel catfish remained the line with the highest percentage of foodsize fish present, however, increasing from 64.4 percent of foodsize fish for Catfish 2003 to 85.8 percent for Catfish 2010.

- The percentage of operations that purchased fry for stocking from another source decreased from 17.5 to 9.6 percent, while the operation average percentage of fish stocked that were fry purchased from another source also decreased, from 15.2 percent of fish stocked to 7.4 percent. These data agree with a trend toward stocking larger fish; for Catfish 2010, the highest operation average percentage of fish stocked in growout ponds was fish more than 8 inches long (56.6 percent), compared with fish 6 to 8 inches long for Catfish 2003 (63.7 percent) (p 88).

- For growout ponds for foodsize fish, the number of ponds, total surface acres, or average size of ponds did not change substantially between studies (page 68).

- Catfish 2010 operations waited longer between pond drainings or renovations, which might be a cost-savings measure. The operation average number of years between pond draining increased from 9.1 to 11.7 years between studies, and the operation average number of years between complete renovations increased from 11.0 to 14.0 years (p 102).

- The percentage of foodsize-fish operations using automated sensors to monitor dissolved oxygen increased from 17.2 percent for Catfish 2003 to 40.9 percent for Catfish 2010, while the percentage of operations using handheld monitors decreased, from 75.1 to 48.9 percent (p 103).

- Changes occurred in several aspects of feeding practices. The average tons of feed fed to foodsize fish per operation per acre increased from 4.3 to 5.5 between studies, and the predominant feed changed from 32 to 28 percent protein. Additionally, the percentage of operations feeding an average of zero days per week during winter increased from 30.1 percent of operations for Catfish 2003 to 56.8 percent of operations for Catfish 2010. This change might be related to cost savings; recent research has indicated that feeding fish during the winter can help fish maintain condition and body weight (p 123).

- The percentage of operations that lost any foodsize fish to bacterial diseases declined from Catfish 2003 to Catfish 2010 (p 129).

- The percentage of operations that fed medicated feed to foodsize fish decreased between studies (from 11.0 to 8.2 percent), but the operation average tons of medicated feed fed increased, with those Catfish 2010 operations that fed medicated feed feeding an average of 22.3 tons of Aquaflor® (p 137).

- The percentage of operations that experienced harvest delays because of off-flavor problems increased from 69.6 percent for Catfish 2003 to 80.7 percent for Catfish 2010. Although the overall percentage of ponds that experienced delays was similar for the two studies, the percentage of ponds with 20 to 49 surface acres that experienced delays increased between studies (p 144).

Acknowledgments

This report was a cooperative effort between two U.S. Department of Agriculture (USDA) agencies: the National Agricultural Statistics Service (NASS) and the Animal and Plant Health Inspection Service (APHIS).

Thanks to the NASS enumerators who contacted catfish producers and collected the data. Their hard work and dedication were invaluable. Thanks also to the personnel at the USDA–APHIS–Veterinary Services' Centers for Epidemiology and Animal Health for their efforts in generating and distributing this report.

All participants are to be commended, particularly the producers whose voluntary efforts made the Catfish 2010 study possible.

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Introduction

Through its periodic national studies of animal health and management practices in the food-animal industries, the U.S. Department of Agriculture's (USDA) National Animal Health Monitoring System (NAHMS) is able to describe changes in animal health and management over time. With both current and trend information, stakeholders can identify opportunities for improving health and management practices, reevaluate priorities for research and special studies, and detect emerging problems.

Catfish 2010 is NAHMS' third study of health and production management practices on U.S. catfish operations. The previous studies were Catfish '97 and Catfish 2003. NAHMS, a nonregulatory program of the USDA Animal and Plant Health Inspection Service (APHIS), is designed to help meet the Nation's animal-health information needs.

This report is the third in a series from Catfish 2010 and focuses primarily on the changes in practices over time, specifically comparing results from Catfish 2003 with those from Catfish 2010 (results from Catfish '97 have not been used in comparisons because of differences in coverage, question wording, and structure). Sections I and II of this report provide national estimates of animal health and management practices from the two studies and describe changes in the U.S. catfish industry from 2003 to 2010.
Section III shows demographic changes of the U.S. catfish industry from data provided by the National Agricultural Statistics Service (NASS) and the Census of Agriculture.

For both Catfish 2003 and Catfish 2010, representatives from NASS and APHIS Veterinary Services queried catfish producers in four participating States: Alabama, Arkansas, Louisiana, and Mississippi. In January 2003 and 2010, NASS enumerators administered a questionnaire—either by phone or through a personal visit—to all known catfish producers in the four participating States. Data presented in Catfish 2003 and Catfish 2010 publications are based on data collected from these producers during this one collection period.

The major publications from Catfish 2010 are described below:

- Part I: Reference of Catfish Health and Production Practices in the United States, 2009—focuses on aspects of disease and production of catfish fingerlings;
- Part II: Health and Production Practices for Foodsize Catfish in the United States, 2009—focuses on aspects of disease and production of foodsize fish;
- Part III: Changes in Catfish Health and Production Practices in the United States, 2002–09—trends.

The methodology used in Catfish 2010 is documented in the last section of each report.

Many factors could influence changes in estimates from Catfish 2003 to Catfish 2010. Differences could reflect true changes in the health and management practices of operations, as well as changes in the composition of the target population, revisions of wording on questionnaires (usually done only to resolve a problem with a question or to update material), and/or random variation. Differences in the composition of the target population and in questionnaire wording are documented in each summary table to aid in interpretation.

Further information on NAHMS studies and copies of reports are available at http://www.aphis.usda.gov/nahms

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Study Objectives and Related Outputs

1. Investigate foodsize-fish production practices
   - Part II: Health and Production Practices for Foodsize Catfish in the United States, 2009, July 2011
   - Part III: Changes in Catfish Health and Production Practices in the United States, 2002–09, December 2011

2. Describe fingerling production practices
   - Part I: Reference of Catfish Health and Production Practices in the United States, 2009, December 2010
   - Part III: Changes in Catfish Health and Production Practices in the United States, 2002–09, December 2011

3. Address a broad range of fish health issues
   - Part I: Reference of Catfish Health and Production Practices in the United States, 2009, December 2010
   - Part III: Changes in Catfish Health and Production Practices in the United States, 2002–09, December 2011

4. Quantify the magnitude of the problem of off-flavor
   - Info sheet, August 2011

Terms Used in This Report

Agitator: A vertical paddle that spins to aerate water in a small area (1/10 horsepower electric motor with a blade attached).

Air stones: Porous stones attached to an air source to create air bubbles.

Algal toxins: Algae-produced chemicals that can kill fish.

Alkalinity: The quality in water that neutralizes acids, especially calcium sulfate or bicarbonate, measured in mg/L $CaCO_3$, and usually expressed as ppm.

Bacterial infection: Sometimes called bacterial egg rot. It often occurs when egg masses contain large numbers of infertile eggs or when egg hatching baskets are crowded, reducing water circulation. The condition is often recognized when egg masses begin to fall apart prematurely, before embryos develop eye spots. Infected egg masses also will feel slimy, which occurs when bacteria destroy the egg shell. If the problem progresses, prematurely hatched embryos without eye spots often will be found on the trough bottom.

Breeding operation: For 2003 study, an operation that bred catfish for egg production. For 2010 study, an operation that bred catfish for egg collection in 2009. The definition was made more specific for Catfish 2010 to exclude those operations that might have allowed natural breeding in ponds but did not pursue active management of breeding for production goals (such as some fee-fishing operations).

Broodfish: Adult catfish (male and female) intended for use in spawning.

Channel x blue hybrid catfish: First-generation offspring from an artificial mating of a female channel catfish and a male blue catfish.

Degassing: The process of removing excess gas (particularly nitrogen) from water.

Egg mass: Eggs from a single female catfish, naturally held together by a gelatinous substance. Egg masses are sometimes referred to as spawns.

ESC: Enteric septicemia of catfish, an economically important bacterial disease of catfish; also known as hole-in-head disease.

Fingerling: This study defined fingerling fish according to the National Agricultural Statistics Service’s weight-based size category of 2 to 60 pounds per 1,000 fish. Typically, fish considered to be fingerlings and falling into this weight-based category would be about 1 to 8 inches long.

Foodsize fish: Fish of marketable size, generally more than 10 inches long and up to 3 pounds in weight.

Fry: Newly hatched fish less than 1 inch long.

Fungal infection: Fungus growth on infertile or dead eggs that occurs when water temperature is below 78°F. Appears as a white or brown cottonlike growth.

Growout: The process of raising fingerlings to harvest size (generally 1.3 to 3.0 pounds).

Growout pond: Typically, pond in which fingerlings are stocked and allowed to grow until they attain harvest size.

Hardness: The quality in water that is imparted by the presence of dissolved chemical compounds, especially of calcium or magnesium, often expressed as ppm.

Hatchery: Portion of operation devoted to hatching of eggs and the initial rearing of fry.

Ich (pronounced “ick”): Also known as white spot disease, ich is caused by a protozoan parasite, *Ichthyophthirius multifiliis*. Ich typically occurs in freshwater fish and is characterized by white nodules on the skin that can rupture, releasing thousands of new infective parasitic forms. Many affected fish die. Ich can also infest the gills.

Krill: Species of small marine shrimp commonly dried and sold as fish food.

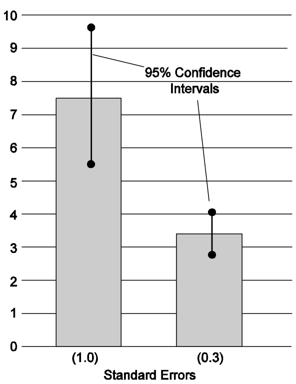
Multibatch (or multiple batch) production: A production method in which ponds are incompletely harvested and then restocked with fingerlings. This method is considered to be continuous production (compare with single-batch production).

Operation average: The average value for all operations. The value reported for each operation is summed for all operations reporting; the sum is then divided by the number of operations reporting. For example, operation average number of fry hatched (shown on p 44) is calculated by summing the reported average number of fry hatched over all operations divided by the number of operations.

Paddles: Attached to a horizontal rotating bar over hatching troughs; promote water movement over eggs to simulate the natural fanning action of a male catfish’s tail.

Pond-run channel catfish: Fish originating from foodsize-fish production ponds that lack the documented history of genetic improvement that is usually associated with identifiable broodfish lines. (Some hatcheries might perform some type of mass selection, such as retaining the largest fingerlings, or fingerlings from the earliest spawn, to use as broodfish. Such fish might be called “unselected commercial lines.”)

Examples of a 95% Confidence Interval



Population estimates: Estimates in this report are provided with a measure of precision called the **standard error** (abbreviated within as Std. Error). A 95-percent confidence interval can be created with bounds equal to the estimate plus or minus two standard errors. If the only error is sampling error, the confidence intervals created in this manner will contain the true population mean 95 out of 100 times. In the example to the left, an estimate of 7.5 with a standard error of 1.0 results in limits of 5.5 to 9.5 (two times the standard error above and below the estimate). The second estimate of 3.4 shows a standard error of 0.3 and results in limits of 2.8 and 4.0. Alternatively, the 90-percent confidence interval would be created by multiplying the standard error by 1.65 instead of 2. Most estimates in this report are rounded to the nearest tenth. If rounded to 0, the standard error was reported (0.0). If there were no reports of the event, no standard error was reported (—).

Raceway: A fish culture unit with a continuous flow of water.

Regions:
- **East:** Alabama and eastern Mississippi.
- **West:** Arkansas, Louisiana, and the delta of Mississippi.

Renovation: The draining and drying of ponds, followed by collection and use of accumulated sediments from the pond bottom for rebuilding of levees.

Sac fry: Newly hatched fry that still have an external yolk sac evident.

Sample profile: Information that describes characteristics of the sites from which data were collected for Catfish 2003 and for Catfish 2010.

Single-batch production: A production method in which all fish are stocked in a pond at a single time and the pond is not restocked until all fish have been harvested (compare with multibatch production).

Size of operation: Operation size is based on inventory on January 1, 2003, for Catfish 2003 and on January 1, 2010, for Catfish 2010.

	Size of Operation	
Production Phase	**Small**	**Large**
Breeding operations	2,000 or fewer broodfish	More than 2,000 broodfish
Hatchery operations	1,000 or fewer egg masses	More than 1,000 egg masses
Fingerling operations	1 million or fewer fry stocked	More than 1 million fry stocked
Acres for foodsize fish	Defined in tables.	

Spawns: See egg masses.

Stocker: A small to medium-sized fish. One thousand stockers typically weigh 61 to 750 pounds. This definition follows weight-based size categories the National Agricultural Statistics Service uses in its inventory surveys.

Swim-up fry: Newly hatched fry that seek food by swimming to the water surface, typically 3 to 4 days after hatching.

Trough: Generally a flat-bottom wooden, fiberglass, or metal structure about 8 feet long, 2 feet wide, and 20 inches deep, with a water inlet at one end and drain at the other.

Understock: The practice of stocking smaller fish (fingerlings or stockers) in ponds that have existing inventories of foodsize fish from previous stockings (carryover).

Vaccination: Two vaccines are in use in the catfish industry: one for ESC and one for columnaris. Fry are vaccinated by being immersed briefly in a bath containing the vaccine.

Section I: Population Estimates, Fry and Fingerling Catfish

Note: This report compares results from Catfish 2003 study with those from Catfish 2010 study. In some cases, questions asked about practices or occurrences during the calendar year preceding the study (i.e., 2002 for Catfish 2003 and 2009 for Catfish 2010), while other questions asked about usual or ongoing practices or occurrences without a specific time frame (i.e., what the producer typically does). This report has maintained these distinctions in narratives and tables in the interest of accuracy and proper representation of the producers' responses.

A. General Operation Trends

1. Changes in operation demographics

From Catfish 2003 to Catfish 2010, some major changes occurred in the demographics of catfish operations. For all States, the number of catfish operations decreased from 1,161 on January 1, 2003, to 994 on January 1, 2010 (see Appendix II). Additionally, the water surface acres used for production decreased from 187,200 for the period January 1 through June 30, 2003, to 115,100 for the same 6-month time frame in 2010. The number of operations in each State is no longer published by NASS on an annual basis, but all four study States experienced substantial declines in the number of water surface acres used for production (see Appendix II, table D).

2. Distribution of catfish production phases

Almost all catfish operations grew out foodsize fish, and the percentage of operations that raised foodsize fish was similar for the Catfish 2003 and 2010 studies. The percentages of operations participating in the other three production phases declined, however, with the percentage of operations that raised fry to fingerlings declining by more than half. For both studies, a higher percentage of operations raised fry to fingerlings than either bred catfish or operated a hatchery. Some operations that bred catfish did not operate a hatchery; these operations might have allowed eggs to hatch in breeding ponds.

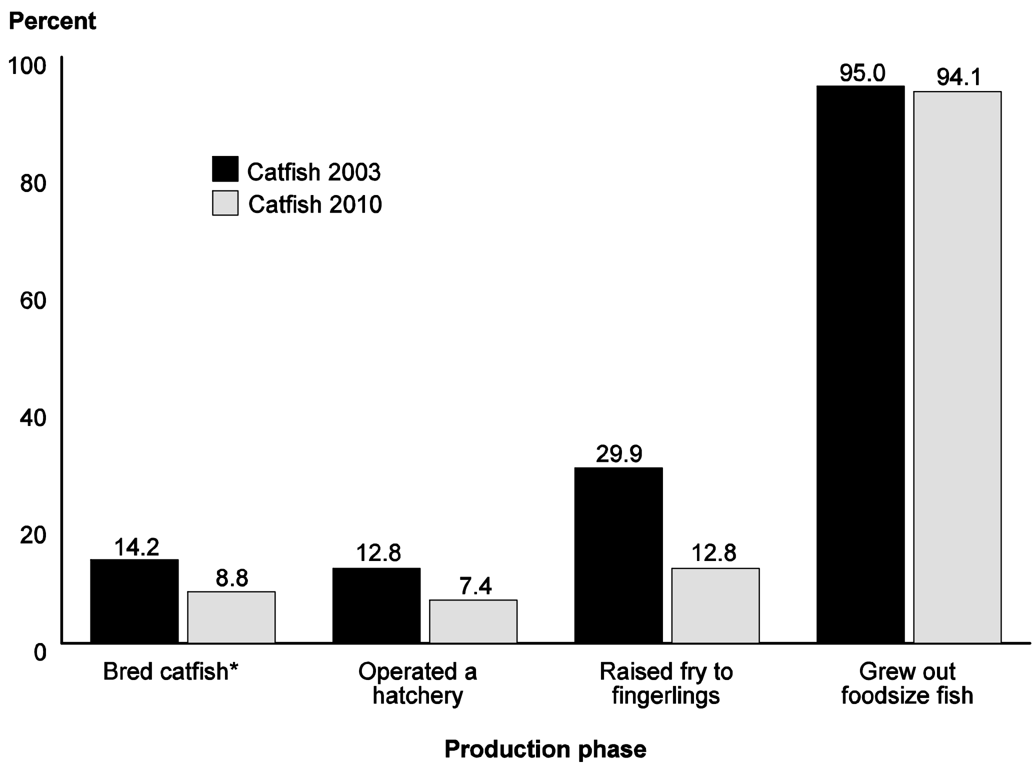
The decline in the percentage of operations that bred catfish might in part be due to a change between studies in the definition of a breeding operation. For Catfish 2003, a breeding operation was one that bred catfish for egg production, whereas for Catfish 2010, a breeding operation was one that bred catfish for egg collection. Some operations that bred catfish but did not collect the eggs might not have been counted as breeding operations for Catfish 2010.

Percentage of all catfish operations by production phase:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Production Phase	Percent	Std. Error	Percent	Std. Error
Bred catfish*	14.2	(0.7)	8.8	(0.4)
Operated a hatchery	12.8	(0.7)	7.4	(0.4)
Raised fry to fingerlings	29.9	(0.9)	12.8	(0.5)
Grew out foodsize fish	95.0	(0.4)	94.1	(0.3)

*The definition of a breeding operation differed slightly between the two studies:
Catfish 2003: bred catfish for egg production.
Catfish 2010: bred catfish for egg collection in 2009.

Percentage of all catfish operations by production phase



*The definition of a breeding operation differed slightly between the two studies:
Catfish 2003: bred catfish for egg production.
Catfish 2010: bred catfish for egg collection in 2009.

B. Broodfish Management

1. Broodfish lines

The percentage of operations raising blue catfish increased from 9.2 percent in 2003 to 19.4 percent in 2010, which suggests a shift toward production of channel x blue hybrid catfish. The percentage of operations maintaining broodfish lines of pond-run catfish almost doubled from 2003 to 2010 (from 34.8 to 69.4 percent). The percentages of operations with NWAC103, Goldkist, and other channel catfish lines declined from 2003 to 2010.

a. Percentage of breeding operations that had the following broodfish lines on January 1 of the study year:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Line	**Percent**	**Std. Error**	**Percent**	**Std. Error**
NWAC103	23.7	(2.6)	2.8	(0.0)
Kansas	5.8	(1.2)	2.8	(0.4)
Goldkist*	27.5	(2.7)	11.1	(0.5)
Norris	0.0	(—)		
Auburn			5.6	(0.1)
Blue catfish	9.2	(1.5)	19.4	(0.5)
Other channel catfish line	32.8	(2.6)	13.9	(0.5)
Pond-run channel catfish**	34.8	(2.8)	69.4	(0.6)

*Catfish 2010 included Harvest Select catfish with Goldkist catfish.
**Defined in study questionnaires as “fish selected from foodsize-fish production ponds.”

b. Percentage of broodfish by broodfish line present on January 1 of the study year:

	Percent Broodfish			
	Catfish 2003		Catfish 2010	
Line	**Percent**	**Std. Error**	**Percent**	**Std. Error**
NWAC103	14.0	(2.3)	0.4	(0.0)
Kansas	5.8	(1.7)	1.5	(0.2)
Goldkist*	18.6	(2.7)	4.7	(0.4)
Norris	0.0	(—)		
Auburn			0.2	(0.0)
Blue catfish	4.0	(1.7)	3.6	(0.2)
Other channel catfish line	24.2	(4.1)	7.3	(0.5)
Pond-run channel catfish**	33.4	(4.1)	82.3	(1.0)
Total	100.0		100.0	

*Catfish 2010 included Harvest Select catfish with Goldkist catfish.
**Defined in study questionnaires as “fish selected from foodsize-fish production ponds.”

2. Broodfish by age

For breeding operations, channel catfish 3 to 6 years old are likely better broodfish because they are more productive and easier to handle. Although channel catfish can breed at 2 years of age, they breed more reliably at 3 years or older. Once they have reached age 7, however, they might produce fewer eggs per pound of fish, be more difficult to handle, and have difficulty using spawning containers.

Data from Catfish 2010 indicate that producers might be keeping broodfish longer than they did in 2003. Although the percentage of 3- to 4-year-old broodfish declined from 57.8 percent in 2003 to 39.4 percent in 2010, the percentage of 5- to 6-year-old broodfish increased from 21.1 percent in 2003 to 46.9 percent in 2010, with the majority of those being in the 5-year-old category.

Percentage of broodfish by age on January 1 of the study year:

	Percent Broodfish			
	Catfish 2003		Catfish 2010	
Age (years)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 3	17.8	(3.6)	11.1	(0.5)
3 to 4	57.8	(4.9)	39.4	(1.1)
5 to 6	21.1	(2.9)		
5			41.7	(1.2)
6			5.2	(0.3)
More than 6	3.3	(0.8)	2.6	(0.1)
Total	100.0		100.0	

3. Annual cycle rate (cull rate) of broodfish

For both studies, in the year preceding the study (2002 or 2009), catfish producers annually culled about 15 percent of their broodfish.

a. Percentage of broodfish inventory culled during the year preceding the study:

Percent Broodfish			
Catfish 2003		Catfish 2010	
Percent	**Std. Error**	**Percent**	**Std. Error**
16.3	(3.4)	14.4	(0.9)

In each study, more than half of breeding operations did not cull any broodfish in the year before the study. About one-fifth of operations culled 1.0 to 10.9 percent of broodfish. The increase in the percentage of operations culling 11.0 to 20.9 percent of broodfish (from 3.5 to 13.5 percent) and the decrease in operations culling 21.0 percent of broodfish or more (from 19.1 to 10.8 percent) is consistent with culling about one-sixth of broodfish each year and maintaining a population of broodfish with a higher percentage of older fish.

b. Percentage of breeding operations by percentage of broodfish culled during the year preceding the study year:

	Percent Breeding Operations			
	Catfish 2003		**Catfish 2010**	
Percent Broodfish Culled	**Percent**	**Std. Error**	**Percent**	**Std. Error**
0.0	54.5	(3.0)	54.1	(0.7)
1.0 to 10.9	22.9	(2.3)	21.6	(0.7)
11.0 to 20.9	3.5	(0.8)	13.5	(0.5)
21.0 or more	19.1	(2.6)	10.8	(0.4)
Total	100.0		100.0	

4. Reasons for culling

For Catfish 2003, more than half of broodfish culled were culled for “other” reasons, which might have reflected a downsizing of inventory by some producers. For Catfish 2010, “other” was not provided as an answer option and “business or financial” and “poor appearance” were added as options; only about one-fourth of broodfish (25.8 percent) were culled for these two reasons.

The apparent decrease in percentage of broodfish culled for business or financial reasons might indicate that Catfish 2010 producers were maintaining broodfish populations appropriate for the business climate or that they'd trimmed the broodfish population to the minimum needed. (Also, the overall decrease in percentage of operations that bred catfish [table I.A.a] might represent reductions in broodfish for other reasons.) The decrease from Catfish 2003 to Catfish 2010 in percentage of broodfish culled because of weight or poor health and the increase in percentage of broodfish culled for old age might reflect improved production conditions and better overall health of broodfish.

Percentage of broodfish culled for the following reasons in the year preceding the study:

	Percent Broodfish Culled			
	Catfish 2003		Catfish 2010	
Reason for Culling	Percent	Std. Error	Percent	Std. Error
Old age	22.6	(6.3)	69.8	(2.5)
Weight	7.9	(2.6)	0.1	(0.0)
Poor health	4.1	(1.4)	0.1	(0.0)
Poor reproductive success	15.1	(7.2)	4.2	(0.3)
Business or financial			2.5	(0.2)
Poor appearance			23.3	(2.2)
Other	50.3	(11.7)		
Total	100.0		100.0	

5. Broodfish loss

For both studies, producers reported that about 15 percent of broodfish (14.5 percent for Catfish 2003 and 17.0 percent for Catfish 2010) were lost in the year prior to the study to disease, predation, or other problems. Combined with the culling rate for broodfish (table B.4.a), it appears that about one-third of broodfish inventory is culled or lost each year.

a. Percentage of broodfish lost to disease, predation, or other problems in the year prior to the study:

Percent Broodfish			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
14.5	(2.8)	17.0	(0.5)

For both studies, producers were asked to estimate the percentage of total broodfish loss attributed to each of the following listed reasons of loss. Fighting increased as a cause of broodfish loss from Catfish 2003 to Catfish 2010, with the percentage of operations affected increasing from 26.4 to 34.6 percent and the percentage of total loss increasing from 11.1 to 48.8 percent. The cause of the highest percentage of broodfish loss for Catfish 2003—visceral toxicosis of catfish (VTC), a disease of catfish first identified in 1998—affected a similar percentage of operations for Catfish 2010 but caused lower percentages of broodfish loss (from 37.8 percent of total broodfish loss to 2.5 percent). For Catfish 2003, when VTC had only recently been identified, there were reports of severe losses of broodfish to VTC when it occurred on operations. Predation affected a similar percentage of operations for both studies but affected a higher percentage of broodfish for Catfish 2010 than for Catfish 2003. Winter kill declined as a cause of broodfish loss, affecting a lower percentage of operations and lower percentages of broodfish.

b. For the listed reasons for loss of broodfish in the year prior to the study, percentage of breeding operations that lost broodfish, percentage of broodfish lost, and percentage of total loss:

	Percent											
	Catfish 2003						Catfish 2010					
	Operations		Broodfish		Total Loss		Operations		Broodfish		Total Loss	
Reason for Loss	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Enteric septicemia of catfish	9.1	(1.4)	0.2	(0.0)	1.4	(0.3)	11.5	(0.7)	0.2	(0.0)	0.9	(0.1)
Columnaris	9.0	(1.8)	0.6	(0.2)	4.2	(1.4)	11.5	(0.7)	0.2	(0.0)	1.4	(0.2)
Proliferative gill disease	0.0	(—)	0.0	(—)	0.0	(—)	0.0	(—)	0.0	(0.0)	0.0	(—)
Anemia*	0.0	(—)	0.0	(—)	0.0	(—)						
Winter kill	8.6	(1.7)	0.4	(0.1)	2.6	(0.7)	3.8	(0.1)	0.1	(0.0)	0.5	(0.0)
Visceral toxicosis of catfish	4.9	(1.3)	5.5	(2.1)	37.8	(10.1)	3.8	(0.1)	0.4	(0.0)	2.5	(0.1)
Fighting	26.4	(2.5)	1.6	(0.5)	11.1	(3.6)	34.6	(0.9)	8.3	(0.6)	48.8	(3.0)
Predation	14.8	(1.7)	0.1	(0.0)	0.5	(0.1)	15.4	(0.7)	1.8	(0.2)	10.9	(1.1)
Other	10.5	(2.0)	3.6	(1.2)	25.1	(0.7)	15.4	(0.5)	3.2	(0.2)	18.9	(1.5)
Unknown causes	19.6	(2.5)	2.5	(1.1)	17.3	(0.7)	23.1	(0.7)	2.8	(0.2)	16.1	(1.5)
Total	NA		14.5	(2.8)	100.0		NA		17.0	(0.5)	100.0	

*Anemia was not listed as an answer option for causes of loss of broodfish in Cafish 2010 because there were no reports of anemia in Catfish 2003.

6. Seasonal feeding practices

The frequency with which breeding operations fed broodfish varied seasonally. The percentage of operations that fed broodfish every day during spring and early summer increased from Catfish 2003 to Catfish 2010, from 23.5 percent of operations to 35.2 percent of operations. A concomitant decrease occurred in the percentage of operations feeding every third day, which declined from 33.1 to 18.9 percent. The percentages of operations feeding every other day or every third day during the winter increased slightly from Catfish 2003 to Catfish 2010.

Percentage of breeding operations by typical seasonal feeding frequency for broodfish:

	Percent Breeding Operations											
	Catfish 2003						Catfish 2010					
	Spring/Early Summer		Midsummer/ Fall		Winter		Spring/Early Summer		Midsummer/ Fall		Winter	
Feeding Frequency	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
Daily	23.5	(2.3)	28.9	(2.6)	4.3	(0.8)	35.2	(0.5)	29.8	(0.5)	2.7	(0.0)
Every other day	35.7	(2.8)	28.9	(2.6)	3.4	(0.8)	35.1	(0.7)	32.4	(0.7)	8.1	(0.4)
Every third day	33.1	(2.7)	29.7	(2.7)	5.6	(1.1)	18.9	(0.6)	27.0	(0.6)	10.8	(0.1)
Less often than every third day	6.2	(1.4)	8.5	(1.6)	44.7	(2.9)	5.4	(0.1)	8.1	(0.5)	43.3	(0.7)
Other	1.5	(1.0)	4.0	(1.3)	42.0	(2.9)	5.4	(0.1)	2.7	(0.0)	35.1	(0.7)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

7. Protein level of feed

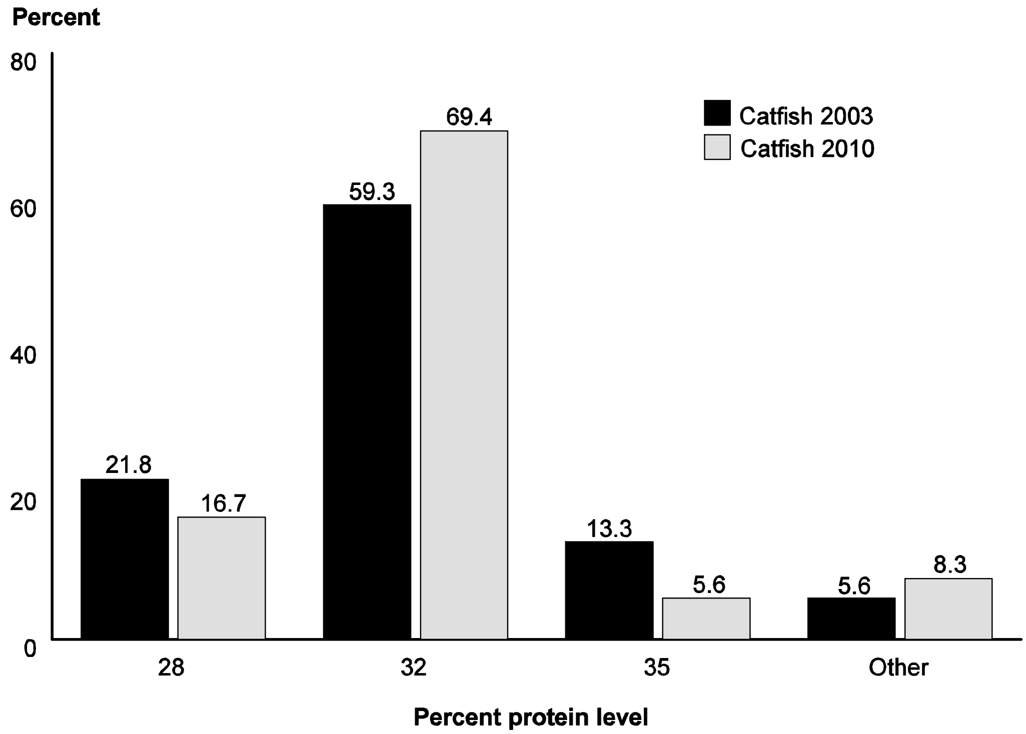
From Catfish 2003 to Catfish 2010, the percentage of operations feeding 32-percent-protein feed to broodfish increased by about 10 percent, whereas the percentage of operations feeding broodfish feed that was 35 percent protein decreased from 13.3 to 5.6 percent. Although inadequate protein in the diet can result in poor egg quality and quantity, some research suggests that feeds containing 28- to 30-percent protein might be a reasonable choice for larger fish, which do not grow substantially better on a higher-protein food.

Percentage of breeding operations by protein level of feed fed to broodfish*:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Percent Protein Level	Percent	Std. Error	Percent	Std. Error
28	21.8	(2.5)	16.7	(0.4)
32	59.3	(2.9)	69.4	(0.6)
35	13.3	(2.2)	5.6	(0.4)
Other	5.6	(1.1)	8.3	(0.4)
Total	100.0		100.0	

*Catfish 2003 asked about current practice and Catfish 2010 asked about protein level of feed primarily fed to broodfish in 2009.

Percentage of breeding operations by protein level of feed fed to broodfish*



*Catfish 2003 asked about current practice and Catfish 2010 asked about protein level of feed primarily fed to broodfish in 2009.

8. Additional species stocked

Stocked forage fish serve as a supplemental food source for broodfish. The percentage of breeding operations stocking forage fish in broodfish ponds as a supplemental food source increased from about one-third of operations (32.5 percent) for Catfish 2003 to almost half of operations for Catfish 2010 (48.7 percent).

Percentage of breeding operations that stocked forage fish in broodfish ponds as a supplemental food source for broodfish:

Percent Breeding Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
32.5	(2.5)	48.7	(0.7)

C. Spawning Management: Ponds and Broodfish

1. Number of spawning ponds

The percentage of breeding operations using two or three spawning ponds in the year prior to the study declined from 33.6 to 24.3 percent, while the percentage of operations using only one spawning pond increased slightly (from 21.1 to 27.1 percent). The percentages of operations using four or more spawning ponds were similar for the two studies. The changes among operations with fewer than four spawning ponds might indicate a desire on the part of operators to breed fewer fish and/or to conserve resources and use more ponds for production of fingerlings and foodsize fish. Conversely, these results could indicate that some operations breeding catfish at the time of Catfish 2003 were not breeding catfish when Catfish 2010 was conducted. Also, hybrids are not bred in ponds, so some production might have shifted to other facilities.

Percentage of breeding operations by number of spawning ponds used in the year prior to the study:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Number Spawning Ponds	Percent	Std. Error	Percent	Std. Error
1	21.1	(2.0)	27.1	(0.4)
2 to 3	33.6	(2.6)	24.3	(0.4)
4 to 5	21.3	(2.6)	24.3	(0.7)
6 or more	24.0	(2.6)	24.3	(0.7)
Total	100.0		100.0	

2. Draining and renovation of spawning ponds

Although some experts recommend draining and drying ponds every year to maintain spawning success, the percentage of operations that usually drain and dry ponds every 1 to 3 years declined from 79.0 percent for Catfish 2003 to 61.1 percent for Catfish 2010. Concomitantly, the percentage of operations that usually wait 6 or more years to drain and dry ponds increased from 13.6 percent for Catfish 2003 to 30.6 percent in for Catfish 2010. These changes might reflect economic pressures and reduced availability of resources.

For each study, about three-fourths of operations usually wait 6 or more years between complete renovations of ponds.

a. Percentage of breeding operations by usual number of years between draining and drying of spawning ponds and between complete renovations of ponds:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Number Years Between…	Percent	Std. Error	Percent	Std. Error
Draining and drying of ponds				
1 to 3	79.0	(2.2)	61.1	(0.7)
4 to 5	7.4	(1.2)	8.3	(0.1)
6 or more	13.6	(1.8)	30.6	(0.6)
Total	100.0		100.0	
Complete renovations				
1 to 3	15.5	(2.7)	19.4	(0.3)
4 to 5	11.1	(2.2)	6.4	(0.1)
6 or more	73.4	(3.3)	74.2	(0.4)
Total	100.0		100.0	

The average interval between draining and drying of ponds increased slightly from 3.1 years for Catfish 2003 to 3.9 years for Catfish 2010. The average time between complete renovations for all operations remained the same, at almost 10 years.

b. Average number of years between draining and drying of spawning ponds and average number of years between complete renovations of spawning ponds:

	Average Number of Years			
	Catfish 2003		Catfish 2010	
Procedure	**Average**	**Std. Error**	**Average**	**Std. Error**
Draining and drying of ponds	3.1	(0.2)	3.9	(0.1)
Complete renovations	9.4	(0.3)	9.9	(0.1)

3. Broodfish stocking densities

Maximum recommended broodfish stocking densities are about 1,200 pounds per acre. The percentage of operations stocking broodfish at a density of 1,200 pounds or more per acre increased from 26.9 percent for Catfish 2003 to 35.1 percent for Catfish 2010, while the percentage of operations stocking broodfish at a density of 1,000 to 1,199 pounds per acre declined from 38.9 percent for Catfish 2003 to 18.9 percent for Catfish 2010. The percentage of operations stocking broodfish at less than 800 pounds per acre increased from 22.7 percent for Catfish 2003 to 32.5 percent for Catfish 2010.

The percentages of broodfish by broodfish stocking density were similar for the two studies.

Percentage of operations and percentage of broodfish by broodfish stocking density (pounds per acre):

	Percent							
	Operation				Broodfish			
	Catfish 2003		Catfish 2010		Catfish 2003		Catfish 2010	
Stocking Density (lb/acre)	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Less than 800	22.7	(2.1)	32.5	(0.5)	7.0	(4.1)	4.5	(2.6)
800 to 999	11.5	(1.8)	13.5	(0.7)	7.0	(3.4)	14.1	(7.5)
1,000 to 1,199	38.9	(3.0)	18.9	(0.4)	44.4	(9.4)	14.4	(8.8)
1,200 or more	26.9	(2.6)	35.1	(0.7)	41.6	(10.5)	67.0	(12.5)
Total	100.0		100.0		100.0		100.0	

4. Female-to-male ratio in spawning ponds

Female-to-male broodfish ratios ranging from 1:1 to as high as 4:1 have been shown to have equal spawning success. From Catfish 2003 to Catfish 2010, the percentage of operations using a 1:1 female-to-male ratio declined, while the percentage of operations using a 3:1 female-to-male broodfish ratio increased from 11.4 to 27.8 percent. Using a 3:1 female-to-male ratio would enable producers to increase production of eggs while more efficiently using feed, ponds, and other resources. The surveys did not capture data on “other” ratios used.

Percentage of breeding operations by typical female-to-male broodfish ratio in spawning ponds:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Female-to-male Ratio	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 to 1	29.9	(2.6)	22.2	(0.7)
2 to 1	39.5	(2.9)	36.1	(0.6)
3 to 1	11.4	(1.5)	27.8	(0.7)
Other	19.2	(2.6)	13.9	(0.2)
Total	100.0		100.0	

D. Hatchery Management

1. Operations that operated a hatchery

For both Catfish 2003 and Catfish 2010, producers were asked if they had a hatchery for hatching catfish eggs, and 12.8 percent of Catfish 2003 operations and 9.0 percent of Catfish 2010 operations reported that they had a hatchery. For Catfish 2010, however, operations were subsequently asked if they produced any catfish fry in 2009, and 7.4 percent of all operations had produced catfish fry. For Catfish 2003, operations with hatcheries were not asked whether they had operated the hatchery in 2002, but the data suggested that all operations with hatcheries did operate them (data not shown).

The percentage of operations that had a hatchery for hatching eggs declined slightly between studies, from 12.8 to 9.0 percent (data not shown), which might reflect the loss of some operations with hatcheries from the industry or reallocation of resources for other purposes. The apparent percentage of operations that operated the hatchery declined from 12.8 to 7.4 percent, which likely reflects decreased demand for fingerlings.

a. Percentage of all catfish operations that operated a hatchery for hatching catfish eggs:

Percent Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
12.8	(0.7)	7.4	(0.4)

All operations that operated a hatchery at the time of Catfish 2010 had their own broodfish, so they likely produced the eggs that were hatched in the hatchery. Catfish 2003 operations that operated a hatchery but had no broodfish likely purchased egg masses from other operations.

b. Percentage of hatchery operations by broodfish inventory status:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Broodfish Inventory Status	Percent	Std. Error	Percent	Std. Error
Hatchery with own broodfish	97.2	(1.0)	100.0	(—)
Hatchery with no broodfish	2.8	(1.0)	0.0	(—)
Total	100.0		100.0	

2. Average number of egg masses and pounds of eggs

The average number of egg masses and the average total pounds of eggs brought into hatcheries for hatching were similar for the two studies. The average weight per egg mass, however, did increase from Catfish 2003 to Catfish 2010 (1.4 and 1.9 pounds, respectively), which might be related to the increase in the percentage of broodfish more than 4 years old (see table B.2).

Average number of egg masses, average total pounds of eggs, and average pounds per egg mass for eggs brought into the hatchery for hatching*:

	Catfish 2003		Catfish 2010	
	Average	Std. Error	Average	Std. Error
Number of egg masses	1,712	(143)	1,585	(48)
Total pounds of eggs	2,144	(204)	2,680	(128)
Pounds per egg mass	1.4	(0.1)	1.9	(0.0)

*For a typical production year for Catfish 2003 and for 2009 for Catfish 2010.

3. Egg mass treatment and placement in hatchery

Operations can treat egg masses with an appropriate compound to control bacterial and fungal diseases, but to avoid extra handling, the treatment is best done immediately after eggs are placed into hatching troughs. From Catfish 2003 to Catfish 2010, the percentage of operations that usually did not treat egg masses before placing them in the hatchery increased from 37.5 to 51.8 percent. The percentage of operations that usually treated egg masses with Betadine® or another iodine compound declined from 48.0 to 38.5 percent.

Percentage of breeding operations by usual treatment of egg masses before they are placed into hatching troughs:

	Percent Breeding Operations			
	Catfish 2003		Catfish 2010	
Treatment of Egg Masses	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Betadine® (iodine compounds)	48.0	(3.1)	38.5	(0.8)
Other compound	14.5	(2.1)	9.7	(0.4)
No treatment	37.5	(2.9)	51.8	(0.8)
Total	100.0		100.0	

4. Hatchery water management

Compared with surface water, well water has the advantage of generally being free of disease agents and vectors, wild fish, suspended matter, and pollutants. Water obtained directly from a well, however, can have issues associated with supersaturation of gases. Storing well water in a holding pond before use prevents problems with supersaturated gases and also facilitates availability of water.

The percentage of operations using well water stored in a holding pond as the primary water source for the hatchery declined from 28.8 to 16.2 percent from Catfish 2003 to Catfish 2010. The percentage of operations using, as their primary water source, water from a creek or watershed that was then stored in a holding pond increased slightly, from 5.9 to 9.8 percent. Rather than reflecting changes individual operations made in their water sources, these differences more likely reflect changes caused by some operations leaving the business.

a. Percentage of hatchery operations by primary water source for the hatchery:

	Percent Hatchery Operations			
	Catfish 2003		**Catfish 2010**	
Primary Water Source	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Well water stored in a holding pond	28.8	(2.3)	16.2	(0.4)
Water from a creek or watershed, then stored in a holding pond	5.9	(1.0)	9.8	(0.1)
Water directly from a well	52.2	(2.8)	57.7	(0.7)
Mixture of water directly from a well and from a holding pond	9.2	(1.7)	13.0	(0.2)
Other	3.9	(1.1)	3.3	(0.4)
Total	100.0		100.0	

For both studies, about half of the hatcheries that used water directly from a well degassed the water before using it in the hatchery. Water used directly from a well also can be cold; Catfish 2003 did not ask about heating well water, but Catfish 2010 found that 44.6 percent of operations heated water obtained directly from a well before using it in the hatchery (data not shown).

b. For hatchery operations that used water directly from a well, percentage of operations that degassed water used in the hatchery:

Percent Hatchery Operations			
Catfish 2003		**Catfish 2010**	
Percent	**Std. Error**	**Percent**	**Std. Error**
51.3	(4.8)	55.1	(1.1)

For a typical 100-gallon hatching trough, between 2 and 5 gallons of water should flow through the trough per minute; this flow rate provides adequate water exchange to maintain water quality.

The percentage of operations with average flow rates of 1 to 3 gallons per minute decreased from 36.5 percent for Catfish 2003 to 22.7 percent for Catfish 2010. This decline might represent an improvement in hatchery conditions because, if these troughs are the typical 100-gallon size, flow rates of 1 to 3 gallons per minute might be inadequate. The percentage of operations with flow rates of more than 5 gallons per minute increased from 16.6 to 27.5 percent; the surveys did not ask about trough size, so troughs with these flow rates might be larger than 100 gallons.

c. Percentage of hatchery operations by average water flow rate (gallons/minute) in each hatching trough:

	Percent Hatchery Operations			
	Catfish 2003		**Catfish 2010**	
Flow Rate (gal/min)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 to 3	36.5	(4.0)	22.7	(0.6)
4 to 5	46.9	(4.1)	49.8	(0.8)
More than 5	16.6	(2.6)	27.5	(0.6)
Total	100.0		100.0	

The percentage of operations using paddles to circulate water in hatching troughs declined slightly between studies, while the percentage of operations using an “other” method to circulate water increased from 6.2 percent of operations to 25.9 percent. The study did not collect information on “other” methods of circulating water, but the change might reflect the use of vertical-lift egg incubator systems.

d. Percentage of hatchery operations by method of circulating water in hatching troughs:

	Percent Hatchery Operations			
	Catfish 2003		**Catfish 2010**	
Water Circulation Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Paddles	88.7	(2.1)	80.5	(0.3)
Air stones	38.8	(3.0)	35.4	(0.7)
Agitators	6.7	(1.5)	9.8	(0.1)
Other	6.2	(1.2)	25.9	(0.6)

Water hardness of at least 20 parts per million (ppm) is recommended for use in hatcheries because low calcium levels can result in poor hatching and survival (for water hardness levels, parts per million usually refers to 1 milligram of calcium carbonate per liter of water). The percentages of operations that used different levels of water hardness were similar for Catfish 2003 and Catfish 2010; in both studies, about three-fourths of hatcheries used water with hardness of 20 ppm or more.

e. Percentage of hatchery operations by water hardness (parts per million) used by hatcheries:

	Percent Hatchery Operations			
	Catfish 2003		**Catfish 2010**	
Hardness (ppm)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 to 19	24.9	(4.0)	25.8	(0.9)
20 to 50	24.4	(3.9)	17.5	(0.8)
Greater than 50	50.7	(4.3)	56.7	(0.9)
Total	100.0		100.0	

Although the percentages of operations using the listed levels of water hardness were similar for Catfish 2003 and Catfish 2010, the overall average water hardness for hatchery operations increased from 78.8 to 109.3 ppm. The percentage of operations adding calcium to the water to maintain water hardness did not change substantially from Catfish 2003 to Catfish 2010. These changes might reflect a loss of operations with lower water hardness than an actual change in water hardness levels at existing operations.

f. Average water hardness (parts per million) used by hatcheries:

Average Water Hardness (ppm)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
78.8	(5.6)	109.3	(1.6)

g. Percentage of hatchery operations that added calcium* to water to maintain alkalinity:

Percent Hatchery Operations			
Catfish 2003		**Catfish 2010**	
Percent	**Std. Error**	**Percent**	**Std. Error**
37.7	(3.1)	35.1	(0.9)

* Catfish 2003 asked whether the operation added calcium without specifying a time frame; Catfish 2010 asked specifically whether the operation added calcium to the water during 2009.

5. Density of egg masses in hatching troughs

Placing too many egg masses in hatching troughs can inhibit water circulation, potentially causing problems with dissolved oxygen levels. Also, overlapping of egg masses can facilitate the transfer of bacterial or fungal diseases.

For both Catfish 2003 and Catfish 2010, the majority of hatcheries (more than 90.0 percent) placed fewer than 31 egg masses per 100 gallons of water, and the percentages of operations with the listed densities of egg masses were similar for the two studies. From Catfish 2003 to Catfish 2010, however, the average number of egg masses per 100 gallons increased from 17.7 to 19.8, which suggests that operators were trying to increase the number of eggs hatched while still maintaining healthy conditions for egg masses. Also, because the average weight of egg masses was greater for Catfish 2010 (table D.2), the overall volume of eggs in troughs increased between studies.

a. Percentage of hatchery operations by density of egg masses (number of egg masses per 100 gallons of water) in hatching troughs*:

	Percent Hatchery Operations			
	Catfish 2003		**Catfish 2010**	
Density (egg masses per 100 gallons)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 to 15	52.0	(3.2)	47.7	(0.9)
16 to 30	38.5	(3.2)	43.7	(0.9)
Greater than 30	9.5	(2.1)	8.6	(0.6)
Total	100.0		100.0	

* Catfish 2003 asked about density of egg masses without specifying a time frame; Catfish 2010 asked specifically about density of egg masses in hatching troughs during 2009.

6. Turning of egg masses

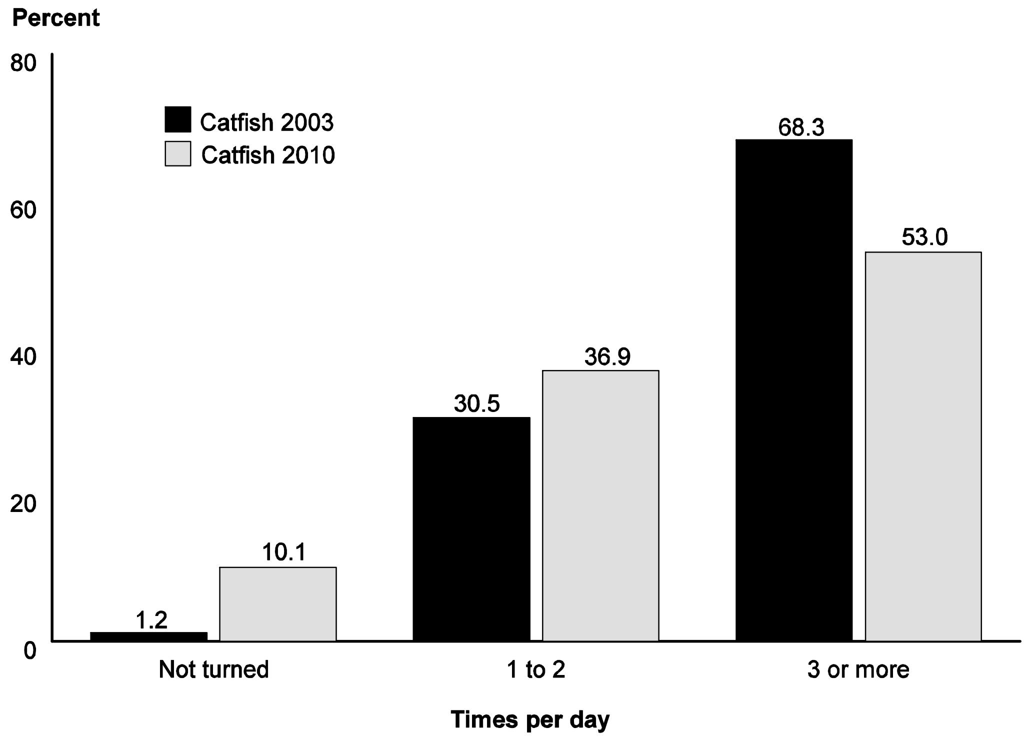
Egg masses should be turned over on a regular basis to check for infected or dead eggs. Although the majority of Catfish 2010 hatcheries (53.0 percent) turned eggs at least three times per day, this percentage was a decline from 68.3 percent of operations in Catfish 2003. The percentage of operations that did not turn eggs on a daily basis increased from 1.2 to 10.1 percent from Catfish 2003 to Catfish 2010. The apparent decrease in the number of times per day egg masses were turned might reflect reduced availability of labor during difficult economic times or improvements in other management practices that could reduce rates of egg infection or death, such as improved water circulation.

Percentage of hatchery operations by number of times per day egg masses were turned*:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Number Times per Day	Percent	Std. Error	Percent	Std. Error
Not turned	1.2	(0.4)	10.1	(0.2)
1 to 2	30.5	(2.7)	36.9	(0.8)
3 or more	68.3	(2.7)	53.0	(0.8)
Total	100.0		100.0	

* Catfish 2003 asked how many times per day egg masses in hatching troughs were turned without specifying a year or time period; Catfish 2010 asked specifically how many times per day egg masses in hatching troughs were turned during 2009.

Percentage of hatchery operations by number of times per day egg masses were turned*



*Catfish 2003 asked how many times per day egg masses in hatching troughs were turned without specifying a year or time period. Catfish 2010 asked specifically how many times per day egg masses in hatching troughs were turned during 2009.

E. Egg Health Issues

1. Survival of eggs until hatching

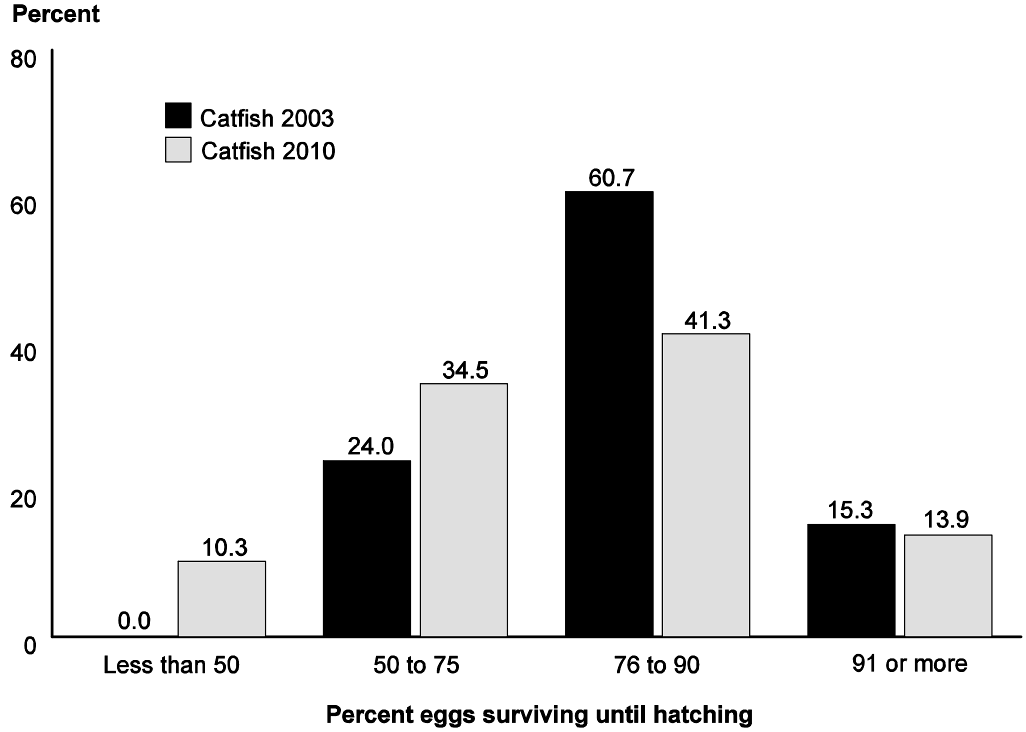
The percentage of hatcheries with 76 to 90 percent of eggs surviving until hatching declined from Catfish 2003 to Catfish 2010, while the percentage of hatcheries with 50 to 75 percent of eggs surviving to hatching increased. Additionally, 10.3 percent of hatcheries had less than 50 percent of eggs survive until hatching for Catfish 2010, compared with zero hatcheries for Catfish 2003. The apparent decline in survival of eggs until hatching might in part result from reduced turning of eggs (table D.6) and/or increased production of channel x blue hybrid catfish, which tend to have lower hatching rates (for Catfish 2010, 9.5 percent of operations hatched some channel x blue hybrid catfish, and 12.9 percent of fry hatched were channel x blue hybrids; data not shown).

a. Percentage of hatchery operations by percentage of eggs brought to the hatchery that survived to hatching*:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Percent Eggs Surviving until Hatching	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 50	0.0	(—)	10.3	(0.5)
50 to 75	24.0	(2.7)	34.5	(0.8)
76 to 90	60.7	(3.0)	41.3	(0.8)
91 to 100	15.3	(2.2)	13.9	(0.2)
Total	100.0		100.0	

* For Catfish 2003, the question asked about the percentage of eggs brought to the hatchery that typically survive to hatching. For Catfish 2010, the question asked specifically about the percentage of eggs brought to the hatchery that survived to hatching in 2009.

Percentage of hatchery operations by percentage of eggs brought to the hatchery that survived to hatching*



*For Catfish 2003, the question asked about the percentage of eggs brought to the hatchery that typically survive to hatching. For Catfish 2010, the question asked specifically about the percentage of eggs brought to the hatchery that survived to hatching in 2009.

Overall, about three-fourths of eggs brought into hatcheries survived to hatching in both Catfish 2003 and Catfish 2010.

b. Percentage of eggs brought into the hatchery operation (weighted by number of egg masses) that survived to hatching*:

Percent Eggs			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
79.3	(2.1)	74.2	(3.6)

* For Catfish 2003, the question asked about the percentage of eggs brought to the hatchery that typically survive to hatching. For Catfish 2010, the question asked specifically about the percentage of eggs brought to the hatchery that survived to hatching in 2009.

2. Causes of egg loss

The percentages of eggs brought into the hatchery that failed to hatch because of the listed causes were similar for Catfish 2003 and Catfish 2010.

a. Percentage of eggs brought into the hatchery operation (weighted by number of egg masses) that did not hatch,* by cause:

	Percent Eggs			
	Catfish 2003		Catfish 2010	
Cause	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Fungal infections	8.3	(1.7)	3.5	(2.1)
Bacterial egg rot (or other bacterial infections)	3.7	(0.7)	1.6	(0.7)
Infertility	4.8	(1.6)	10.0	(3.3)
Other known	0.8	(0.7)	1.7	(1.4)
Unknown	3.1	(0.9)	9.0	(4.5)
Total	20.7	(2.1)	25.8	(3.6)

* For Catfish 2003, the question asked about the percentage of eggs brought to the hatchery that typically did not hatch. For Catfish 2010, the question asked specifically about the percentage of eggs brought to the hatchery that did not hatch in 2009.

The percentages of operations that lost eggs to fungal or bacterial infections declined from Catfish 2003 to Catfish 2010. The percentage of operations that lost eggs to unknown causes increased slightly, however.

b. Percentage of hatchery operations with any eggs that did not hatch,* by cause:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Cause	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Fungal infections	65.1	(2.9)	38.9	(0.7)
Bacterial egg rot (or other bacterial infections)	44.8	(3.0)	25.7	(0.7)
Infertility	52.5	(3.0)	48.3	(0.8)
Other	9.6	(1.4)	9.6	(0.6)
Unknown	44.4	(3.0)	55.0	(0.8)

* For Catfish 2003, the question asked about the percentage of eggs brought to the hatchery that typically did not hatch. For Catfish 2010, the question asked specifically about the percentage of eggs brought to the hatchery that did not hatch in 2009.

3. Fungal/bacterial prevention and treatment

Operators can take a variety of measures to prevent disease in hatcheries, such as maintaining adequate water flow and quality (including dissolved oxygen levels), keeping eggs from being too crowded in hatching baskets, and treating eggs with chemicals.

Chemical treatment can help prevent fungal or bacterial infections in hatching troughs. For Catfish 2010, about three-fourths of hatchery operations (74.0 percent) used some sort of chemical treatment to prevent fungal or bacterial infections of eggs, a slight decline from 79.3 percent of operations for Catfish 2003. From Catfish 2003 to Catfish 2010, the percentage of operations using Betadine or other iodine compounds decreased (from 43.0 to 28.8 percent of operations, respectively), while the percentage of operations using salt increased (from 16.9 to 26.0 percent of operations, respectively); these changes might reflect the relative cost of the two treatments.

a. Percentage of hatchery operations that used chemicals to **prevent** fungal or bacterial infections in hatching troughs:*

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Preventive Chemical	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Betadine (iodine compounds)	43.0	(3.0)	28.8	(0.8)
Copper sulfate	42.7	(3.1)	38.4	(0.8)
Formalin	26.1	(2.8)	32.2	(0.7)
Potassium permanganate	7.9	(1.5)		
Hydrogen peroxide			9.7	(0.4)
Salt	16.9	(2.1)	26.0	(0.6)
Any of the above	79.3	(2.1)	74.0	(0.5)

*For Catfish 2003, the question asked about general use of chemicals to prevent fungal or bacterial infections in hatching troughs; for Catfish 2010, the question asked specifically about chemicals used during 2009.

For each of the listed chemicals, the average number of times per day that hatchery operations treated eggs to prevent fungal or bacterial infections was similar for Catfish 2003 and Catfish 2010.

b. Average number of times per day hatchery operations used chemicals to **prevent** fungal or bacterial infections in hatchery troughs:*

	Average Times per Day			
	Catfish 2003		**Catfish 2010**	
Preventive Chemical	**Average**	**Std. Error**	**Average**	**Std. Error**
Betadine (iodine compounds)	1.4	(0.1)	1.3	(0.2)
Copper sulfate	1.7	(0.1)	1.3	(0.2)
Formalin	2.0	(0.2)	1.5	(0.2)
Potassium permanganate	1.0	(0.0)		
Hydrogen peroxide			1.0	(0.0)
Salt	1.5	(0.2)	1.3	(0.3)

*For Catfish 2003, the question asked about general use of chemicals to prevent fungal or bacterial infections in hatching troughs; for Catfish 2010, the question asked specifically about chemicals used during 2009.

The primary disease concerns for catfish eggs are bacterial and fungal infections, which can spread quickly once the disease-causing organisms are present. The changes from Catfish 2003 to Catfish 2010 in use of chemicals to **treat** fungal infections are similar to those seen for use of chemicals to **prevent** fungal or bacterial infections (see tables E.3.a and E.3.c). The percentage of operations using Betadine or other iodine compounds to treat fungal infections declined between studies, the percentage of operations using salt increased, and the percentage of operations using any of the listed chemicals to treat fungal infections decreased.

c. Percentage of hatchery operations that used chemicals to **treat fungal** infections in hatching troughs:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Treatment Chemical	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Betadine (iodine compounds)	41.9	(3.1)	19.3	(0.7)
Copper sulfate	35.0	(2.9)	28.8	(0.9)
Formalin	22.9	(2.6)	29.1	(0.7)
Potassium permanganate	9.2	(1.6)		
Hydrogen peroxide			6.5	(0.4)
Salt	13.9	(1.8)	22.8	(0.6)
Any of the above	75.7	(2.3)	61.4	(0.7)

*For Catfish 2003, the question asked about general use of chemicals to treat fungal infections in hatching troughs; for Catfish 2010, the question asked specifically about chemicals used during 2009.

The changes in use of chemicals to treat bacterial infections are slightly different from those seen for use of chemicals to prevent fungal or bacterial infections (see table E.3.a). As seen for prevention of fungal or bacterial infections, the percentage of operations using Betadine or other iodine compounds to treat bacterial infections declined between studies and the percentage of operations using salt increased. Additionally, however, the percentage of operations using copper sulfate to treat bacterial infections increased from Catfish 2003 to Catfish 2010. The percentage of operations using any of the chemical treatments was similar for the two studies.

d. Percentage of hatchery operations that used chemicals to **treat bacterial** infections in hatching troughs:*

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Treatment Chemical	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Betadine (iodine compounds)	28.5	(2.9)	19.3	(0.8)
Copper sulfate	21.1	(2.4)	28.8	(0.9)
Formalin	22.4	(2.7)	29.1	(0.7)
Potassium permanganate	6.5	(1.4)		
Hydrogen peroxide			6.5	(0.4)
Salt	12.9	(1.8)	19.5	(0.6)
Any of the above	57.2	(2.9)	61.3	(0.7)

*For Catfish 2003, the question asked about general use of chemicals to treat bacterial infections in hatching troughs; for Catfish 2010, the question asked specifically about chemicals used during 2009.

F. Fry Management

1. Number of fry hatched

The operation average number of fry hatched declined from 2003 to 2010.

Operation average number of fry hatched annually*:

Operation Average Number Hatched			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
17,216,000	(1,346)	16,256,000	(578)

*For Catfish 2003, the question asked about the number of fry hatched annually; for Catfish 2010, the question asked specifically about fry hatched during 2009.

2. Length of time fry left in fry troughs

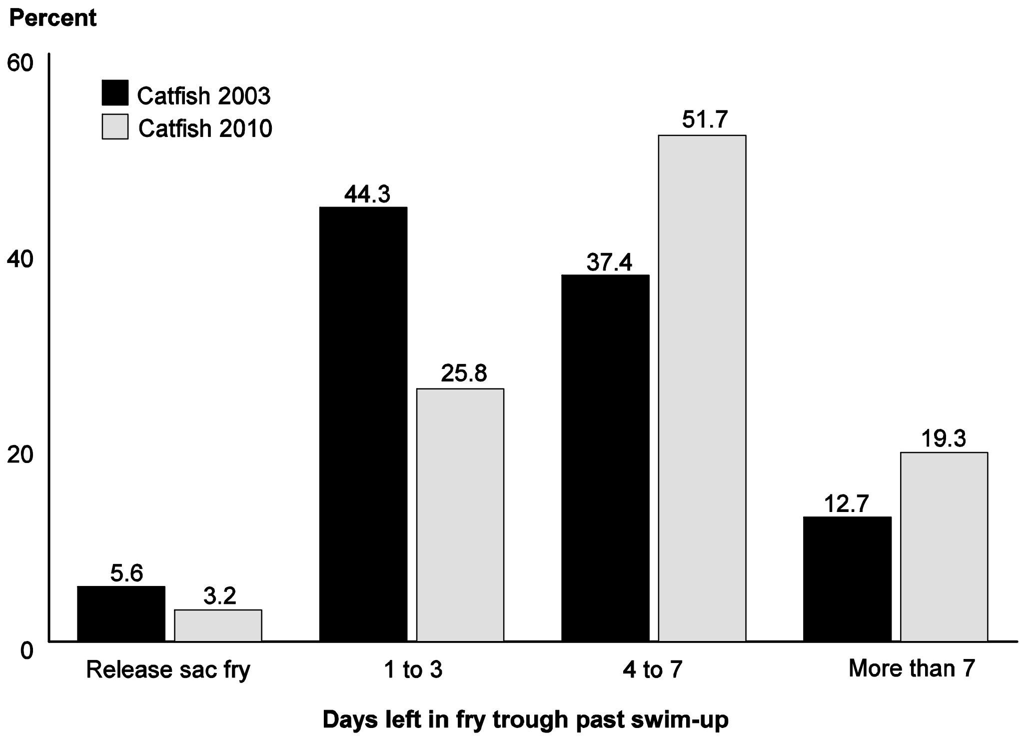
Although fry that have not fully absorbed the yolk sac can be stocked into fry/fingerling ponds, survival is likely better if they are not stocked until they have absorbed the entire yolk sac and been fed for a brief period. The percentage of operations leaving fry in fry troughs for a longer period beyond swim-up increased between studies, with 71.0 percent of operations leaving fry in fry troughs for 4 days or more past swim-up for Catfish 2010, compared with 50.1 percent of operations for Catfish 2003. Concomitantly, the percentage of operations leaving fry in fry troughs only 1 to 3 days past swim-up declined from 44.3 percent for Catfish 2003 to 25.8 percent for Catfish 2010.

Percentage of hatchery operations by how many days fry were normally left in fry troughs past swim-up*:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Days Left in Fry Trough Past Swim-up	Percent	Std. Error	Percent	Std. Error
Release sac fry	5.6	(1.5)	3.2	(0.4)
1 to 3	44.3	(3.1)	25.8	(0.7)
4 to 7	37.4	(2.9)	51.7	(0.8)
More than 7	12.7	(1.7)	19.3	(0.7)
Total	100.0		100.0	

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

Percentage of hatchery operations by how many days fry were normally left in fry troughs past swim-up*



*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

3. Primary feed in fry troughs

Perhaps in association with the increase in the percentage of operations keeping fry in fry troughs for 4 or more days after swim-up (see table F.2), the percentage of operations that did not feed fry in fry troughs declined between the two studies, from 9.5 percent of operations for Catfish 2003 to 3.2 percent of operations for Catfish 2010. Other changes in the primary feed fed in fry troughs were a decrease in the percentage of operations feeding catfish starter (from 68.3 to 51.7 percent of operations) and an increase in the percentage of operations feeding salmon/trout starter (from 11.1 to 35.4 percent of operations). The apparent shift toward salmon/trout starter might be related to research indicating that fry gained 50 to 75 percent more body weight on salmon or trout starter than on catfish starter.

Percentage of hatchery operations by primary feed fed in fry troughs*:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Primary Feed	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Catfish starter	68.3	(2.9)	51.7	(0.8)
Salmon/trout starter	11.1	(2.0)	35.4	(0.7)
Krill	6.2	(1.8)	3.2	(0.4)
Other	4.9	(1.0)	6.5	(0.1)
Nothing fed to fry in fry troughs	9.5	(1.8)	3.2	(0.4)
Total	100.0		100.0	

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

4. Number of feedings per day for fry

There were no substantial changes from 2003 to 2010 in percentages of operations based on the number of times per day that fry in fry troughs were fed.

For hatchery operations that fed fry in fry troughs, percentage of operations by number of times fry were fed in a 24-hour period*:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Number Times Fed Per 24-hour Period	Percent	Std. Error	Percent	Std. Error
1 to 2	12.5	(1.8)	13.5	(0.2)
3 to 4	19.2	(2.1)	20.2	(0.5)
5 to 6	20.7	(2.6)	20.1	(0.5)
7 or more	47.6	(3.1)	46.2	(0.8)
Total	100.0		100.0	

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

5. Water circulation in fry troughs

As with hatchery troughs (see table D.4.d), the percentage of operations using paddles to circulate water in fry troughs declined from Catfish 2003 to Catfish 2010, while the percentage of operations using an “other” method to circulate water increased, from 11.3 to 25.9 percent of operations. The study did not collect information on “other” methods of circulating water. With fry troughs, the percentage of operations using air stones to circulate water increased slightly from Catfish 2003 to Catfish 2010, while the percentage of operations using agitators decreased slightly.

Percentage of hatchery operations by method of circulating water in fry troughs:

	Percent Hatchery Operations			
	Fry Troughs			
	Catfish 2003		Catfish 2010	
Water Circulation Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Paddles	29.0	(2.6)	9.7	(0.4)
Air stones	63.1	(2.9)	70.8	(0.7)
Agitators	16.2	(2.2)	9.8	(0.4)
Other	11.3	(1.6)	25.9	(0.6)

6. Fry trough disinfection

For both studies, the vast majority of hatchery operations disinfected fry troughs between batches of fry. The percentage of operations disinfecting fry troughs annually increased slightly.

Percentage of hatchery operations by frequency of fry trough disinfection:

	Percent Hatchery Operations			
	Catfish 2003		Catfish 2010	
Frequency	Percent	Std. Error	Percent	Std. Error
Between batches of fry	85.8	(1.9)	87.0	(0.2)
Annually	2.5	(0.8)	6.5	(0.1)
Other	2.7	(0.9)	0.0	(—)
Do not disinfect	9.0	(1.6)	6.5	(0.1)
Total	100.0		100.0	

7. Raising of fry to fingerlings

The percentage of catfish operations that raised any fry to fingerlings declined from 29.9 percent for Catfish 2003 to 12.8 percent for Catfish 2010.

Percentage of all catfish operations that grew any fry to fingerlings*:

Percent Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
29.9	(0.9)	12.8	(0.5)

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

G. Management of Fry/Fingerling Ponds Prior to Stocking

1. Placement of fry in raceways or tanks prior to stocking

Moving fry from the fry trough directly to another tank or raceway might increase survival rate by giving fry more time to develop and grow before they are placed in a fry/fingerling pond. The percentage of operations that moved fry from the fry trough to raceways or tanks before stocking them into fry/fingerling ponds increased slightly, from 6.7 percent of operations for Catfish 2003 to 11.5 percent of operations for Catfish 2010.

a. Percentage of fingerling operations that moved swim-up fry from fry troughs to raceways or tanks before stocking them into fry/fingerling ponds*:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	**Std. Error**	**Percent**	**Std. Error**
6.7	(0.9)	11.5	(0.5)

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

For fingerling operations that placed fry in raceways or tanks before moving them into fry/fingerling ponds, 100.0 percent of Catfish 2010 operations waited until fry were at least 8 days old to move them, an increase from 59.3 percent of Catfish 2003 operations. Although 40.7 percent of Catfish 2003 operations moved fry from raceways or tanks when they were 4 to 7 days old, no Catfish 2010 operations moved fry from raceways or tanks at this age.

b. For fingerling operations that placed fry in raceways or tanks, percentage of operations by average age of fry (days) when moved from the raceway or tank to fry/fingerling ponds*:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Average Age (days after hatching)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
4 to 7	40.7	(6.7)	0.0	(—)
8 to 14	33.9	(6.5)	66.7	(2.1)
15 or more	25.4	(6.2)	33.3	(2.1)
Total	100.0		100.0	

*For Catfish 2003, the question did not specify a time frame; for Catfish 2010, the question asked specifically about 2009.

2. Number and size of fry/fingerling ponds

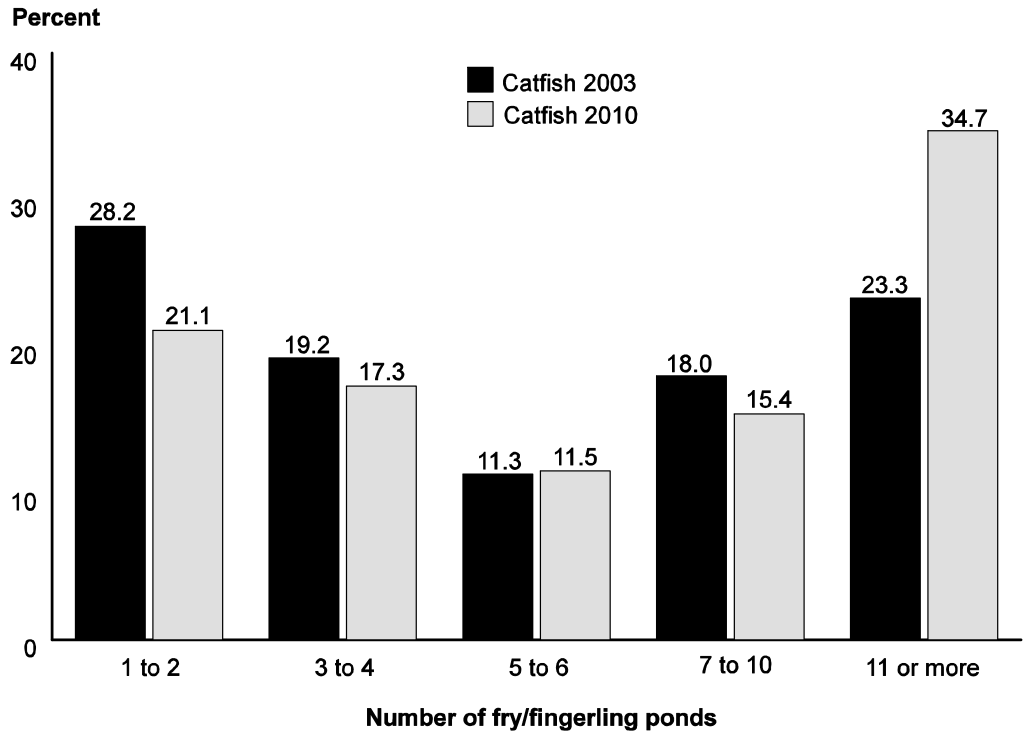
From Catfish 2003 to Catfish 2010, the percentage of operations with 1 to 2 fry/fingerling ponds decreased from 28.2 to 21.1 percent, while the percentage of operations with 11 or more fry/fingerling ponds increased from 23.3 to 34.7 percent. These changes might reflect the economic climate for catfish operations, with smaller operators leaving the business and/or operations increasing in size to gain from economies of scale and improve profitability.

a. Percentage of fingerling operations by number of fry/fingerling ponds*:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Number of Fry/Fingerling Ponds	Percent	Std. Error	Percent	Std. Error
1 to 2	28.2	(1.5)	21.1	(0.7)
3 to 4	19.2	(1.5)	17.3	(0.6)
5 to 6	11.3	(1.2)	11.5	(0.6)
7 to 10	18.0	(1.6)	15.4	(0.7)
11 or more	23.3	(1.7)	34.7	(0.9)
Total	100.0		100.0	

*Catfish 2003 asked about the number of fry/fingerling ponds on the operation, whereas Catfish 2010 asked specifically about the number of fry/fingerling ponds used for production during 2009.

Percentage of fingerling operations by number of fry/fingerling ponds*



*Catfish 2003 asked about the number of fry/fingerling ponds on the operation, whereas Catfish 2010 asked specifically about the number of fry/fingerling ponds used for production during 2009.

From Catfish 2003 to Catfish 2010, the average number of fry/fingerling ponds on fingerling operations increased from 10.3 to 15.6 ponds. Additionally, the average pond size increased between the two studies from 7.6 to 8.7 surface acres, with the total surface acres per operation also increasing, from 77.0 to 136.5 surface acres. Again, these changes might reflect the exit of smaller operations from the business and/or enlargement of operations to become more cost-effective and competitive.

b. For fingerling operations, average number of fry/fingerling ponds, average pond size (surface acres), and average total surface acres of ponds*:

	Average			
	Catfish 2003		Catfish 2010	
	Average	**Std. Error**	**Average**	**Std. Error**
Number of ponds	10.3	(0.8)	15.6	(0.6)
Pond size (surface acres)	7.6	(0.2)	8.7	(0.2)
Total surface acres	77.0	(5.5)	136.5	(6.6)

*Catfish 2003 asked about the number of fry/fingerling ponds on the operation, whereas Catfish 2010 asked specifically about the number of fry/fingerling ponds used for production during 2009.

3. Treatment of fry/fingerling ponds before stocking

Preparing fingerling ponds before stocking helps minimize loss of catfish to aquatic predators and establish zooplankton as a food source for catfish. Pond treatments typically include some combination of draining, drying, and/or poisoning with an approved toxicant registered with the U.S. Environmental Protection Agency (such as chlorine, rotenone, or antimycin A).

With the exception of “other” treatments, the percentages of operations using the various treatment options were similar for Catfish 2003 and Catfish 2010. For both studies, almost three-fourths of operations drained and dried ponds or drained and poisoned ponds before stocking them with catfish. A small percentage of operations (2.1 percent) used “other” treatments for Catfish 2003, but no operations did for Catfish 2010.

Percentage of fingerling operations by procedure that best describes the treatment of fry/fingerling ponds before stocking*:

	Percent Fingerling Operations			
	Catfish 2003		**Catfish 2010**	
Treatment	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Drained and dried	48.9	(1.9)	45.0	(0.9)
Drained and poisoned	24.3	(1.8)	29.5	(0.9)
Poisoned but not drained	13.4	(1.4)	11.8	(0.6)
Neither drained nor poisoned	11.3	(1.0)	13.7	(0.5)
Other	2.1	(0.5)	0.0	(—)
Total	100.0		100.0	

*Catfish 2010 asked specifically about the treatment of ponds before stocking in 2009.

4. Number of days between filling of ponds and stocking

The amount of time operators wait between refilling a drained pond and stocking it with catfish is a balance requiring enough time for proper zooplankton populations to become established but not enough time for predatory aquatic insects to become established.

The percentages of operations waiting the listed numbers of days between filling a drained pond with water and stocking it with fish were similar for Catfish 2003 and Catfish 2010. For each study, more than half of operations waited 7 to 14 days between filling and restocking the pond.

a. For fingerling operations that drained fingerling ponds before stocking,* percentage of operations by usual number of days between filling fingerling ponds with water and stocking with fry:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Days Between Filling and Stocking	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Fewer than 7	20.6	(1.9)	19.4	(0.9)
7 to 14	53.1	(2.3)	55.6	(1.1)
15 or more	26.3	(2.1)	25.0	(1.0)
Total	100.0		100.0	

*Catfish 2010 asked specifically about the treatment of ponds before stocking in 2009.

For both studies, fingerling operations waited on average about 2 weeks between refilling ponds and stocking them.

b. For fingerling operations that drained fingerling ponds before stocking,* average usual number of days between filling fry/fingerling ponds with water and stocking fry*:

Average Number of Days			
Catfish 2003		Catfish 2010	
Average	**Std. Error**	**Average**	**Std. Error**
14.0	(0.5)	15.4	(0.3)

*Catfish 2010 asked specifically about the treatment of ponds before stocking in 2009.

5. Number of years between complete renovations of fry/fingerling ponds

Complete renovations of ponds are an expensive and time-consuming process. From Catfish 2003 to Catfish 2010, the percentage of operations waiting 6 to 10 years between complete renovations increased from 48.3 to 57.8 percent. Concomitantly, the percentage of operations waiting only 1 to 5 years between complete renovations decreased, from 32.0 to 21.0 percent.

a. Percentage of fingerling operations by usual number of years between complete renovations of fry/fingerling ponds:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Years Between Complete Renovations	Percent	Std. Error	Percent	Std. Error
1 to 5	32.0	(2.0)	21.0	(0.8)
6 to 10	48.3	(2.3)	57.8	(1.1)
11 or more	19.7	(2.0)	21.2	(1.0)
Total	100.0		100.0	

The average time operations waited between complete renovations of fingerling ponds increased from Catfish 2003 to Catfish 2010.

b. Average usual time (in years) between complete renovations of fingerling ponds:

Average Time (years)			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
8.5	(0.2)	9.3	(0.1)

6. Fertilization of fry/fingerling ponds

Fertilizing fingerling ponds promotes a bloom of beneficial zooplankton, providing food for catfish fry. This process can be especially important for ponds that have been drained, dried, and/or poisoned. From Catfish 2003 to Catfish 2010, the percentage of operations that fertilized fry/fingerling ponds decreased from 57.5 to 46.2 percent.

a. Percentage of fingerling operations that fertilized fry/fingerling ponds*:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
57.5	(1.9)	46.2	(0.9)

*Catfish 2003 asked about the operations' usual practice, whereas Catfish 2010 asked specifically about pond fertilization practices during 2009.

Some time is needed between fertilizing ponds and stocking catfish to let zooplankton populations develop in the ponds. For both studies, at least three-fourths of operations that fertilized fingerling ponds began fertilizing ponds at least 7 days before stocking fry.

b. For operations that fertilized fry/fingerling ponds, percentage of operations by number of days between beginning fertilization and stocking ponds:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Days Between Beginning Fertilization and Stocking	Percent	Std. Error	Percent	Std. Error
Fewer than 7	22.4	(1.9)	23.7	(1.2)
7 to 14	64.1	(2.3)	57.3	(1.4)
15 or more	13.5	(1.8)	19.0	(1.0)
Total	100.0		100.0	

7. Chloride level

High chloride levels in ponds can help prevent methemoglobinemia, or brown blood disease, in catfish. Methemoglobinemia develops when nitrite in pond water crosses the gill epithelium and enters the bloodstream, complexing with hemoglobin to form methemoglobin. Red blood cells containing methemoglobin cannot transport oxygen, causing fish to become hypoxic even in water with high oxygen content. High chloride levels in water can prevent nitrite from crossing the gill epithelium, thereby preventing development of brown blood disease.

Pond chloride levels in excess of 100 ppm are considered adequate to preclude the need to regularly monitor nitrite levels. The operation average chloride level during summer months in fry/fingerling ponds exceeded 100 ppm for both Catfish 2003 and Catfish 2010, and the level was similar for the two studies.

Operation average chloride level in fry/fingerling ponds (parts per million) during summer:

Operation Average Chloride Level (ppm)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
135.0	(23.0)	153.5	(5.7)

8. Salt use

Fingerling producers can add salt to ponds if chloride levels are not high enough to prevent problems with nitrites. From Catfish 2003 to Catfish 2010, however, the percentage of operations that did not add salt to fry/fingerling ponds increased from about one-third of operations (32.3 percent) to almost two-thirds of operations (61.4 percent). The percentages of operations that added salt—either routinely to maintain a desired chloride level or only in response to health problems—declined between studies. The operation average chloride level was similar for the studies, however (table G.7), which suggests these findings might be related to changes in the population of operations.

Percentage of fingerling operations by use of salt in fry/fingerling ponds*:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Salt Use	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Routinely added salt to maintain a desired chloride level	45.5	(1.8)	30.9	(0.9)
Added salt only in response to health problems	22.2	(1.6)	7.7	(0.5)
Did not add salt	32.3	(1.5)	61.4	(0.9)
Total	100.0		100.0	

*Catfish 2010 asked specifically about the use of salt in ponds during 2009, whereas Catfish 2003 did not specify a time frame.

H. Management of Fry/Fingerling Ponds after Stocking

1. Fry stocked in years preceding the study

The stocking rates obtained for Catfish 2010 (11.5 million fry in 2008 and 9.7 million fry in 2009) were increases over the stocking rates obtained for Catfish 2003 (7.0 million fry in 2001 and 6.0 million fry in 2002). This finding is likely related to the increase in operation size and/or the loss of smaller operations (see table G.2.b).

Operation average number of fry stocked into fry/fingerling ponds for the previous 2 years, by year:

Operation Average Number of Fry (x1,000)							
Catfish 2003				**Catfish 2010**			
2001		**2002**		**2008**		**2009**	
Avg.	**Std. Error**	**Avg.**	**Std. Error**	**Avg.**	**Std. Error**	**Avg.**	**Std. Error**
6,963.5	(487.6)	6,039.7	(478.8)	11,493	(534)	9,711	(502)

2. Fry stocking rates

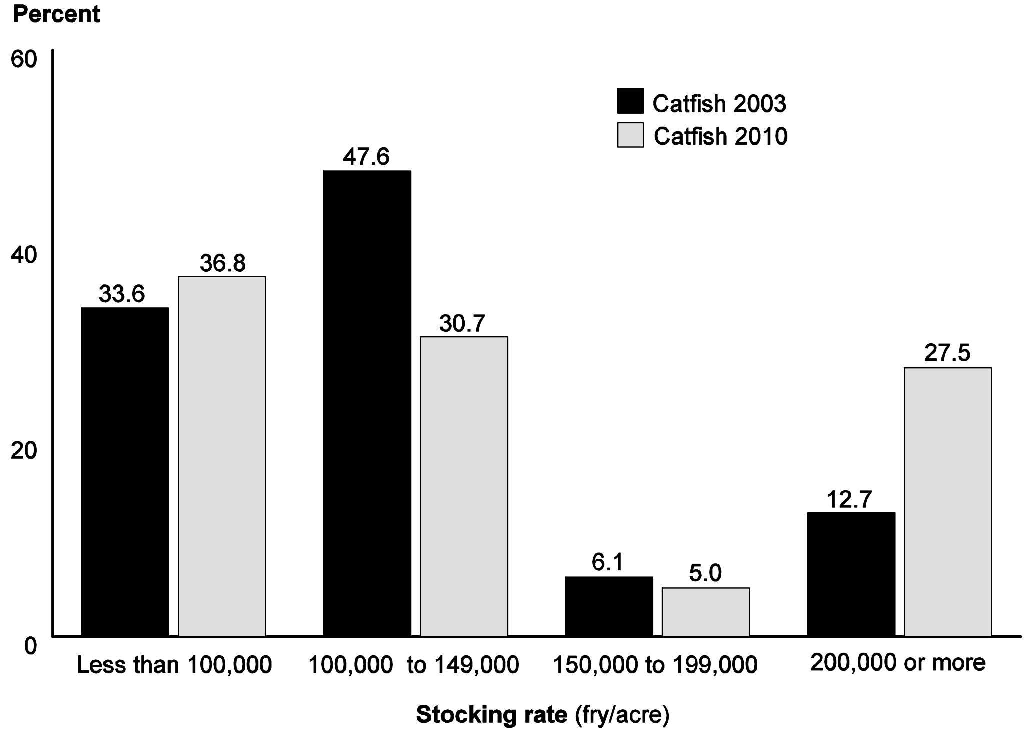
Stocking density affects health, growth rate, and survival of fish. From 2003 to 2010, the percentage of ponds stocked at a rate of 100,000 to 149,000 fry per acre decreased, while the percentage of ponds stocked at a rate of 200,000 or more fry per acre increased.

The percentage of operations that did not stock fry/fingerling ponds in the year preceding the study decreased from 11.9 percent in Catfish 2003 to 1.9 percent in 2010.

Percentage of fry/fingerling ponds by stocking rate in the year preceding the study:

	Percent Fry/Fingerling Ponds			
	Catfish 2003		**Catfish 2010**	
Stocking Rate (fry/acre)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 100,000	33.6	(3.5)	36.8	(1.3)
100,000 to 149,000	47.6	(3.4)	30.7	(1.6)
150,000 to 199,000	6.1	(1.0)	5.0	(0.3)
200,000 or more	12.7	(1.7)	27.5	(1.8)
Total	100.0		100.0	

Percentage of fry/fingerling ponds by stocking rate in the year preceding the study



3. Fry feed type

Although almost all operations provided fry with some feed before they accepted larger floating feeds, the percentage of operations that did not offer feed to fry at this stage increased from Catfish 2003 to Catfish 2010. Fines or meals remained the primary feed type offered to fry by the highest percentage of operations, but the percentage of operations offering fines or meals declined from 53.9 percent for Catfish 2003 to 38.4 percent for Catfish 2010. The percentage of operations offering fry starter also declined from Catfish 2003 to Catfish 2010, while the percentages of operations offering pellets, crumbles, and “other” feed types to fry increased from one study to the next.

Percentage of fingerling operations by primary type of feed provided to fry before the acceptance of floating feeds*:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Fry Feed Type	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Fines or meals	53.9	(1.9)	38.4	(0.9)
Crumbles	14.8	(1.2)	25.1	(0.9)
Pellets	5.5	(0.8)	11.5	(0.6)
Fry starter	21.8	(1.6)	17.3	(0.6)
Other	1.0	(0.2)	1.9	(0.1)
None	3.0	(0.7)	5.8	(0.5)
Total	100.0		100.0	

*Catfish 2010 asked specifically about feed type fed to fry during 2009, whereas Catfish 2003 did not specify a time frame.

4. Fry feeding frequency

Fingerling feeding frequency tends to vary by season. From Catfish 2003 to Catfish 2010, the percentage of operations that fed fish at least twice a day increased in the spring, when fry are present. The percentage of operations that fed fish at least twice a day in the summer declined between studies, while the percentage of operations that fed fish every other day in the summer increased. The percentage of operations that fed fish at an “other” rate in the summer also increased from Catfish 2003 to Catfish 2010. For both studies, the highest percentage of operations fed once a day during summer.

a. Percentage of fingerling operations by how often fry/fingerlings were usually fed during spring and summer*:

	Percent Fingerling Operations							
	Catfish 2003				**Catfish 2010**			
	Spring		**Summer**		**Spring**		**Summer**	
Feeding Frequency	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
At least twice a day	37.3	(1.9)	33.6	(1.9)	46.2	(0.9)	26.9	(0.8)
Once a day	40.8	(1.9)	60.7	(1.9)	38.4	(0.9)	57.7	(0.9)
Every other day	12.5	(1.3)	3.3	(0.6)	9.6	(0.5)	9.6	(0.6)
Every third day	4.0	(0.8)	1.3	(0.5)				
Other	5.4	(0.8)	1.1	(0.4)	5.8	(0.4)	5.8	(0.5)
Total	100.0		100.0		100.0		100.0	

*Catfish 2010 asked specifically about feeding practices during 2009, whereas Catfish 2003 did not specify a time frame.

For both studies, the highest percentage of operations in the fall fed once a day, while in the winter the highest percentage of operations fed at an "other" frequency. From Catfish 2003 to Catfish 2010, the percentage of operations that fed fish at least twice a day in the fall increased, and the percentages of operations that fed fish every other day or at an "other" frequency in the winter also increased.

Of Catfish 2010 operations that reported an "other" feeding frequency for winter (80.8 percent), about two-thirds either fed irregularly as needed or did not feed. Most of the remaining one-third fed between one time per week and one time per month. As reported in Catfish 2003, "other" feeding frequencies in winter were influenced by weather and pond levee conditions.

b. Percentage of fingerling operations by how often fry/fingerlings were usually fed during fall and winter*:

	Percent Fingerling Operations							
	Catfish 2003				**Catfish 2010**			
	Fall		**Winter**		**Fall**		**Winter**	
Feeding Frequency	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
At least twice a day	9.9	(1.3)	2.3	(0.5)	15.4	(0.7)	1.9	(0.3)
Once a day	49.1	(1.9)	4.3	(0.7)	53.9	(0.9)	5.8	(0.3)
Every other day	20.4	(1.5)	5.8	(0.7)	25.0	(0.8)	11.5	(0.5)
Every third day	16.7	(1.5)	13.6	(1.3)				
Other	3.9	(0.7)	74.0	(1.6)	5.7	(0.3)	80.8	(0.6)
Total	100.0		100.0		100.0		100.0	

*Catfish 2010 asked specifically about feeding practices during 2009, whereas Catfish 2003 did not specify a time frame.

5. Protein level of feed

Intermediate-sized fingerlings (2 inches or more but less than 5 inches in length) can be fed higher protein levels (such as 35 percent protein). Protein levels of 28 to 32 percent are suitable for small fingerlings (less than 2 inches in length) or large fingerlings (5 inches or more in length).

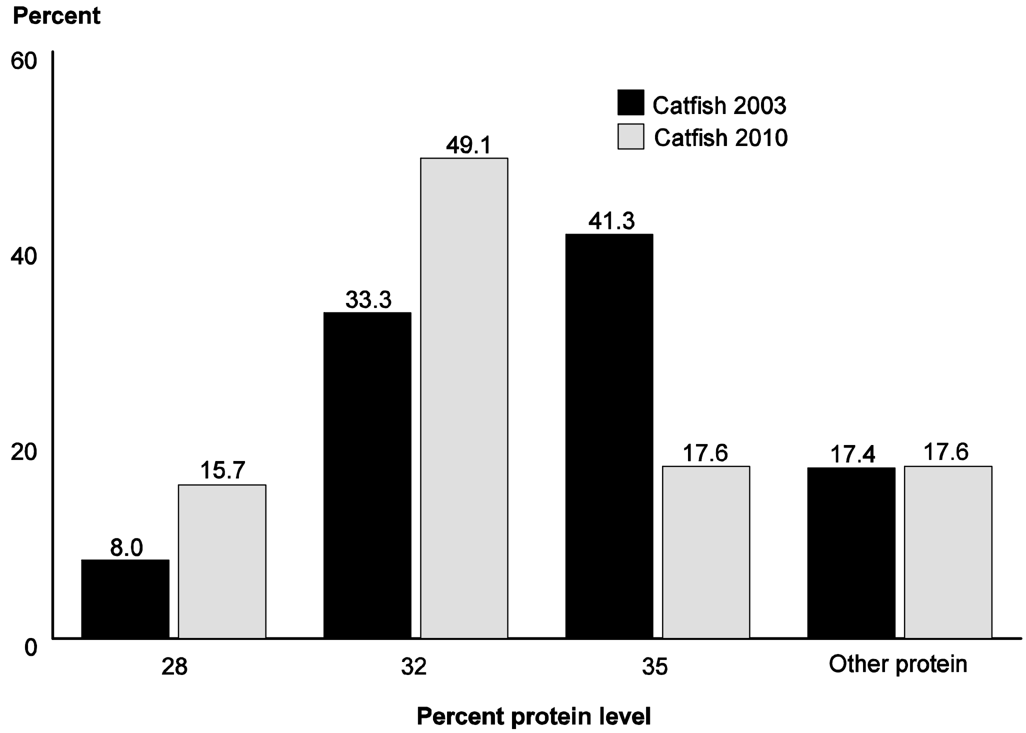
The percentages of operations primarily feeding 28 or 32 percent protein increased from Catfish 2003 to Catfish 2010, while the percentage of operations providing feed with 35 percent protein declined. From Catfish 2003 to Catfish 2010, the protein level primarily fed by the highest percentage of operations changed from 35 to 32 percent protein. For Catfish 2010, the "other" protein levels specified by respondents were primarily a combination of 36 and 38 percent protein.

Percentage of fingerling operations by percentage of protein in the floating feed primarily fed to fry/fingerlings*:

	Percent Fingerling Operations			
	Catfish 2003		**Catfish 2010**	
Percent Protein Level	**Percent**	**Std. Error**	**Percent**	**Std. Error**
28	8.0	(1.0)	15.7	(0.7)
32	33.3	(1.8)	49.1	(0.9)
35	41.3	(1.9)	17.6	(0.7)
Other protein	17.4	(1.3)	17.6	(0.6)
Total	100.0		100.0	

*Catfish 2010 asked specifically about feeding practices during 2009, whereas Catfish 2003 did not specify a time frame.

Percentage of fingerling operations by percentage of protein in the floating feed primarily fed to fry/fingerlings*



*Catfish 2010 asked specifically about feeding practices during 2009, whereas Catfish 2003 did not specify a time frame.

6. Primary method for monitoring dissolved oxygen

Notably, the percentage of operations that did not regularly monitor dissolved oxygen in fry/fingerling ponds increased from Catfish 2003 to Catfish 2010, with more than one-fourth of Catfish 2010 operations not regularly monitoring dissolved oxygen. Although the percentage of operations using hand monitors as the primary method to monitor dissolved oxygen declined from 85.9 to 73.1 percent between studies, hand monitors were the only method used for Catfish 2010, as the percentage of operations using automated sensors or “other” methods dropped to zero.

Percentage of fingerling operations by primary method used to regularly monitor dissolved oxygen in fry/fingerling ponds*:

	Percent Fingerling Operations			
	Catfish 2003		**Catfish 2010**	
Monitoring Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Automated sensors	7.7	(0.9)	0.0	(—)
Hand monitor (oxygen meter)	85.9	(1.1)	73.1	(0.7)
Other	1.6	(0.3)	0.0	(—)
Did not regularly monitor dissolved oxygen levels	4.8	(0.7)	26.9	(0.7)
Total	100.0		100.0	

*Catfish 2010 asked specifically about monitoring practices during 2009, whereas Catfish 2003 did not specify a time frame.

7. Horsepower of fixed aeration

Recommended fixed aeration rates range from 2.0 to 2.5 horsepower (hp) per acre, but the value varies with many factors, including feeding rate and stocking density. The average horsepower of fixed aeration per surface acre of fry/fingerling ponds declined from 1.8 to 1.6 hp from Catfish 2003 to Catfish 2010.

Average horsepower of fixed aeration per surface acre of fry/fingerling ponds:

Average Horsepower			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
1.8	(0.0)	1.6	(0.0)

8. Water quality testing

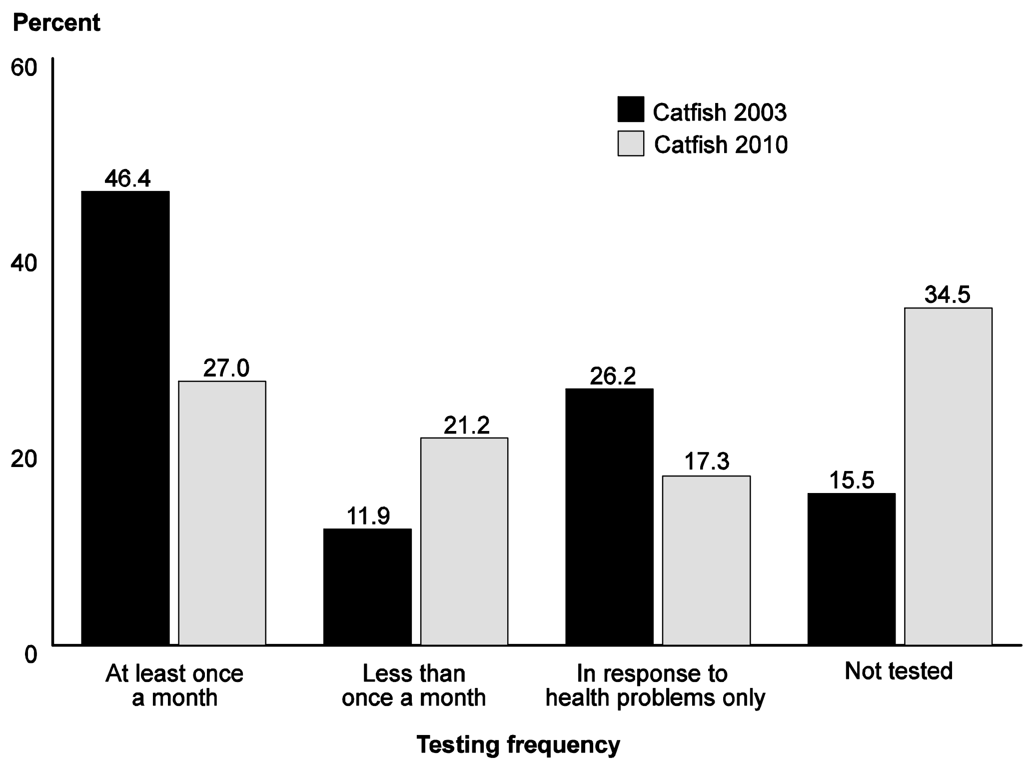
From Catfish 2003 to Catfish 2010, the percentage of operations that did not test water quality in fry/fingerling ponds more than doubled, with 34.5 percent of Catfish 2010 operations not testing. The percentage of operations testing water quality at least once a month declined from close to half of operations (46.4 percent) for Catfish 2003 to slightly more than one-fourth of operations (27.0 percent) for Catfish 2010. Concomitantly, the percentage of operations testing water quality in fry/fingerling ponds less than once a month increased between studies, from 11.9 to 21.2 percent of operations. The percentage of operations testing water quality only in response to health problems decreased from 26.2 percent of operations for Catfish 2003 to 17.3 percent of operations for Catfish 2010.

a. Percentage of fingerling operations by frequency of water quality testing in fry/fingerling ponds*:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Testing Frequency	Percent	Std. Error	Percent	Std. Error
At least once a month	46.4	(1.9)	27.0	(0.9)
Less than once a month	11.9	(1.2)	21.2	(0.8)
In response to health problems only	26.2	(1.6)	17.3	(0.7)
Not tested	15.5	(1.2)	34.5	(0.8)
Total	100.0		100.0	

*Catfish 2010 asked specifically about water quality testing during 2009, whereas Catfish 2003 did not specify a time frame.

Percentage of fingerling operations by frequency of water quality testing in fry/fingerling ponds*



*Catfish 2010 asked specifically about water quality testing during 2009, whereas Catfish 2003 did not specify a time frame.

The only changes from Catfish 2003 to Catfish 2010 were increases in the percentages of operations not testing for chloride or nitrite. These results might reflect the known higher chloride levels on operations (table G.7).

b. For operations that tested water quality in fry/fingerling ponds at least once a month, percentage of operations by number of times per month fry/fingerling ponds were tested for specific chemicals*:

	Percent Operations											
	Catfish 2003						Catfish 2010					
	Ammonia		Chloride		Nitrite		Ammonia		Chloride		Nitrite	
Times Tested	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
0	9.3	(2.2)	6.7	(1.1)	6.9	(1.2)	7.6	(0.6)	21.6	(1.4)	14.2	(0.8)
1 to 2	44.5	(3.0)	59.4	(3.0)	42.1	(3.1)	46.0	(2.1)	49.9	(2.0)	35.6	(1.8)
3 to 4	40.8	(3.0)	31.2	(2.9)	45.6	(3.1)	46.4	(2.1)	28.5	(1.9)	50.2	(2.0)
5 to 7	0.0	(—)	0.0	(—)	1.1	(0.4)	0.0	(—)	0.0	(—)	0.0	(—)
8 or more	5.4	(1.5)	2.7	(1.1)	4.3	(1.5)	0.0	(—)	0.0	(—)	0.0	(—)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

*Catfish 2010 asked specifically about water quality testing during 2009, whereas Catfish 2003 did not specify a time frame.

I. Fingerling Health Issues

1. Vaccination for enteric septicemia of catfish (ESC)

Although the time frame covered by the survey question is 2 years for Catfish 2003 and 1 year for Catfish 2010, the percentage of operations vaccinating fry against ESC appears to have declined between the two studies. Because fry hatched each year would need to be vaccinated, the data do seem to represent a true decrease in the percentage of operations vaccinating any fry against ESC.

a. Percentage of fingerling operations that vaccinated fry against ESC*:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	**Std. Error**	**Percent**	**Std. Error**
11.4	(1.3)	3.9	(0.4)

*Catfish 2003 asked about vaccination of fry against ESC in the past 2 years; Catfish 2010 asked about vaccination of fry against ESC during 2009.

On operations that vaccinated any fry against ESC, the percentage of fry vaccinated increased from 18.1 to 49.1 percent.

b. For fingerling operations that vaccinated any fry against ESC in the year prior to the study,* percentage of fry (weighted by number of fry stocked) that were vaccinated:

Percent Fry			
Catfish 2003		Catfish 2010	
Percent	**Std. Error**	**Percent**	**Std. Error**
18.1	(4.9)	49.1	(1.2)

*Although Catfish 2003 asked about vaccination of fry against ESC in the past 2 years; data on the percentage of fry vaccinated are presented only for the year prior to the study to be consistent with data from Catfish 2010.

2. Average age of fry at ESC vaccination

Fry should be at least 7 days old before they are vaccinated for ESC. The operation average number of days after hatching that fry were vaccinated increased from 8.8 days for Catfish 2003 to 15.1 days for Catfish 2010.

For fingerling operations that vaccinated any fry against ESC, operation average number of days after hatching that fry typically were vaccinated against ESC:

Operation Average			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
8.8	(0.4)	15.1	(0.6)

3. ESC vaccination of fry intended for on-farm growout

Although it appears that vaccination practices for fry intended for growout on the operation changed considerably from Catfish 2003 to Catfish 2010, it is not possible to draw conclusions about vaccination practices because few producers (3.9 percent) vaccinated for ESC for Catfish 2010.

For fingerling operations that vaccinated any fry against ESC, percentage of operations by routine vaccination practice* for fry **intended for growout** on the operation:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Vaccination Practice	**Percent**	**Std. Error**	**Percent**	**Std. Error**
All fry intended for growout on operation	29.4	(5.1)	0.0	(—)
A portion of the fry	39.0	(6.3)	100.0	(0.0)
None of the fry	16.9	(5.1)	0.0	(—)
No fry growout on this operation	14.7	(3.8)	0.0	(—)
Total	100.0		100.0	

*Catfish 2010 asked specifically about vaccination practices during 2009, whereas Catfish 2003 asked about routine practices without specifying a time frame.

4. ESC vaccination of fry intended for sale as fingerlings

Similar to findings shown in the table above for ESC vaccination of fry intended for on-farm growout, 100.0 percent of Catfish 2010 operations that vaccinated any fry against ESC vaccinated a portion of the fry that were intended for sale as fingerlings, but only on customer request; this was an increase from 30.6 percent of operations for Catfish 2003. As noted above, however, few producers vaccinated for ESC, which makes it difficult to draw conclusions.

For fingerling operations that vaccinated any fry against ESC, percentage of operations by vaccination practice for fry **intended for sale***:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Vaccination Practice	**Percent**	**Std. Error**	**Percent**	**Std. Error**
All fry intended for sale	5.2	(2.6)	0.0	(—)
A portion of the fry for sale based on customer request	30.6	(5.6)	100.0	(0.0)
A portion of the fry for sale regardless of customer request	16.6	(5.0)	0.0	(—)
None of the fry intended for sale	16.3	(4.9)	0.0	(—)
No fry for sale	31.3	(5.7)	0.0	(—)
Total	100.0		100.0	

*Catfish 2010 asked specifically about vaccination practices during 2009, whereas Catfish 2003 asked about routine practices without specifying a time frame.

5. Survival of stocked fry until harvest

The operation average percent survival of fry stocked until harvest as fingerlings declined slightly between the two studies, from 69.0 for Catfish 2003 to 66.7 for Catfish 2010. The percent survival of fry (weighted by the number of fry stocked) was similar for the two studies.

For stocked fry,* operation average and fry average (weighted by the number of fry stocked) percent survival until harvest as fingerlings:

	Average			
	Catfish 2003		Catfish 2010	
Percent Survival	**Average**	**Std. Error**	**Average**	**Std. Error**
Operation average	69.0	(0.7)	66.7	(0.3)
Fry average	66.2	(1.6)	65.1	(4.4)

*For Catfish 2003, the question asked about survival of stocked fry during the past 2 years; for Catfish 2010, the question asked about survival of stocked fry during 2009.

6. Causes of fingerling loss

With large numbers of fry being stocked into ponds and not readily visible, it can be very difficult for producers to observe losses and identify causes of loss. The percentage of operations that lost any fry/fingerlings to unknown causes increased from slightly less than half for Catfish 2003 to almost three-fourths of operations for Catfish 2010, and 38.5 percent of all fingerling operations participating in the 2010 study attributed all fry/fingerling loss to unknown causes (data not shown).

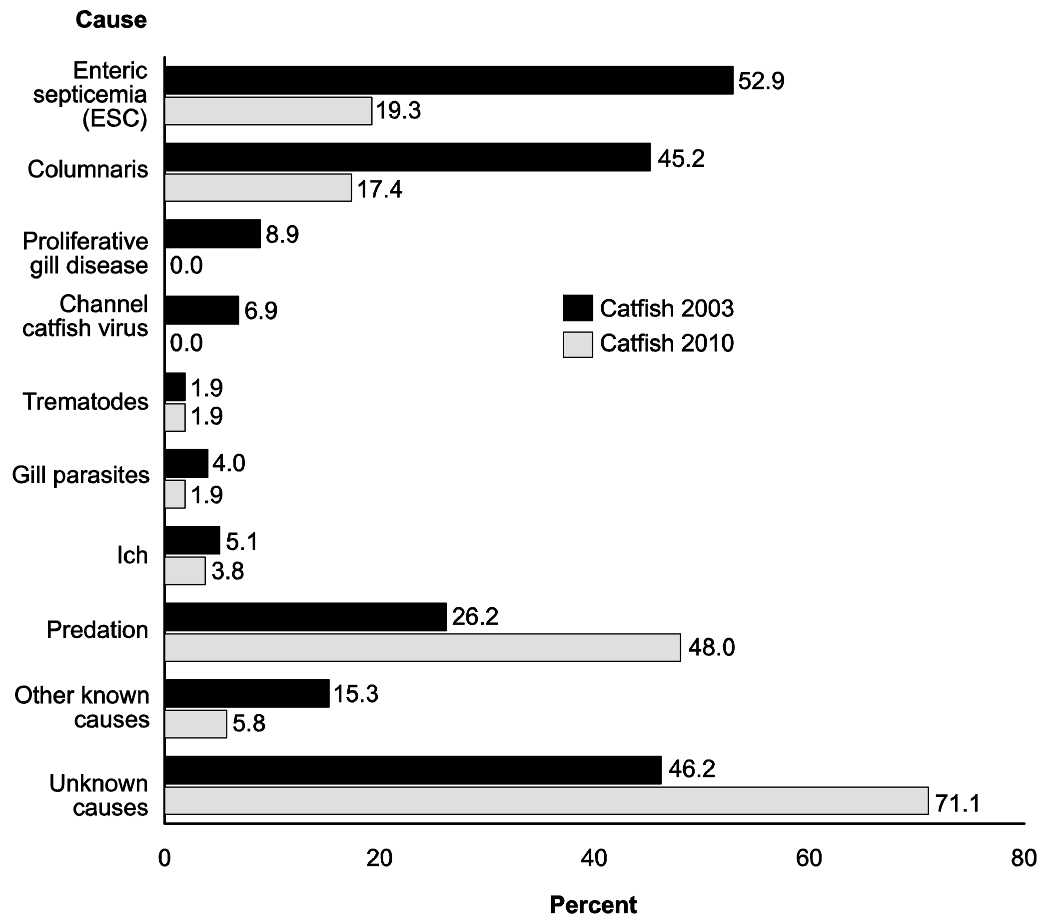
The percentages of operations that lost any fry/fingerlings to ESC, columnaris, proliferative gill disease, or channel catfish virus (CCV) declined between studies. The percentages of operations that lost any fry/fingerlings to gill parasites or "other" known causes also decreased between the two studies. The percentages of operations that lost any fry/fingerlings to predation increased from Catfish 2003 to Catfish 2010.

a. Percentage of fingerling operations that lost any fry/fingerlings* to the following causes:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Cause of Loss	Percent	Std. Error	Percent	Std. Error
Enteric septicemia (ESC)	52.9	(1.9)	19.3	(0.8)
Columnaris	45.2	(1.9)	17.4	(0.7)
Proliferative gill disease	8.9	(1.3)	0.0	(—)
Channel catfish virus	6.9	(1.2)	0.0	(—)
Trematodes	1.9	(0.6)	1.9	(0.1)
Gill parasites	4.0	(0.7)	1.9	(0.1)
Ich	5.1	(0.7)	3.8	(0.2)
Predation	26.2	(1.7)	48.0	(0.9)
Other known causes	15.3	(1.5)	5.8	(0.5)
Unknown causes	46.2	(1.9)	71.1	(0.8)

*For Catfish 2003, the question asked about fry stocked during the last 2 years that did not survive until harvest as fingerlings; for Catfish 2010, the question asked about fry stocked in 2009 that did not survive until harvest as fingerlings.

Percentage of fingerling operations that lost any fry/fingerlings* to the following causes



*For Catfish 2003, the question asked about fry stocked during the last 2 years that did not survive until harvest as fingerlings; for Catfish 2010, the question asked about fry stocked in 2009 that did not survive until harvest as fingerlings.

From Catfish 2003 to Catfish 2010, trends in the percentages of fry/fingerlings lost were difficult to assess because of high variability associated with the estimates. Although the percentages of operations that had losses from ESC or columnaris declined between the two studies (table I.6.a), the percentages of fry/fingerlings lost to those causes on affected operations did not change substantially. The percentages of fry/fingerlings lost to proliferative gill disease, CCV, gill parasites, or ich declined to zero or near zero.

b. Percentage of fry/fingerlings (weighted by the number of fry stocked[1]) lost to the following causes:

	Percent Fry Lost			
	Catfish 2003		Catfish 2010	
Cause of Loss	Percent	Std. Error	Percent	Std. Error
Enteric septicemia (ESC)	27.3	(2.6)	20.2	(11.2)
Columnaris	24.8	(2.9)	19.1	(11.4)
Proliferative gill disease	3.0	(0.8)	0.0	(—)
Channel catfish virus	8.2	(3.1)	0.0	(—)
Trematodes	0.9	(0.6)	0.0[2]	(0.0)
Gill parasites	0.7	(0.3)	0.0[2]	(0.0)
Ich	0.9	(0.3)	0.1	(0.0)
Predation	6.0	(1.1)	10.5	(7.3)
Other known causes	9.8	(4.0)	4.3	(3.5)
Unknown causes	18.4	(3.5)	45.8	(18.2)
Total	100.0		100.0	

[1]For Catfish 2003, the question asked about fry stocked during the last 2 years that did not survive until harvest as fingerlings; for Catfish 2010, the question asked about fry stocked in 2009 that did not survive until harvest as fingerlings.
[2]Although 1.9 percent of operations reported losses to trematodes and gill parasites in 2009, these losses rounded to zero.

7. Primary treatment for ESC outbreaks

From Catfish 2003 to Catfish 2010, the percentage of fingerling operations that experienced ESC outbreaks decreased from 78.2 percent of operations to 40.4 percent.

a. Percentage of fingerling operations that experienced ESC outbreaks:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
78.2	(1.4)	40.4	(0.9)

From Catfish 2003 to Catfish 2010, the primary treatment the majority of operations used to treat fry/fingerlings with ESC changed from cessation of feeding to medicated feed. This result is likely due to the recent availability of a new antibiotic to treat ESC. Of Catfish 2003 operations that experienced ESC outbreaks, the majority (70.0 percent) treated fry/fingerlings with ESC by taking them off feed. For Catfish 2010, the majority of operations (66.7 percent) fed medicated feed to fry/fingerlings with ESC. The percentages of operations that treated fish by reducing their feed or taking them off feed declined between the two studies, whereas the percentage of operations treating fingerlings with medicated feed increased.

b. Percentage of fingerling operations by primary treatment for fry/fingerlings with ESC:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Primary Treatment	Percent	Std. Error	Percent	Std. Error
Medicated feed	23.1	(1.8)	66.7	(1.5)
Regular feed on alternate days (reduce feed)	3.8	(0.9)	0.0	(—)
Take off feed	70.0	(2.0)	28.6	(1.5)
Other	3.1	(0.8)	4.7	(0.7)
Total	100.0		100.0	

8. Diagnostic laboratory testing

Submitting samples to a diagnostic laboratory and obtaining a firm diagnosis can help producers choose the best treatment to fight the disease. Producers who have seen diseases affect their fish before, however, might be able to identify some diseases and treatments on their own and might choose not to submit samples to a laboratory. Additionally, some producers might opt to use certain treatments for ill fish regardless of the cause of disease, or there might not be effective treatments available.

Overall, the percentage of fingerling operations that submitted any fingerling samples to a diagnostic laboratory for any reason declined between studies. As for Catfish 2003 producers, however, about one-fifth of Catfish 2010 producers submitted samples to a diagnostic laboratory to detect a problem early. The percentages of operations submitting samples to confirm a cause of disease, identify an unknown disease, or for an "other" reason declined from Catfish 2003 to Catfish 2010.

Percentage of fingerling operations that submitted any fingerling samples to a diagnostic laboratory in the year preceding the study, by reason for submission:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Reason	Percent	Std. Error	Percent	Std. Error
Detect problem early	18.0	(1.6)	21.1	(0.8)
Confirm cause of disease	27.5	(1.8)	13.5	(0.7)
Identify unknown disease	26.4	(1.8)	5.8	(0.4)
Other reason	3.1	(0.8)	0.0	(—)
Any reason	40.3	(1.9)	25.0	(0.9)

9. Use of medicated feed

Medicated feed is used to treat disease in catfish. The percentage of operations that fed medicated feed to catfish fry did not change from Catfish 2003 to Catfish 2010.

a. Percentage of fingerling operations that fed medicated feed to fry in the year preceding the study:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
27.0	(1.8)	28.9	(0.8)

Since Catfish 2003, Aquaflor® has joined Terramycin® and Romet® in having Food and Drug Administration approval for use in catfish feed. For Catfish 2010, three-fifths of operations that fed medicated feed (60.2 percent) used Aquaflor, which is the only antimicrobial approved for treatment of both ESC and columnaris, the two most important bacterial diseases of catfish. For Catfish 2003, some operations that fed medicated feed to fry/fingerlings used both Terramycin and Romet; by Catfish 2010, the percentage of operations using these two medicated feeds had declined, from 80.7 percent of operations to 14.2 percent for Terramycin and from 42.3 percent of operations to 26.6 percent for Romet.

b. For operations that fed medicated feed to fry/fingerlings in the year preceding the study, percentage of fingerling operations by type of medicated feed used:

	Percent Fingerling Operations			
	Catfish 2003		Catfish 2010	
Medicated Feed	Percent	Std. Error	Percent	Std. Error
Terramycin®	80.7	(2.8)	14.2	(0.8)
Romet®	42.3	(4.2)	26.6	(1.3)
Aquaflor®			60.2	(1.5)

By the 2010 study, Aquaflor had supplanted Terramycin and Romet as the primary medicated feed fed to catfish fry, with 26.2 tons fed to fry/fingerlings in the year preceding the study. In contrast, the amount of Terramycin fed to fry/fingerlings declined to 0.1 tons, while the amount of Romet fed to fry/fingerlings declined to 1.6 tons.

c. For fingerling operations that fed medicated feed to fry/fingerlings in the year preceding the study, average tons of medicated feed fed:

	Average Tons of Feed			
	Catfish 2003		Catfish 2010	
Medicated Feed	**Average**	**Std. Error**	**Average**	**Std. Error**
Terramycin	8.4	(0.9)	0.1	(0.0)
Romet	4.7	(0.8)	1.6	(0.2)
Aquaflor			26.2	(2.0)

10. Snail control

Ramshorn snails are an intermediate host in the complex life cycle of the trematode *Bolbophorus* spp*,* an important parasite in the catfish industry. Snails must be present for the trematode to complete its life cycle, but the presence of snails does not necessarily mean that operations will have trematode problems. The percentage of operations that had a problem with snails in fry/fingerling ponds increased from 11.6 percent for Catfish 2003 to 23.1 percent for Catfish 2010.

a. Percentage of fingerling operations that had a problem with snails in any fry/fingerling ponds in the year preceding the study:

Percent Fingerling Operations			
Catfish 2003		Catfish 2010	
Percent	**Std. Error**	**Percent**	**Std. Error**
11.6	(1.4)	23.1	(0.8)

To evaluate whether the absence of a snail problem was tied to use of snail-control measures, all fingerling operations were asked if they used measures to control snails. No operations that did not report a snail problem used snail-control measures; consequently, the absence of snail problems was not directly due to control measures.

Although the percentage of operations using any measures to control snails in fry/fingerling ponds declined from Catfish 2003 to Catfish 2010, the percentages of operations using the individual measures listed increased (for weed control) or stayed the same between the two studies.

b. Percentage of fingerling operations that used the following measures to control snails in fry/fingerling ponds:

	Percent Fingerling Operations			
	Catfish 2003		**Catfish 2010**	
Measure	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Lime	8.6	(1.2)	7.7	(0.4)
Copper	14.5	(1.5)	11.5	(0.6)
Weed control	7.7	(1.1)	11.6	(0.6)
Biological control	3.8	(0.9)	1.9	(0.3)
Other measures	2.3	(0.6)	0.0	(—)
Any measures	26.8	(1.7)	19.2	(0.7)

Section II: Population Estimates, Foodsize Catfish

A. Inventory Characteristics

1. Genetic lines

From Catfish 2003 to Catfish 2010, the percentages of operations raising channel x blue hybrid catfish or unspecified channel catfish increased, while the percentages of operations raising NWAC103, Kansas, Goldkist, or other channel catfish lines decreased. For both study years, the majority of operations raised unspecified channel catfish.

a. Percentage of foodsize-fish operations that had any of the following lines of fish present on January 1 of the study year:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Line	Percent	Std. Error	Percent	Std. Error
NWAC103	5.9	(0.5)	1.5	(0.1)
Kansas	7.0	(0.5)	3.1	(0.2)
Goldkist[1]	28.4	(0.9)	7.0	(0.3)
Auburn			1.3	(0.1)
Norris	0.3	(0.1)		
Channel x blue hybrid catfish	2.1	(0.3)	21.2	(0.5)
Other channel catfish line	10.0	(0.6)	1.0	(0.1)
Unspecified channel catfish[2]	65.3	(1.0)	81.9	(0.4)

[1]Catfish 2010 included Harvest Select catfish with Goldkist catfish.
[2]Catfish 2003 asked about “unknown line.”

The percentages of foodsize fish by genetic line showed similar patterns to the percentages of operations raising particular lines of catfish. From one study to the next, unspecified channel catfish and channel x blue hybrid catfish increased as a percentage of fish present, while NWAC103, Goldkist, and other channel catfish lines declined as a percentage of fish present. For both studies, the majority of fish present were unspecified channel catfish.

b. Percentage of foodsize fish by line of fish present on January 1 of the study year:

	Percent Foodsize-fish			
	Catfish 2003		**Catfish 2010**	
Line	**Percent**	**Std. Error**	**Percent**	**Std. Error**
NWAC103	2.4	(0.5)	0.5	(0.2)
Kansas	2.6	(0.5)	2.2	(0.8)
Goldkist[1]	22.4	(3.3)	4.2	(1.2)
Auburn			0.1	(0.0)
Norris	0.1	(0.0)		
Channel x blue hybrid catfish	1.2	(0.3)	5.9	(1.0)
Other channel catfish line	6.9	(1.4)	1.3	(0.8)
Unspecified channel catfish[2]	64.4	(3.5)	85.8	(2.4)
Total	100.0		100.0	

[1]Catfish 2010 included Harvest Select catfish with Goldkist catfish.
[2]Catfish 2003 asked about “unknown line.”

2. Selection criteria for fingerlings or stockers

From Catfish 2003 to Catfish 2010, the reason selected by the highest percentage of operations as the most important in selecting fingerlings or stockers changed from producer reputation to price. The percentage of operations that considered price to be the most important reason increased between the two studies (from 29.3 to 33.9 percent of operations), while the percentage of operations that considered producer reputation to be the most important reason declined (from 34.3 to 28.8 percent of operations). The percentage of operations that chose distance from source or supplier or other considerations as the most important reason increased between studies, while the percentage of operations that considered disease resistance to be the most important reason declined.

Percentage of foodsize-fish operations by the **most important reason** for selecting fingerlings or stockers:

	Percent Foodsize Operations			
	Catfish 2003		Catfish 2010	
Selection Criterion	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Price	29.3	(0.9)	33.9	(0.6)
Growth characteristics	14.0	(0.7)	15.0	(0.4)
Disease resistance	6.9	(0.5)	3.9	(0.2)
Fish size	13.1	(0.7)	11.1	(0.4)
Distance from source or supplier	0.7	(0.2)	1.5	(0.1)
Producer reputation	34.3	(1.0)	28.8	(0.6)
Other considerations	1.7	(0.2)	5.8	(0.3)
Total	100.0		100.0	

B. Stocking Practices

1. Stocking density

The stocking density of fingerlings in catfish production ponds is a key production variable and can have far-reaching production implications. Variability in stocking rate among operations has been attributed to differences in production goals, facilities, and other resources that vary from farm to farm.

From Catfish 2003 to Catfish 2010, the operation average number of fish stocked per acre declined.

a. Operation average and weighted average stocking rate (fish typically stocked per surface acre) for foodfish ponds, by size of operation:

	Average Number Stocked per Acre			
	Catfish 2003		Catfish 2010	
Stocking Rate	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Operation	5,752	(38)	5,553	(24)
Weighted average	6,390	(178)	5,836	(176)

For both the 2003 and 2010 studies, most foodsize-fish operations usually stocked between 4,001 and 8,000 fish per acre. Although this overall pattern was similar for the two studies, there was a slight decrease between studies in the percentage of operations stocking 6,001 to 8,000 fish per acre and a slight increase in the percentage of operations stocking fewer than 2,001 fish per acre.

b. Percentage of operations by number of fish per acre usually stocked in growout ponds:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Number Fish per Acre	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Fewer than 2,001	3.6	(0.3)	6.4	(0.3)
2,001 to 4,000	14.9	(0.7)	16.6	(0.4)
4,001 to 6,000	48.4	(1.0)	47.3	(0.6)
6,001 to 8,000	26.5	(0.9)	23.4	(0.5)
More than 8,000	6.6	(0.5)	6.3	(0.3)
Total	100.0		100.0	

2. Sources of fish

From Catfish 2003 to Catfish 2010, the percentage of operations that purchased fish as fingerlings from another operation to stock into ponds increased, while the percentage of operations that purchased fish as fry from another source decreased. Purchasing fish as fingerlings rather than as fry might have fewer risks and result in greater productivity.

a. Percentage of foodsize-fish operations that stocked any fish into growout ponds, by source of fish in the year preceding the study:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Source	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Purchased as fry from another source	17.5	(0.8)	9.6	(0.5)
Purchased as fingerlings from another operation	69.4	(0.9)	78.6	(0.7)
Produced by this operation	19.6	(0.8)	17.6	(0.6)

The percentages of fish stocked by source showed a similar pattern to the percentages of operations that used the listed sources. From Catfish 2003 to Catfish 2010, the percentage of fish purchased as fingerlings from another operation increased, while the percentage of fish purchased as fry from another operation decreased.

b. Operation average percentage of fish stocked into growout ponds, by source of fish in the year preceding the study:

	Operation Average Percent Fish Stocked			
	Catfish 2003		Catfish 2010	
Source	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Purchased as fry from another source	15.2	(0.7)	7.4	(0.4)
Purchased as fingerlings from another operation	66.6	(0.9)	76.1	(0.7)
Produced by this operation	18.2	(0.8)	16.5	(0.6)
Total	100.0		100.0	

3. Sizes of fish stocked

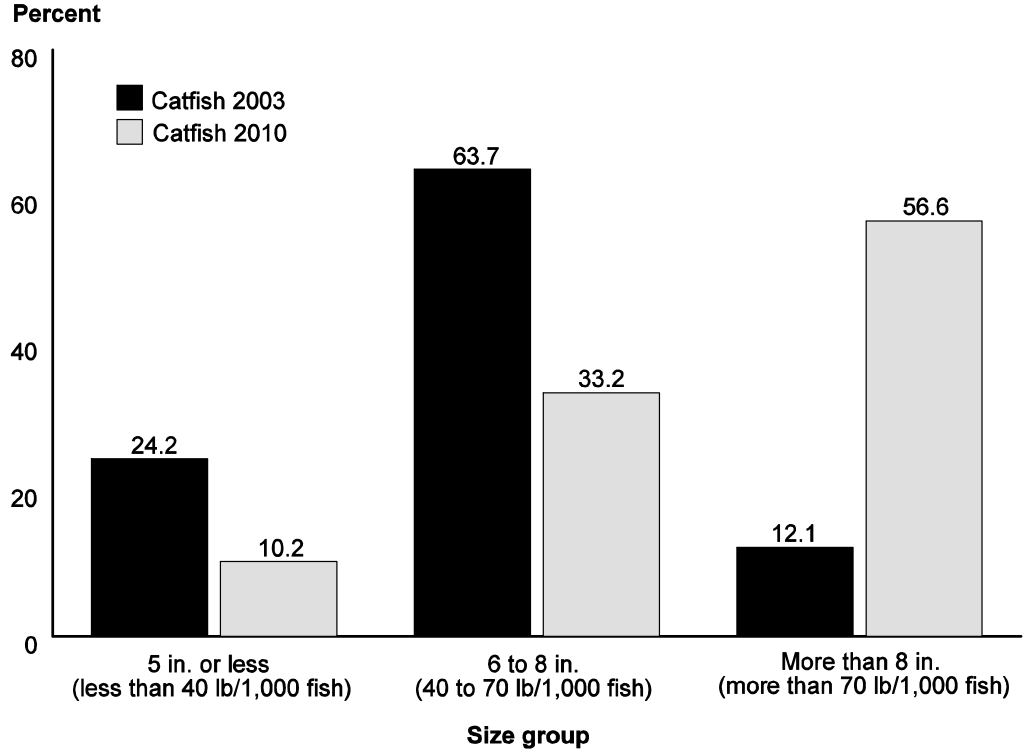
The tables in Section B.1 (above) indicate a slight trend between the two studies of higher percentages of operations stocking fewer fish per acre. This apparent trend might be related to the size of fish being stocked in growout ponds. From Catfish 2003 to Catfish 2010, the operation average percentage of fish stocked that were more than 8 inches long increased from 12.1 to 56.6 percent, while the percentage of 6- to 8-inch fish stocked declined from 63.7 to 33.2 percent. The percentage of fish stocked that were 5 inches long or less also decreased between studies. One factor that has likely contributed to the increased size of fish stocked in growout ponds is the increased use of channel x blue hybrid catfish (see Section II, tables A.1.a and A.1.b), because hybrid fingerlings grow faster and are typically larger at the end of the fingerling growing season.

Operation average percentage of fish stocked in growout ponds by size group*:

	Operation Average Percent Fish Stocked			
	Catfish 2003		Catfish 2010	
Size Group	Percent	Std. Error	Percent	Std. Error
5 in. or less (less than 40 lb/ 1,000 fish)	24.2	(0.8)	10.2	(3.7)
6 to 8 in. (40 to 70 lb/1,000 fish)	63.7	(0.8)	33.2	(8.3)
More than 8 in. (more than 70 lb/1,000 fish)	12.1	(0.6)	56.6	(9.3)
Total	100.0		100.0	

*Catfish 2003 asked about typical stocking practices, while Catfish 2010 asked about fish stocked during 2009.

Operation average percentage of fish stocked in growout ponds by size group*



*Catfish 2003 asked about typical stocking practices, while Catfish 2010 asked about fish stocked during 2009.

4. Types of ponds stocked

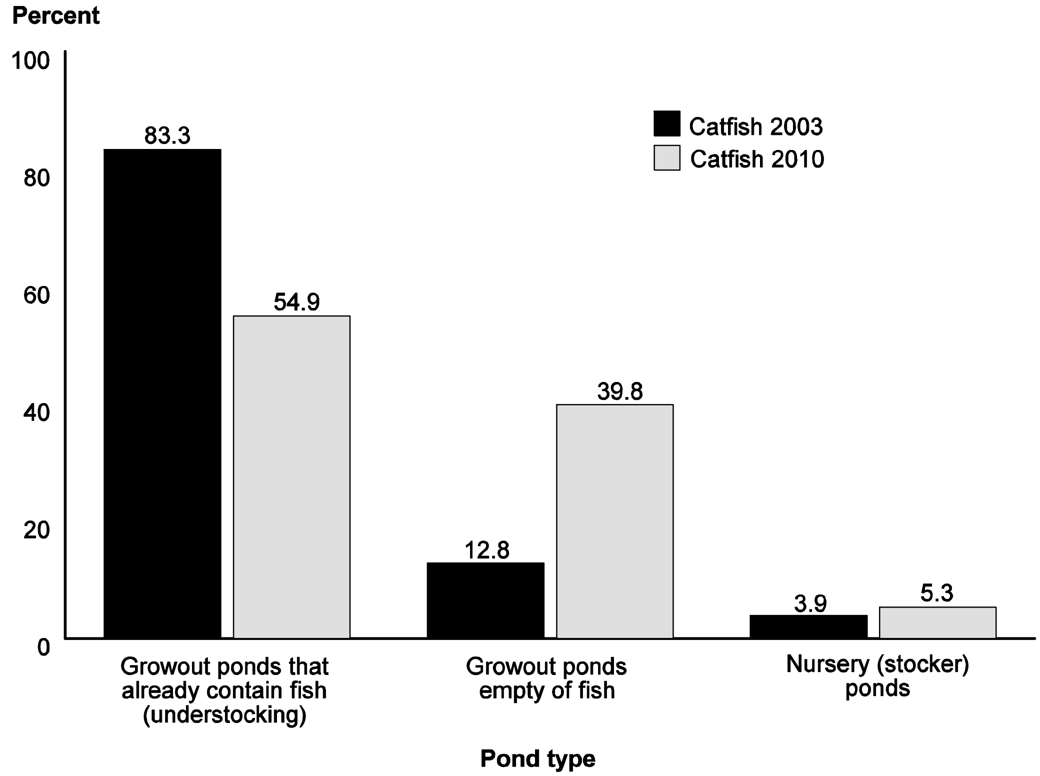
Many catfish producers place fingerlings into ponds with existing catfish, a practice known as understocking. Understocking enhances use of pond resources and provides for more continual harvesting of fish (and resulting increased cash flow).

Despite the large standard errors for Catfish 2010, the data indicate that the operation average percentage of fingerlings stocked into growout ponds already containing fish decreased between studies, while the operation average percentage of fingerlings stocked in growout ponds empty of fish increased slightly. The increased use of channel x blue hybrid catfish (see Section II, tables A.1.a and A.1.b) might be contributing to the decline in understocking because of the single-batch production processes typically used for hybrid catfish.

Operation average percentage of fingerlings stocked in the year preceding the study by pond type:

	Operation Average Percent Fingerlings Stocked			
	Catfish 2003		Catfish 2010	
Pond Type	Percent	Std. Error	Percent	Std. Error
Growout ponds that already contain fish (understocking)	83.3	(0.7)	54.9	(12.1)
Growout ponds empty of fish	12.8	(0.6)	39.8	(12.8)
Nursery (stocker) ponds	3.9	(0.4)	5.3	(2.0)
Total	100.0		100.0	

Operation average percentage of fingerlings stocked in the year preceding the study by pond type



5. Additional species stocked

Catfish producers sometimes add fish species other than catfish to production ponds. These other species can benefit the production pond in several ways, such as serving as a food source for catfish, grazing on undesirable vegetation, or feeding on phytoplankton or zooplankton. Some of the noncatfish species can be harvested and sold.

The percentage of foodsize-fish operations that stocked at least one fish species in addition to the primary fish (catfish) declined between the two studies, from 53.3 to 46.4 percent. Although the percentage of operations that stocked threadfin shad increased from 13.1 to 29.6 percent, the percentages of operations that stocked other species specifically listed for both studies decreased. Threadfin shad graze on phytoplankton and are a natural prey item for catfish.

Percentage of operations by additional fish species stocked into ponds used for foodsize catfish:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Species	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Threadfin shad	13.1	(0.6)	29.6	(0.6)
Gizzard shad			9.1	(0.4)
Redear sunfish (shellcrackers)	2.7	(0.3)	1.0	(0.1)
Fathead minnows	10.9	(0.5)	7.8	(0.3)
Black carp	4.1	(0.4)		
Grass carp	42.1	(1.0)	25.4	(0.5)
Other	4.8	(0.4)	2.2	(0.1)
Any	53.3	(1.0)	46.4	(0.6)

C. Characteristics of Growout Ponds

1. Pond size

Although the average number of ponds and total water surface acres used by foodsize-fish operations appeared to decline slightly between the two studies, there were no differences, in large part because of high associated standard errors.

a. Average number of ponds and total surface acres used by foodsize-fish operations*:

	Average			
	Catfish 2003		Catfish 2010	
Ponds/Acres	Average	Std. Error	Average	Std. Error
Number of ponds	18.8	(1.1)	16.7	(0.6)
Total surface acres	205.6	(12.7)	180.4	(6.5)

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

The average growout pond size was similar for the two studies. This finding might indicate that there was little construction of new ponds

b. Average size in surface acres of growout ponds*:

Average Pond Size (surface acres)			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
11.0	(0.1)	10.8	(0.1)

For both studies, more than half of all growout ponds were 10 to 15 surface acres. The only change from Catfish 2003 to Catfish 2010 in the sizes of growout ponds used was a decrease in the percentage of ponds of 16 to 20 surface acres.

c. Percentage of all growout ponds used for production* by size of pond (surface acres):

	Percent Growout Ponds			
	Catfish 2003		Catfish 2010	
Pond Size (surface acres for foodsize fish)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 5	9.8	(0.8)	8.2	(0.3)
5 to 9	20.0	(0.8)	23.1	(0.9)
10 to 15	52.7	(1.7)	57.8	(1.1)
16 to 20	15.2	(1.6)	7.3	(0.2)
More than 20	2.3	(0.6)	3.6	(0.2)
Total	100.0		100.0	

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

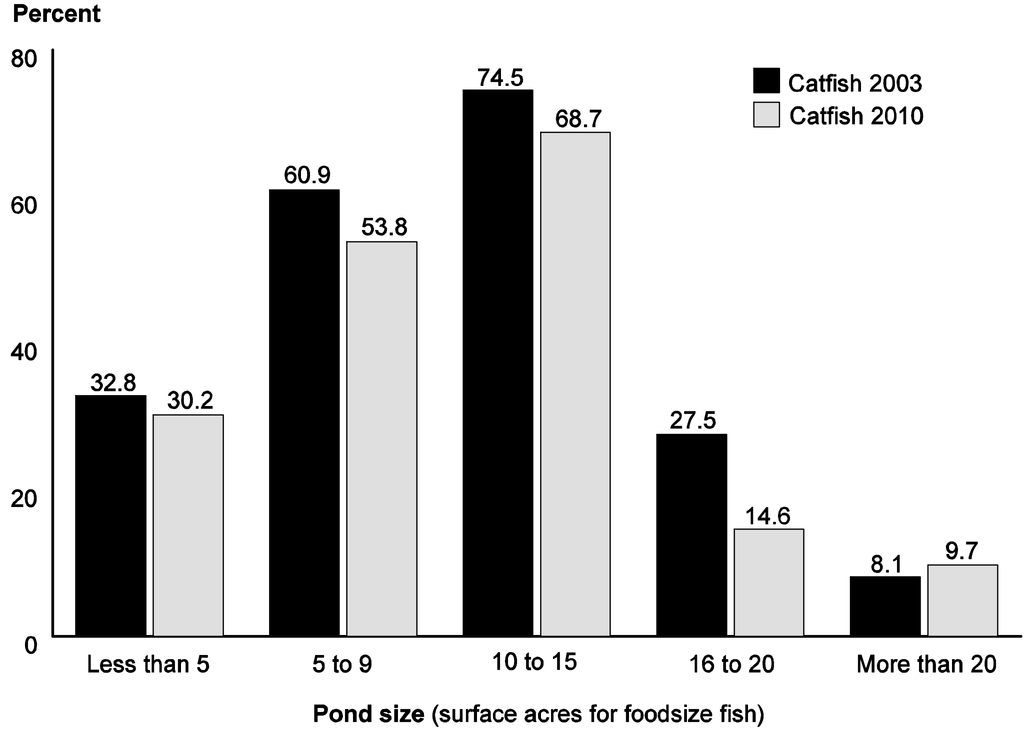
For both studies, more than half of operations had some ponds that were 5 to 9 or 10 to 15 surface acres. The percentages of operations having ponds of this size, however, declined from Catfish 2003 to Catfish 2010, as did the percentage of operations with any ponds of 16 to 20 surface acres. The percentages of operations with ponds less than 5 surface acres or more than 20 surface acres were similar for the two studies.

d. Percentage of operations with growout ponds* of particular size:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Pond Size (surface acres for foodsize fish)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 5	32.8	(0.9)	30.2	(0.5)
5 to 9	60.9	(1.0)	53.8	(0.6)
10 to 15	74.5	(0.8)	68.7	(0.5)
16 to 20	27.5	(0.9)	14.6	(0.4)
More than 20	8.1	(0.6)	9.7	(0.3)

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

Percentage of operations with growout ponds* of particular size



*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

2. Water source

Although well water is typically dependable, free of wild fish and potential fish pathogens, and less likely to contain undesirable materials, pumping the water necessitates additional equipment and is costly. Surface water is not always dependable and can contain wild fish, potential pathogens, and other undesirable materials.

The percentages of ponds filled by the listed water sources were similar for the two studies, with the exception of ponds filled by “other” sources, which declined from 2 percent to zero.

Percentage of growout ponds* by water source:

	Percent Growout ponds			
	Catfish 2003		Catfish 2010	
Water Source	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Well (levee pond)	72.5	(2.1)	76.5	(1.0)
Surface water (watershed pond, stream, spring)	25.5	(1.9)	23.5	(1.0)
Other	2.0	(0.3)	0.0	(—)
Total	100.0		100.0	

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

3. Pond water depth

The recommended depth for growout ponds is 3 to 5 feet deep, but depth tends to vary in watershed ponds, which often are constructed in hilly terrain with variations in topography.

From Catfish 2003 to Catfish 2010, the percentage of operations with an average pond depth less than 4.0 feet deep decreased, from 4.1 percent of operations to 2.7 percent. The percentages of operations with an average pond depth in the remaining listed depth categories were similar for the studies.

a. Percentage of foodsize-fish operations by **average** pond* water depth:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Average Pond Water Depth (feet)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 4.0	4.1	(0.4)	2.7	(0.2)
4.0 to 5.0	72.8	(0.8)	74.8	(0.5)
Greater than 5.0 to 6.0	14.1	(0.7)	14.3	(0.4)
Greater than 6.0	9.0	(0.5)	8.2	(0.3)
Total	100.0		100.0	

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

The percentage of operations with a maximum pond depth greater than 6.0 feet deep increased from 56.9 percent for Catfish 2003 to 71.7 percent for Catfish 2010. Concomitantly, the percentages of operations with maximum pond depths of 4.0 to 5.0 feet or greater than 5.0 to 6.0 feet declined between studies. These changes are more likely due to changes in the population of operations (e.g., operations going out of business) than to changes in existing pond depths or to new pond construction.

b. Percentage of foodsize-fish operations by **maximum** pond* water depth:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Maximum Pond Water Depth (feet)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 4.0	0.2	(0.1)	0.5	(0.1)
4.0 to 5.0	16.5	(0.7)	10.3	(0.3)
Greater than 5.0 to 6.0	26.4	(0.9)	17.5	(0.4)
Greater than 6.0	56.9	(0.9)	71.7	(0.5)
Total	100.0		100.0	

*Ponds in use at time of study for Catfish 2003 and ponds used during 2009 for Catfish 2010.

D. Management of Production Ponds

1. Levee management

The percentage of operations using either of the listed measures for levee management increased slightly from Catfish 2003 to Catfish 2010, with more than 95 percent of foodsize-fish operations using at least one of the two listed measures in 2010. Interestingly, the percentages of operations using the specific listed measures decreased slightly between studies.

Percentage of foodsize-fish operations that use the following measures to control erosion or improve vehicle access on levees:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Levee Management Measure	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Vegetation on levee sides	94.1	(0.4)	91.0	(0.3)
Gravel on levee tops	86.2	(0.6)	81.3	(0.4)
Either measure	94.1	(0.4)	95.7	(0.2)

2. Draining and renovation

Data from the two studies indicate that, overall, foodsize-fish operations are waiting longer between drainings or complete renovations of growout ponds. From Catfish 2003 to Catfish 2010, the percentage of operations waiting 16 or more years to drain ponds increased, with more than one-fifth of operations (22.2 percent) waiting 16 or more years in 2010. Concomitantly, the percentages of operations waiting 2 to 5 or 6 to 10 years to drain ponds declined between studies.

The trend was similar for complete renovations of ponds. From Catfish 2003 to Catfish 2010, the percentage of operations waiting 16 or more years between complete renovations of ponds increased, with almost one-third of operations (31.0 percent) waiting 16 or more years between complete renovations of ponds in 2010. For all other waiting times (1, 2 to 5, 6 to 10, or 11 to 15 years), the percentages of operations declined between studies.

a. Percentage of foodsize-fish operations by usual number of years between draining or complete renovations of growout ponds:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Years Between…	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Draining				
1	3.1	(0.5)	2.2	(0.2)
2 to 5	24.6	(1.2)	16.5	(0.5)
6 to 10	48.5	(1.4)	41.9	(0.7)
11 to 15	17.0	(1.2)	17.2	(0.6)
16 or more	6.8	(0.8)	22.2	(0.6)
Total	100.0		100.0	
Complete renovations				
1	1.0	(0.2)	0.0	(—)
2 to 5	8.9	(0.7)	5.8	(0.3)
6 to 10	52.1	(1.5)	38.9	(0.7)
11 to 15	28.8	(1.4)	24.3	(0.7)
16 or more	9.2	(0.9)	31.0	(0.7)
Total	100.0		100.0	

The trends seen above (table D.2.a) are supported by the operation average number of years between pond management activities, which increased from Catfish 2003 to Catfish 2010 for both draining and complete renovations of ponds.

b. Operation average number of years between draining or complete renovations of ponds:

	Operation Average Number of Years			
	Catfish 2003		Catfish 2010	
Pond Management Activity	Average	Std. Error	Average	Std. Error
Draining	9.1	(0.1)	11.7	(0.1)
Complete renovations	11.0	(0.1)	14.0	(0.1)

3. Water-level management

Lowering the water level in ponds in the fall can help reduce or prevent levee erosion. From Catfish 2003 to Catfish 2010, the percentage of operations allowing the water level to drop passively increased from 38.4 percent of operations to 44.0 percent. Concomitantly, the percentage of operations actively releasing water to lower the level decreased from 22.2 percent of operations to 14.5 percent. The percentage of operations maintaining the water level was similar for the two studies.

Percentage of foodsize-fish operations by water-level management practice used in the fall:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Management Practice for Water Level	Percent	Std. Error	Percent	Std. Error
Release water to lower level	22.2	(0.9)	14.5	(0.4)
Allow level to drop without intervention	38.4	(1.0)	44.0	(0.6)
Maintain water level (do not let water level drop)	39.4	(1.0)	41.5	(0.6)
Total	100.0		100.0	

4. Monitoring of dissolved oxygen

Problems with low dissolved oxygen are more likely to occur in growout ponds with high phytoplankton blooms, which can be caused by high fish densities and high feeding rates. By closely monitoring oxygen levels in ponds, operations are more likely to identify problems in time to intervene and prevent death losses.

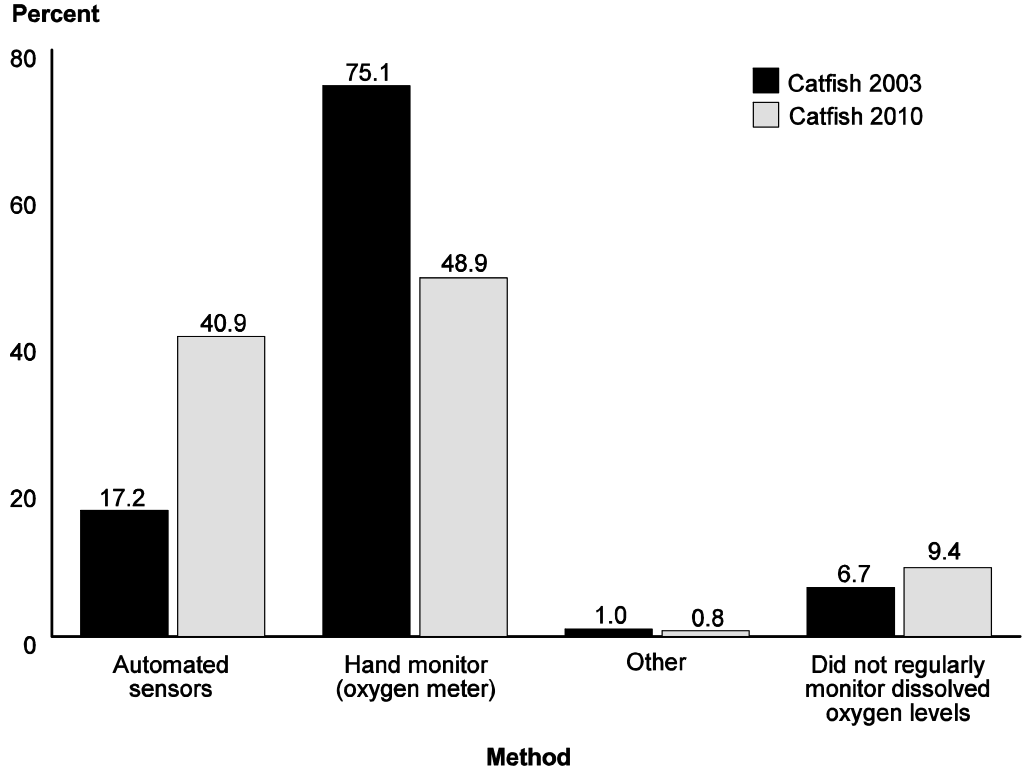
From Catfish 2003 to Catfish 2010, the percentage of operations using automated sensors more than doubled, from 17.2 to 40.9 percent. The percentage of operations using hand monitors decreased between studies from three-fourths of operations (75.1 percent) to slightly less than half of operations (48.9 percent). The percentage of operations that did not regularly monitor dissolved oxygen levels increased slightly from one study to the next.

Percentage of foodsize-fish operations by primary method used to regularly monitor dissolved oxygen in growout ponds*:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Automated sensors	17.2	(0.7)	40.9	(0.6)
Hand monitor (oxygen meter)	75.1	(0.8)	48.9	(0.6)
Other	1.0	(0.2)	0.8	(0.1)
Did not regularly monitor dissolved oxygen levels	6.7	(0.4)	9.4	(0.3)
Total	100.0		100.0	

*Method used during 2002 for Catfish 2003 and during 2009 for Catfish 2010.

Percentage of foodsize-fish operations by primary method used to regularly monitor dissolved oxygen in growout ponds*



*Method used during 2002 for Catfish 2003 and during 2009 for Catfish 2010.

5. Horsepower of fixed aeration

The average horsepower of fixed aeration per surface acre of growout ponds increased from 1.9 hp/acre for Catfish 2003 to 2.5 hp/acre for Catfish 2010.

Operation average horsepower of fixed aeration per surface acre of growout ponds:

Operation Average Horsepower (hp/acre)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
1.9	(0.0)	2.5	(0.0)

6. Emergency aerators

Emergency aerators are mobile units used to supplement fixed aeration; they are usually run by tractors using power take-offs. The number of emergency aerators available for use was similar for Catfish 2003 and Catfish 2010.

Average number of emergency aerators (power take-offs or PTOs) on foodsize-fish operations:

Average Number of Emergency Aerators			
Catfish 2003		Catfish 2010	
Average	Std. Error	Average	Std. Error
9.1	(0.5)	10.1	(0.3)

E. Water Quality and Treatments

1. Chloride level

As noted for fry/fingerling ponds (see table G.7), high chloride levels in ponds can help protect fish against nitrite exposure, which can cause a problem with oxygen transportation in the blood known as brown blood disease.

Typically, pond chloride levels that exceed 100 ppm make it unnecessary to regularly monitor nitrite levels. The operation average chloride level in growout ponds during summer months was similar for the two studies and exceeded 100 ppm.

Operation average chloride level (parts per million) in growout ponds during summer:

Operation Average Chloride Level (ppm)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
110.4	(4.1)	117.9	(0.8)

2. Salt use

Adding salt to growout ponds increases chloride levels in the water, thereby protecting against brown blood disease. For both studies, more than half of operations routinely added salt to maintain a desired chloride level, although the percentage of operations that routinely added salt declined slightly from Catfish 2003 to Catfish 2010. The percentage of operations that did not add salt increased from 27.4 to 31.3 percent. The percentage of operations that added salt only in response to health problems was similar for the two studies.

Percentage of foodsize-fish operations by use of salt in growout ponds*:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Salt Use	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Routinely added salt to maintain a desired chloride level	53.5	(0.9)	50.1	(0.6)
Added salt only in response to health problems	19.1	(0.8)	18.6	(0.5)
Did not add salt	27.4	(0.7)	31.3	(0.5)
Total	100.0		100.0	

*General method used for Catfish 2003 and during 2009 for Catfish 2010.

3. Alkalinity

Higher alkalinity helps reduce the toxicity of dissolved metals to fish, and alkalinity of at least 20 ppm is recommended.

For both studies, the majority of operations maintained an alkalinity of 20 ppm or more in growout ponds. For most of the listed levels of alkalinity, the percentages of operations were similar for the two studies; however, the percentage of operations with alkalinity of 200 ppm or more increased slightly from Catfish 2003 to Catfish 2010.

a. Percentage of foodsize-fish operations by alkalinity (ppm) of the water used in growout ponds:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Alkalinity (ppm)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Less than 20	9.4	(0.9)	10.8	(0.6)
20 to 99	27.2	(1.3)	26.7	(0.8)
100 to 199	57.3	(1.5)	52.7	(0.9)
200 or more	6.1	(0.6)	9.8	(0.4)
Total	100.0		100.0	

The operation average alkalinity increased from Catfish 2003 to Catfish 2010.

b. Operation average alkalinity (ppm) of water used in growout ponds:

Operation Average Alkalinity (ppm)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
102.3	(1.6)	117.9	(0.8)

From Catfish 2003 to Catfish 2010, the percentage of operations that routinely added calcium (typically in the form of agricultural lime, hydrated lime, or gypsum) to growout ponds to maintain a desired alkalinity decreased from 14.2 to 10.0 percent of operations, while the percentage of operations that added calcium only in response to health problems increased, from 15.8 to 23.3 percent of operations. For both studies, the majority of operations did not add calcium to growout ponds, but this percentage decreased slightly between studies, from 70.0 to 66.7 percent of operations.

c. Percentage of foodsize-fish operations by method of adding calcium (typically in the form of agricultural lime, hydrated lime, or gypsum) to ponds to maintain alkalinity:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Routinely add calcium to maintain a desired alkalinity and hardness	14.2	(0.7)	10.0	(0.4)
Add calcium only in response to health problems	15.8	(0.7)	23.3	(0.5)
Do not add calcium to growout ponds	70.0	(0.9)	66.7	(0.6)
Total	100.0		100.0	

4. Water quality testing

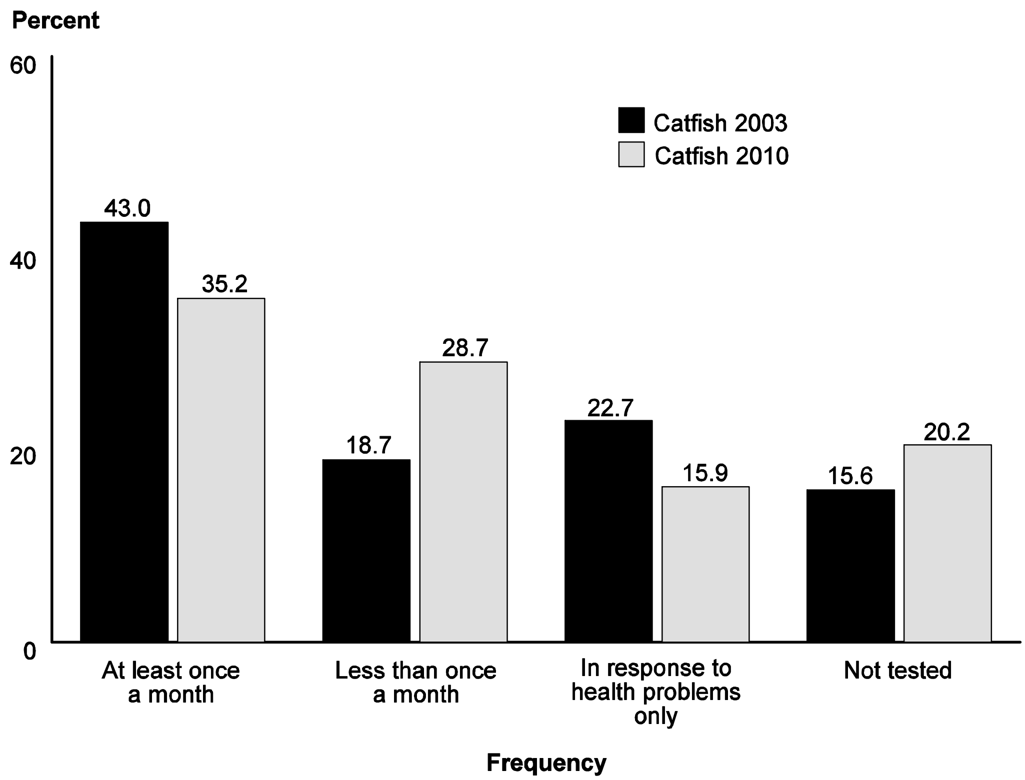
Good water quality can help keep catfish healthy by helping prevent specific diseases and by reducing stress, which makes fish more susceptible to disease problems. Data from the two studies indicate that, in general, operations have reduced the frequency of water quality testing in growout ponds. From Catfish 2003 to Catfish 2010, the percentage of operations that did not test water quality in growout ponds increased from 15.6 to 20.2 percent, and the percentage of operations testing water quality less than once a month also increased, from 18.7 to 28.7 percent. The percentage of operations that tested water quality in growout ponds at least once a month declined, from 43.0 to 35.2 percent. The percentage of operations that tested only in response to health problems decreased, from 22.7 to 15.9 percent of operations.

a. Percentage of foodsize-fish operations by frequency of water quality testing in growout ponds*:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Frequency	Percent	Std. Error	Percent	Std. Error
At least once a month	43.0	(1.0)	35.2	(0.6)
Less than once a month	18.7	(0.8)	28.7	(0.6)
In response to health problems only	22.7	(0.8)	15.9	(0.4)
Not tested	15.6	(0.6)	20.2	(0.4)
Total	100.0		100.0	

*General testing practices used for Catfish 2003; practice during 2009 used for Catfish 2010.

Percentage of foodsize-fish operations by frequency of water quality testing in growout ponds*



*General testing practices used for Catfish 2003; practice during 2009 used for Catfish 2010.

Testing for specific water quality characteristics (ammonia, chloride, and nitrite levels) by those operations in table E.4.a that tested water quality of growout ponds at least once a month tended to support the observation noted above that water quality testing declined from Catfish 2003 to Catfish 2010. The percentages of operations testing for ammonia, chloride, or nitrite three to four times per month decreased, while the percentages of operations testing for those water quality characteristics one to two times per month increased. The percentage of operations testing for nitrite five to seven times per month declined from 0.8 to 0.0 percent. The percentage of operations testing for chloride eight or more times per month increased from 0.0 to 1.5 percent, however.

b. For operations that tested water quality of growout ponds at least once a month,* percentage of operations by number of times per month growout ponds were tested for stated water quality characteristics:

	Percent Operations											
	Catfish 2003						Catfish 2010					
	Ammonia		Chloride		Nitrite		Ammonia		Chloride		Nitrite	
Times per Month	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error	Pct.	Std. Error
0	3.7	(0.7)	3.8	(0.6)	1.2	(0.3)	2.1	(0.2)	5.8	(0.4)	2.2	(0.3)
1 to 2	65.6	(1.5)	72.9	(1.5)	66.2	(1.5)	85.5	(0.8)	85.5	(0.7)	83.2	(0.8)
3 to 4	29.6	(1.5)	23.3	(1.4)	30.0	(1.5)	10.9	(0.8)	7.2	(0.6)	12.4	(0.8)
5 to 7	0.0	(—)	0.0	(—)	0.8	(0.2)	0.0	(—)	0.0	(—)	0.0	(—)
8 or more	1.1	(0.5)	0.0	(—)	1.8	(0.5)	1.5	(0.3)	1.5	(0.3)	2.2	(0.3)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

*General testing practices used for Catfish 2003; practice during 2009 used for Catfish 2010.

5. Algae management

Overgrowth of algae can lead to lower levels of dissolved oxygen in the water at night. Certain types of algae in growout ponds also cause some problems with off-flavor in fish.

The percentage of operations that used a control program to prevent algae overgrowth was similar for Catfish 2003 and Catfish 2010. The percentage of operations that used no algae control treatments, however, increased from 28.1 to 34.3 percent, while the percentage of operations that used algae control only in response to problems decreased from about one-third of operations (34.1 percent) to about one-fourth (24.8 percent).

a. Percentage of foodsize-fish operations by usual algae management practice:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Algae Management Practice	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Prevent algae overgrowth with a control program	37.8	(1.0)	40.9	(0.6)
Control bloom only in response to problems such as off-flavor	34.1	(1.0)	24.8	(0.5)
No algae control treatments	28.1	(0.8)	34.3	(0.5)
Total	100.0		100.0	

On operations that typically used algae control programs, the percentage of growout ponds included in the control program increased from Catfish 2003 to Catfish 2010 for operations with 20 to 49 or 50 to 149 surface acres for foodsize fish.

b. For operations that typically used algae control programs, percentage of growout ponds included in the control program,* by size of operation:

	Percent Growout Ponds			
	Catfish 2003		Catfish 2010	
Size of Operation (surface acres for foodsize fish)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 to 19	98.6	(0.8)	97.9	(0.5)
20 to 49	94.0	(1.2)	98.6	(0.2)
50 to 149	90.1	(1.5)	97.9	(0.3)
150 or more	77.1	(6.3)	88.7	(1.6)
All operations	80.4	(5.0)	91.6	(1.2)

*During 2002 for Catfish 2003 and during 2009 for Catfish 2010.

From Catfish 2003 to Catfish 2010, the percentage of operations using biological control methods in algae control programs increased, while the percentage of operations using “other” algae control methods decreased.

Some operations used more than one method in their algae control programs. For Catfish 2003, about 20 percent of operations used biological control methods and a chemical control method (a copper-based formulation or Diuron), and for Catfish 2010, about 30 percent used biological control methods and a chemical control method (data not shown). This increase likely corresponds to the increase in use of biological control methods between the two studies.

c. For operations that typically used algae control programs, percentage of operations by control method*:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Algae Control Method	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Copper sulfate ($CuSO_4$) or other copper formulation	80.3	(1.4)	82.0	(0.7)
Diuron	72.5	(1.4)	78.1	(0.7)
Biological control (e.g., threadfin or gizzard shad)	26.1	(1.5)	39.7	(0.9)
Other	10.4	(1.0)	4.4	(0.4)

*General use for Catfish 2003; during 2009 for Catfish 2010.

Typically, catfish producers begin algae control programs in the period March through June, when warmer weather and longer days promote algae growth, and end programs as the weather cools. Overall, this pattern was true for operations in the two studies. Some minor differences occurred between the studies that suggest some producers might be extending the length of the algae control program. The percentage of operations that began treatment in May declined from Catfish 2003 to Catfish 2010, and the percentage of operations that started programs in March and April increased from 37.4 to 45.4 percent. The percentage of producers that ended the algae control program in September declined between the two studies and the percentage ending the program in November increased. .

d. For operations that used copper sulfate (or other copper formulation) or Diuron to control algae, percentage of operations by month that the program began and ended during the previous year:

	Percent Foodsize-fish Operations							
	Beginning Month				Ending Month			
	Catfish 2003		Catfish 2010		Catfish 2003		Catfish 2010	
Month	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
January	4.1	(0.7)	4.1	(0.4)	0.0	(—)	0.0	(—)
February	2.0	(0.5)	0.7	(0.2)	0.0	(—)	0.0	(—)
March	12.7	(1.3)	16.4	(0.8)	0.4	(0.1)	0.0	(—)
April	24.7	(1.5)	29.0	(0.9)	0.0	(—)	0.0	(—)
May	34.7	(1.8)	24.6	(0.9)	0.0	(—)	0.0	(—)
June	17.6	(1.4)	19.8	(0.9)	0.0	(—)	0.0	(—)
July	3.7	(0.7)	5.4	(0.4)	2.5	(0.5)	2.7	(0.4)
August	0.5	(0.2)	0.0	(—)	5.9	(0.9)	8.1	(0.6)
September	0.0	(—)	0.0	(—)	27.4	(1.6)	18.1	(0.8)
October	0.0	(—)	0.0	(—)	45.5	(1.8)	42.0	(1.0)
November	0.0	(—)	0.0	(—)	13.2	(1.2)	24.2	(0.9)
December	0.0	(—)	0.0	(—)	5.1	(0.8)	4.9	(0.5)
Total	100.0		100.0		100.0		100.0	

If copper sulfate is applied according to manufacturer recommendations, its use is not restricted. Diuron is approved for weekly use on ponds but cannot be applied more than nine times per year.

Overall, there were few changes in the number of weeks operations waited between algae control treatments. For both studies, more than 90 percent of operations that used copper sulfate or Diuron in algae control programs waited from 1 to 3 weeks between pond treatments. The percentage of operations that waited 4 to 5 weeks between treatments increased slightly from Catfish 2003 to Catfish 2010, while the percentage of operations that waited 6 weeks or more decreased slightly.

e. For operations that used copper sulfate (or other copper formulation) or Diuron to control algae, percentage of operations by number of weeks between algae control treatments during the previous year:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Number Weeks Between Treatments	**Percent**	**Std. Error**	**Percent**	**Std. Error**
1 week	56.6	(1.8)	59.4	(1.1)
2 to 3 weeks	35.9	(1.8)	31.6	(1.0)
4 to 5 weeks	3.9	(0.6)	8.3	(0.6)
6 weeks or more	3.6	(0.7)	0.7	(0.1)
Total	100.0		100.0	

6. Snail control

Ramshorn snails are an intermediate host for trematodes. Controlling snails in ponds can help prevent trematode-related problems.

For both studies, slightly more than one-tenth of operations had a problem with snails in any growout ponds in the year before the study.

a. Percentage of operations that had a problem with snails in any growout ponds in the previous year:

Percent Foodsize-fish Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
12.7	(0.7)	11.1	(0.4)

All operations were asked about their snail-control practices. Although copper remained the control measure used by the highest percentage of operations, the percentage of operations that used copper declined from Catfish 2003 to Catfish 2010. The percentage of operations using lime (most likely hydrated lime) or any control measure also declined between studies.

b. Percentage of operations that used the following measures to control snails in growout ponds:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Snail Control Measure	Percent	Std. Error	Percent	Std. Error
Lime	11.1	(0.7)	4.1	(0.2)
Copper	13.0	(0.7)	9.4	(0.3)
Weed control	4.6	(0.5)	3.5	(0.2)
Biological control	1.8	(0.4)	3.0	(0.2)
Other	0.7	(0.2)	0.0	(—)
Any	19.9	(0.8)	13.0	(0.4)

F. Feeding Practices

1. Tons of feed fed

The average tons of feed fed to foodsize fish per operation for the year preceding the study did not change between studies, although the average tons of feed fed per acre increased from 4.3 tons for Catfish 2003 to 5.5 tons for Catfish 2010. If fish were fed over a 200-day growing period in 2009, the 5.5 tons per acre equals an average of 55 pounds of feed per acre per day.

Average tons of feed fed to foodsize fish per operation and per acre during the year preceding the study:

	Average Tons of Feed			
	Catfish 2003		Catfish 2010	
Tons of Feed Fed	Average	Std. Error	Average	Std. Error
Average per operation	903.8	(48.6)	994.9	(39.2)
Average per acre	4.3	(0.2)	5.5	(0.1)

The direct feed conversion ratio (pounds of feed fed per pound of fish harvested) can be difficult to calculate under typical production conditions. The following table presents the results of three approaches to deriving the value.

1. The operation average (first line of table below) is based on a direct question to producers concerning their estimated feed conversion ratio. Based on producers' answers, an operation average was calculated. For this calculation, the pounds fed and the pounds of fish produced by each operation were not used.
2. The weighted average (second line) is the operation average accounting for the pounds of fish harvested in the year before the study was conducted (2002 or 2009).
3. The gross average (bottom line) is the total weight of feed fed by all operations divided by the total pounds of fish harvested by all operations (ratio estimate).

Although the operation average based on producer estimates of feed conversion ratios was similar for the two studies, the ratios calculated by weighted average or gross average declined. The reduction in the amount of feed fed per pound of fish harvested might reflect improvements in feeds, genetic lines, fish health, or other management factors. The observed decline might also reflect operations that reduced feeding levels and/or production, possibly because of financial constraints.

Average pounds of feed fed per pound of fish harvested during the year prior to the study:

	Operation Average (lb feed/lb fish harvested)			
	Catfish 2003		**Catfish 2010**	
Average	**Average**	**Std. Error**	**Average**	**Std. Error**
Operation average	2.2	(0.0)	2.2	(0.0)
Weighted average[1]	2.3	(0.0)	2.2	(0.0)
Gross average[2]	2.3	(0.0)	2.1	(0.0)

[1]Operation average weighted by pounds of fish harvested.
[2]Annual feed divided by pounds of foodsize fish harvested.

3. Protein in feed

Although a protein level of 32 percent was considered standard for catfish feed in the past, a level of 28 percent has been shown to be adequate for foodsize fish. Some producers feed protein levels as high as 36 percent; these higher protein levels may reduce body fat, leading to a leaner product.

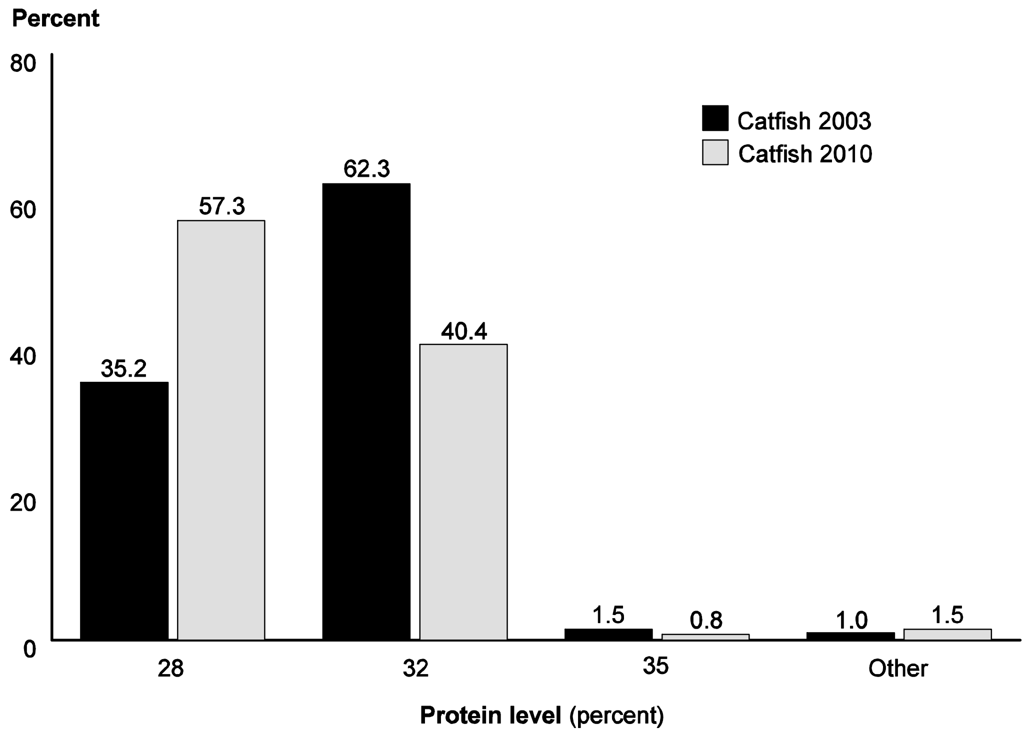
The protein level primarily fed by the highest percentage of operations changed from 32 percent for Catfish 2003 to 28 percent for Catfish 2010. Between studies, the percentage of operations primarily using catfish feed with a protein level of 32 percent declined from 62.3 to 40.4 percent. Concomitantly, the percentage of operations using feed with 28 percent protein increased, from 35.2 to 57.3 percent.

Percentage of foodsize-fish operations by protein level in feed primarily fed to foodsize fish*:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Protein Level (percent)	**Percent**	**Std. Error**	**Percent**	**Std. Error**
28	35.2	(0.9)	57.3	(0.6)
32	62.3	(1.0)	40.4	(0.6)
35	1.5	(0.3)	0.8	(0.1)
Other	1.0	(0.1)	1.5	(0.2)
Total	100.0		100.0	

*Catfish 2003 asked in general about the protein level of feed fed to foodsize fish, whereas Catfish 2010 asked about the protein level of feed fed primarily during 2009.

Percentage of foodsize-fish operations by protein level in feed primarily fed to foodsize fish*



*Catfish 2003 asked in general about the protein level of feed fed to foodsize fish, whereas Catfish 2010 asked about the protein level of feed fed primarily during 2009.

4. Seasonal feeding practices

The amount catfish eat is related to water temperature, and at lower temperatures, they may feed inconsistently; therefore, many producers vary their feeding method by season.

Overall, the seasonal feeding patterns for foodsize fish for the year prior to the study were similar for Catfish 2003 and Catfish 2010. In both studies, the majority of producers fed catfish every day during the warmer months (May through August), while the majority of producers fed catfish on alternate days during the typically cooler months (March and April and September and October). During all seasons in both studies, a higher percentage of operations fed catfish to satiation (combining every day and alternate day feeding) than fed to a maximum feeding limit (combining every day and alternate day feeding).

Some of the individual percentages changed between studies, however. The percentage of operations feeding every day to satiation decreased from Catfish 2003 to Catfish 2010 for the cooler months of March and April and increased for the warmer months of May through August. The percentage of operations feeding every day but with a maximum feeding limit declined between studies for each season. For the March to April period, the percentage of operations feeding alternate days to satiation increased between studies, while the percentage of operations feeding alternate days with a maximum feeding limit decreased.

a. Percentage of foodsize-fish operations by seasonal feeding method most commonly used for foodsize fish in the year prior to the study:

	Percent Foodsize-fish Operations											
	Catfish 2003						Catfish 2010					
	Mar–Apr		May–Aug		Sep–Oct		Mar–Apr		May–Aug		Sep–Oct	
Feeding Method	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Every day to satiation (all they can eat)	12.5	(0.6)	39.9	(1.0)	17.1	(0.8)	7.9	(0.3)	46.1	(0.6)	18.8	(0.5)
Every day but with a maximum feeding limit	13.7	(0.7)	31.4	(0.9)	18.5	(0.8)	8.9	(0.3)	25.0	(0.5)	12.1	(0.4)
Alternate days to satiation	37.8	(1.0)	16.5	(0.7)	35.0	(1.0)	48.1	(0.6)	16.2	(0.4)	38.1	(0.6)
Alternate days with a maximum feeding limit	22.8	(0.9)	9.2	(0.6)	19.0	(0.8)	19.5	(0.5)	8.2	(0.3)	20.8	(0.5)
Other	13.2	(0.7)	3.0	(0.3)	10.4	(0.6)	15.6	(0.5)	4.5	(0.3)	10.2	(0.4)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

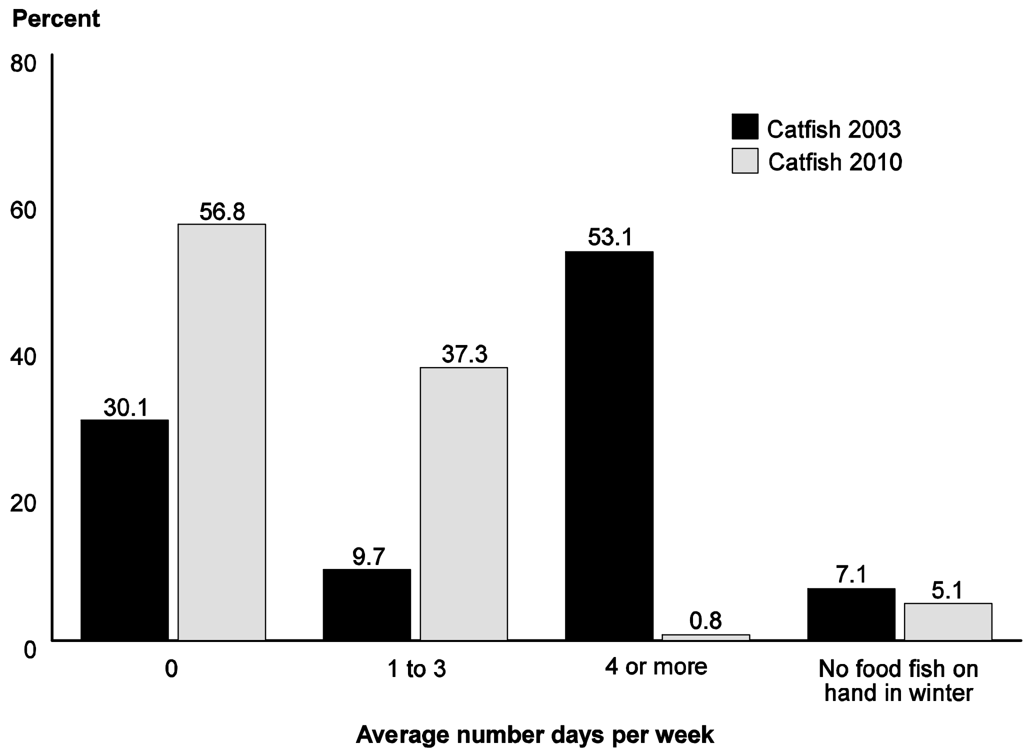
Although catfish feed less during winter, some evidence suggests that, when temperatures are appropriate, producers should provide some feed to help catfish maintain body weight and condition.

For the December to February time period, however, the percentage of operations that fed zero days per week increased from 30.1 percent for Catfish 2003 to 56.8 percent for Catfish 2010. Additionally, of Catfish 2010 operations that fed fish during the winter, the highest percentage (37.3 percent) fed them 1 to 3 days per week, while the highest percentage of Catfish 2003 operations (53.1 percent) fed fish 4 or more days per week.

b. Percentage of operations by average number of days per week foodsize fish were fed from December through February:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Average Number Days per Week	**Percent**	**Std. Error**	**Percent**	**Std. Error**
0	30.1	(0.9)	56.8	(0.6)
1 to 3	9.7	(0.6)	37.3	(0.6)
4 or more	53.1	(1.0)	0.8	(0.1)
No food fish on hand in winter	7.1	(0.4)	5.1	(0.2)
Total	100.0		100.0	

Percentage of operations by average number of days per week foodsize fish were fed from December through February



5. Maximum feed fed to foodsize-fish

The amount of feed fed daily during the highest feeding month reflects the intensity of production. The operation average pounds of feed fed per acre, per day, in the year preceding the study increased from 108.4 pounds per acre for Catfish 2003 to 120.0 pounds per acre for Catfish 2010. This result agrees with the increase in the average tons of feed fed per acre (table F.1).

a. Operation average pounds of feed fed per acre, per day, to foodsize fish in all ponds during the highest feeding month in the year preceding the study:

Operation Average (lb/acre/day)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
108.4	(0.9)	120.0	(0.6)

From Catfish 2003 to Catfish 2010, the highest daily feeding rate for any single growout pond on operations in the year preceding the study increased from 144.0 to 161.1 pounds per acre.

b. Operation average **highest daily** feeding rate in pounds per acre for any single growout pond in the year preceding the study:

Operation Average Highest Daily Feeding Rate (lb/acre)			
Catfish 2003		**Catfish 2010**	
Average	**Std. Error**	**Average**	**Std. Error**
144.0	(1.3)	161.1	(1.0)

G. Vaccination for enteric septicemia of catfish (ESC)

1. ESC-vaccinated fish stocked

The percentage of operations that stocked fish vaccinated for ESC in the year(s) before the study declined from 15.8 percent for Catfish 2003 to 6.2 percent for Catfish 2010.

Percentage of foodsize-fish operations that stocked any fish vaccinated for enteric septicemia of catfish (ESC)*:

Percent Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
15.8	(0.8)	6.2	(0.3)

*Catfish 2003 asked if the operation stocked ESC-vaccinated fry in the past 3 years; Catfish 2010 asked if ESC-vaccinated fry were stocked during 2009.

2. Vaccination of fish to be stocked during the year of the study

In each study, producers were asked what percentage of the fish to be stocked during the year of the study (2003 or 2010) they planned to vaccinate for ESC. The percentage of operations planning to stock at least some vaccinated fish declined between studies, from 16.8 to 7.0 percent.

a. For fish to be stocked during the year of the study, percentage of operations that planned to stock at least some fish vaccinated for ESC:

Percent Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
16.8	(0.8)	7.0	(0.3)

In addition to the decline in the percentage of operations planning to stock fish vaccinated for ESC, the operation average percentage of fish to be vaccinated also decreased between studies, from 11.9 to 5.7 percent.

b. Operation average percentage of foodsize fish to be stocked during the year of the study that would be vaccinated for ESC:

Operation Average Percent Fish			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
11.9	(0.6)	5.7	(0.3)

H. Foodsize-fish Health Issues

1. Causes of foodsize-fish loss

From Catfish 2003 to Catfish 2010, the percentages of operations that lost any foodsize fish to ESC, columnaris, anemia, winter kill, or visceral toxicosis of catfish declined. The percentage of operations that lost fish to ESC declined from 60.6 to 36.6 percent of operations, while the percentage that lost fish to columnaris declined from 50.4 to 39.0 percent.

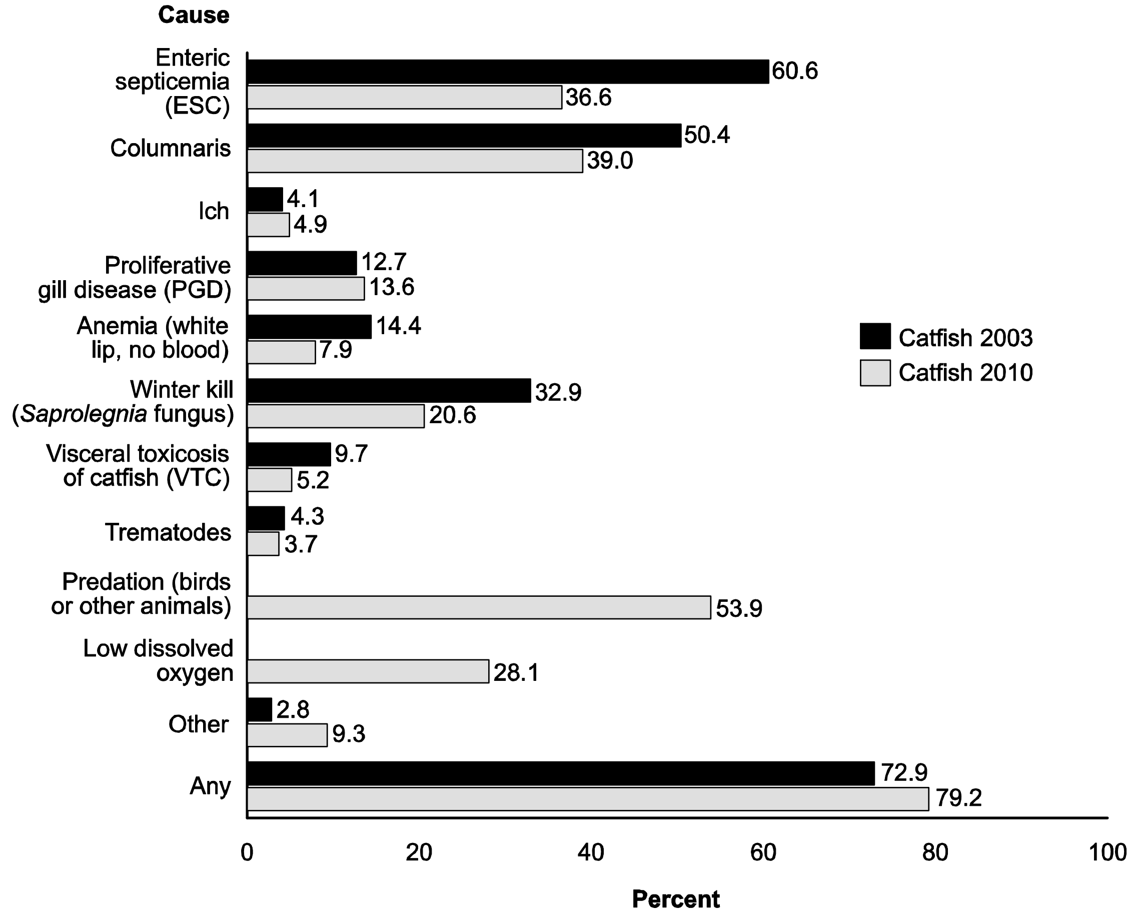
Overall, however, the percentage of operations that lost any fish to any of the causes increased between studies. This might be explained in part by the addition of predation and low dissolved oxygen to the list of causes of loss in Catfish 2010. Predation by birds and other animals caused loss on the highest percentage of operations for Catfish 2010, affecting more than half of all foodsize-fish operations (53.9 percent).

The percentage of operations that reported fish loss to "other" causes increased between studies. In Catfish 2010, respondents specified causes such as *Aeromonas*, heat, and algal toxins, although many did not specify a cause for the "other" loss category.

a. Percentage of foodsize-fish operations that lost any foodsize fish to the following causes in the year preceding the study:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Cause of Loss	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Enteric septicemia of catfish (ESC, hole-in-head disease)	60.6	(0.9)	36.6	(0.6)
Columnaris	50.4	(1.0)	39.0	(0.6)
Ich	4.1	(0.4)	4.9	(0.3)
Proliferative gill disease (PGD, hamburger gill disease)	12.7	(0.7)	13.6	(0.4)
Anemia (white lip, no blood)	14.4	(0.8)	7.9	(0.4)
Winter kill (*Saprolegnia* fungus)	32.9	(1.0)	20.6	(0.5)
Visceral toxicosis of catfish (VTC, twisted gut, botulism)	9.7	(0.7)	5.2	(0.2)
Trematodes	4.3	(0.5)	3.7	(0.2)
Predation (birds or other animals)			53.9	(0.6)
Low dissolved oxygen			28.1	(0.5)
Other	2.8	(0.4)	9.3	(0.3)
Any	72.9	(1.0)	79.2	(0.5)

Percentage of foodsize-fish operations that lost any foodsize fish to the following causes in the year preceding the study



As with the percentages of operations, the percentages of growout ponds that lost any foodsize fish to ESC, columnaris, winter kill, or visceral toxicosis of catfish declined between studies. The percentage of ponds that lost fish to anemia remained the same, while the percentages of ponds that lost any fish to ich or “other” causes of loss increased between studies.

As with operations, predation affected the highest percentage of ponds for Catfish 2010, causing fish losses in 42.5 percent of ponds. The percentage of ponds that lost fish to ESC declined from 28.8 to 14.3 percent of ponds, while the percentage that lost fish to columnaris declined from 23.0 to 13.9 percent.

b. Percentage of growout ponds that lost any foodsize fish to the following causes in the year preceding the study:

	Percent Growout ponds			
	Catfish 2003		**Catfish 2010**	
Cause of Loss	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Enteric septicemia of catfish (ESC, hole-in-head disease)	28.8	(2.5)	14.3	(0.5)
Columnaris	23.0	(2.2)	13.9	(0.5)
Ich	0.3	(0.0)	0.9	(0.1)
Proliferative gill disease (PGD, hamburger gill disease)	2.2	(0.3)	3.2	(0.2)
Anemia (white lip, no blood)	2.2	(0.2)	1.8	(0.1)
Winter kill (*Saprolegnia* fungus)	10.1	(0.9)	6.7	(0.2)
Visceral toxicosis of catfish (VTC, twisted gut, botulism)	3.8	(0.9)	1.7	(0.1)
Trematodes	1.3	(0.3)	1.0	(0.1)
Predation (birds or other animals)			42.5	(1.5)
Low dissolved oxygen			9.5	(0.5)
Other	0.6	(0.2)	4.5	(0.4)

Quantifying the amount of fish lost during a mortality event can be difficult. Producers were asked to categorize the average loss per event as light, moderate, or severe based on the estimated number of pounds of fish lost.

In Catfish 2010, the percentages of operations categorizing losses as light increased for all listed causes of loss with the exception of the “other” causes (and predation and low dissolved oxygen, which weren’t included in Catfish 2003). The percentages of operations categorizing losses as severe decreased for ESC, columnaris, ich, PGD, anemia, winter kill, and VTC and were similar for trematodes. The percentages of operations categorizing losses as moderate decreased for ESC, columnaris, PGD, winter kill, VTC, trematodes, and “other” causes and remained the same for ich and anemia. As noted above, “other” causes of loss were an exception, with a higher percentage of Catfish 2010 operations categorizing these losses as severe. For Catfish 2010, more than two-thirds of “other” losses that were severe were reported to be *Aeromonas* (data not shown).

c. For operations that lost fish in growout ponds to the following causes of loss in the year preceding the study, percentage of operations by severity of average loss (in pounds of fish per operation) per mortality event:

	Percent Foodsize-fish Operations											
	Average Loss per Event (lb)											
	Catfish 2003						**Catfish 2010**					
	Light (Less than 200)		**Moderate** (200–2,000)		**Severe** (More than 2,000)		**Light** (Less than 200)		**Moderate** (200–2,000)		**Severe** (More than 2,000)	
Cause of Loss	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
Enteric septicemia of catfish (ESC, hole-in-head disease)	50.5	(1.4)	39.5	(1.4)	10.0	(0.8)	68.9	(1.0)	24.7	(0.9)	6.4	(0.5)
Columnaris	49.0	(1.5)	36.5	(1.5)	14.5	(1.1)	58.0	(1.0)	31.3	(1.0)	10.7	(0.7)
Ich	44.3	(4.6)	13.3	(3.0)	42.4	(4.9)	89.4	(1.5)	5.3	(1.1)	5.3	(1.1)
Proliferative gill disease (PGD, hamburger gill disease)	37.9	(3.0)	26.7	(2.7)	35.4	(2.9)	74.3	(1.5)	14.7	(1.1)	11.0	(1.2)
Anemia (white lip, no blood)	32.3	(2.7)	25.9	(2.9)	41.8	(3.1)	54.9	(2.4)	19.0	(1.9)	26.1	(2.2)
Winter kill (*Saprolegnia* fungus)	40.6	(1.9)	33.1	(1.9)	26.3	(1.8)	69.2	(1.3)	18.3	(1.1)	12.5	(1.0)
Visceral toxicosis of catfish (VTC, twisted gut, botulism)	42.6	(3.6)	24.2	(3.1)	33.2	(3.6)	71.0	(1.7)	9.1	(0.4)	19.9	(1.7)
Trematodes	41.4	(5.8)	40.0	(5.7)	18.6	(4.7)	60.6	(3.2)	12.8	(2.4)	26.6	(2.9)
Predation (birds or other animals)							67.2	(0.7)	27.7	(0.7)	5.1	(0.3)
Low dissolved oxygen							49.4	(1.1)	27.8	(1.0)	22.8	(1.0)
Other	22.6	(6.1)	41.2	(6.1)	36.2	(6.2)	27.4	(1.8)	19.4	(1.4)	53.2	(1.9)

From Catfish 2003 to Catfish 2010, the percentages of ponds with severe losses decreased for ich, PGD, and winter kill and remained the same for ESC, columnaris, anemia, VTC, and trematodes. In general, the percentages of growout ponds affected by the listed causes of loss increased between studies in the no loss or light loss categories and decreased or remained the same in the moderate or severe loss categories. For example, the percentage of ponds with no loss to ESC increased between studies while the percentages of ponds with light or moderate loss decreased and the percentage of ponds with severe loss remained the same. This pattern did not hold, however, for loss attributed to “other” causes; the percentage of ponds with no loss decreased between studies while the percentages of ponds with light, moderate, or severe losses increased. In Catfish 2010, some respondents specified *Aeromonas,* which has been reported to cause severe losses in portions of the industry, as a cause of “other” losses.

d. Percentage of all growout ponds by severity of average loss (in pounds of fish per operation) per mortality event in the year preceding the study:

		Percent Ponds								
		Average Loss per Event (lb)								
		None		**Light** (Less than 200)		**Moderate** (200–2,000)		**Severe** (more than 2,000)		
Cause of Loss	**Study**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Total**
Enteric septicemia of catfish (ESC, hole-in-head disease)	2003	71.2	(2.5)	16.9	(2.9)	9.2	(0.9)	2.7	(0.6)	100.0
	2010	85.7	(0.5)	8.3	(0.4)	4.8	(0.5)	1.2	(0.2)	100.0
Columnaris	2003	77.0	(2.2)	7.3	(0.6)	12.7	(2.6)	3.0	(0.6)	100.0
	2010	86.1	(0.5)	6.7	(0.3)	3.7	(0.3)	3.5	(0.4)	100.0
Ich	2003	99.7	(0.0)	0.2	(0.0)	0.0	(0.0)	0.1	(0.0)	100.0
	2010	99.1	(0.1)	0.9	(0.1)	0.0	(0.0)	0.0	(0.0)	100.0
Proliferative gill disease (PGD, hamburger gill disease)	2003	97.8	(0.3)	0.6	(0.1)	1.0	(0.2)	0.6	(0.1)	100.0
	2010	96.8	(0.2)	2.3	(0.1)	0.7	(0.1)	0.2	(0.0)	100.0
Anemia (white lip, no blood)	2003	97.8	(0.2)	0.7	(0.1)	0.8	(0.2)	0.7	(0.1)	100.0
	2010	98.2	(0.1)	0.9	(0.1)	0.1	(0.0)	0.8	(0.1)	100.0
Winter kill (*Saprolegnia* fungus)	2003	89.9	(0.9)	3.8	(0.5)	3.6	(0.5)	2.7	(0.5)	100.0
	2010	93.3	(0.2)	5.0	(0.3)	0.8	(0.1)	0.9	(0.1)	100.0
VTC (twisted gut, visceral toxicosis, botulism)	2003	96.2	(0.9)	0.7	(0.1)	2.4	(0.9)	0.7	(0.2)	100.0
	2010	98.3	(0.1)	1.0	(0.1)	0.0	(0.0)	0.7	(0.1)	100.0
Trematodes	2003	98.7	(0.3)	0.5	(0.2)	0.7	(0.2)	0.1	(0.0)	100.0
	2010	99.1	(0.1)	0.7	(0.1)	0.1	(0.0)	0.1	(0.0)	100.0
Predation (birds or other animals)	2003									
	2010	57.5	(1.5)	22.7	(0.9)	14.6	(0.8)	5.2	(0.5)	100.0
Low dissolved oxygen	2003									
	2010	90.5	(0.5)	5.9	(0.5)	2.3	(0.1)	1.3	(0.1)	100.0
Other	2003	99.4	(0.2)	0.4	(0.2)	0.1	(0.0)	0.1	(0.0)	100.0
	2010	95.5	(0.4)	1.2	(0.1)	1.6	(0.3)	1.7	(0.1)	100.0

2. Fish health problems related to algal toxins

Algal toxins are organic molecules produced by freshwater and marine algae that can sicken or kill fish or reduce product quality.

The percentage of operations that had fish health problems related to algal toxins appeared to decrease between the two studies, but the numbers are not directly comparable. For Catfish 2003, only operations that described themselves as very or somewhat familiar with algal toxins were asked the question about fish health problems related to algal toxins during the previous 3 years. For Catfish 2010, all operations were asked about fish health problems related to algal toxins.

Percentage of operations having fish health problems related to algal toxins* in the previous 3 years:

Percent Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
38.4	(1.2)	13.6	(0.4)

*Catfish 2003 asked this question only of operations that were very or somewhat familiar with algal toxins, whereas Catfish 2010 asked the question of all operations.

3. Use of medicated feed

The percentage of operations that fed medicated feed to foodsize fish during the year preceding the study decreased from Catfish 2003 to Catfish 2010. In contrast, the percentage of fingerling operations that fed medicated feed to fry did not change substantially between studies (Section I, table I.9.a).

a. Percentage of operations that fed medicated feed to foodsize fish during the year preceding the study:

Percent Foodsize-fish Operations			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
11.0	(0.7)	8.2	(0.3)

For operations that fed medicated feed to foodsize fish during the year preceding the study, the percentage that fed Terramycin decreased from 67.5 to 26.0 percent; this result likely reflects the introduction of Aquaflor, which is the only antimicrobial approved for treatment of both ESC and columnaris. More than one-third of Catfish 2010 operations (36.3 percent) that fed medicated feed fed Aquaflor to foodsize fish in 2009. The percentage of operations feeding Romet to foodsize fish was similar for the two studies.

b. For operations that fed any medicated feed to foodsize fish during the year preceding the study, percentage of operations by type of medicated feed used:

	Percent Operations			
	Catfish 2003		**Catfish 2010**	
Feed	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Terramycin	67.5	(3.1)	26.0	(1.8)
Romet	45.2	(3.6)	50.2	(2.1)
Aquaflor			36.3	(2.1)

As for catfish fry (see Section I, table I.9.b), Aquaflor was the primary medicated feed fed to foodsize catfish in Catfish 2010, with operations feeding an average of 22.3 tons to foodsize fish in the year preceding the study. The average amount of Romet fed to foodsize fish increased from 6.0 to 10.8 tons, while the amount of Terramycin fed to foodsize fish declined from 11.4 to 2.8 tons.

c. For foodsize-fish operations that fed the listed medicated feed to foodsize fish during the year preceding the study, operation average tons of medicated feed fed:

	Operation Average (tons)			
	Catfish 2003		**Catfish 2010**	
Feed	**Average**	**Std. Error**	**Average**	**Std. Error**
Terramycin	11.4	(0.9)	2.8	(0.1)
Romet	6.0	(0.6)	10.8	(0.5)
Aquaflor			22.3	(2.3)

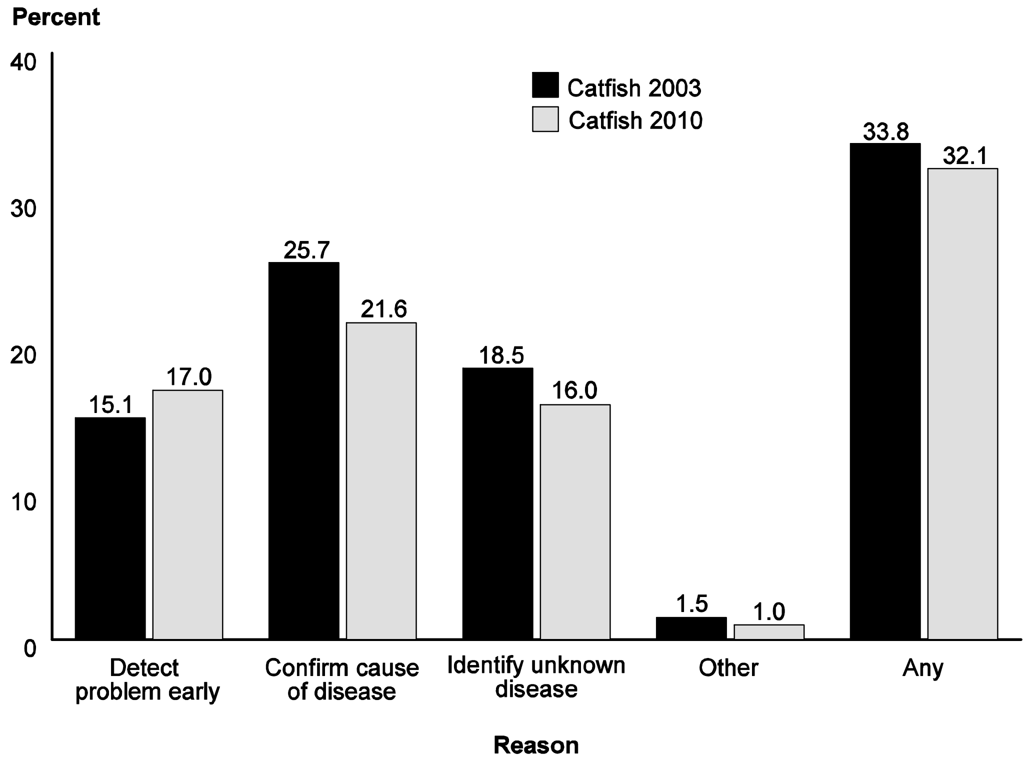
4. Diagnostic laboratory testing

The percentage of operations that submitted foodsize-fish samples to a diagnostic laboratory for any reason during the year preceding the study was similar for Catfish 2003 and Catfish 2010. However, the percentages of operations submitting samples to confirm a cause of disease or identify an unknown disease declined slightly from Catfish 2003 to Catfish 2010. The percentages of operations that submitted samples to detect a problem early or for other reasons were similar for the studies.

a. Percentage of operations that submitted any foodsize-fish samples to a diagnostic laboratory during the year preceding the study, by reason for submission:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Reason	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Detect problem early	15.1	(0.7)	17.0	(0.4)
Confirm cause of disease	25.7	(0.9)	21.6	(0.5)
Identify unknown disease	18.5	(0.8)	16.0	(0.4)
Other	1.5	(0.2)	1.0	(0.1)
Any	33.8	(0.9)	32.1	(0.5)

Percentage of operations that submitted any foodsize-fish samples to a diagnostic laboratory during the year preceding the study, by reason for submission



For both Catfish 2003 and Catfish 2010, the highest percentages of operations that did not submit foodsize-fish samples to a diagnostic laboratory for testing did not submit samples because they had no substantial disease problems; from one study to the next, however, this percentage increased from 54.8 to 72.4 percent of operations. The percentage of operations that cited inconvenience as the primary reason for not submitting samples remained the same between studies, while the percentages of operations decreased for the other three reasons (information rarely of use, already knew what disease was, and "other"). Two other possible reasons, "unaware of available services" and "too costly," were not specifically listed in Catfish 2010 because of their low percentages in 2003.

b. For operations that **did not** submit foodsize-fish samples to a diagnostic laboratory for testing during the year preceding the study, percentage of operations by primary reason for **not** testing:

	Percent Foodsize-fish Operations			
	Catfish 2003		**Catfish 2010**	
Reason	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Inconvenient	3.0	(0.4)	4.1	(0.4)
Information rarely of use (does not help control disease)	3.7	(0.5)	1.5	(0.2)
Already knew what the disease was	32.9	(1.1)	19.1	(0.6)
Unaware of available services	0.5	(0.1)		
Too costly	0.5	(0.1)		
No substantial disease problems	54.8	(1.2)	72.4	(0.7)
Other	4.6	(0.5)	2.9	(0.2)
Total	100.0		100.0	

I. Harvesting Practices

1. Pounds of fish harvested

The operation average pounds of catfish harvested per acre was higher for Catfish 2010 than for Catfish 2003.

Operation average pounds of fish harvested per acre:

Operation Average Pounds Fish Harvested (lb/acre)			
Catfish 2003		Catfish 2010*	
Average	Std. Error	Average	Std. Error
3,698	(187)	4,512	(47)

* Catfish 2003 asked about foodsize fish harvested during 2002. Catfish 2010 asked about channel and channel x blue hybrid foodsize fish harvested during 2009.

2. Ponds harvested

Foodsize fish were harvested from a higher percentage of growout ponds in the year preceding the study for Catfish 2010 than for Catfish 2003. This increase might reflect a need on the part of producers to maximize use of resources.

Percentage of growout ponds from which foodsize fish were harvested during the year preceding the study:

Percent Ponds			
Catfish 2003		Catfish 2010	
Percent	Std. Error	Percent	Std. Error
76.1	(3.7)	85.8	0.5

3. Production method

Harvest methods used were similar for Catfish 2003 and Catfish 2010, with the exception of the percentage of pounds of fish harvested by “other” methods, which decreased between studies. “Other” methods include fee fishing, which would contribute a negligible amount to the pounds of fish harvested. The apparent increase in the percent of fish by weight for single-batch harvest might reflect increased numbers of channel x blue hybrid catfish, although the high standard errors make it difficult to draw conclusions.

Operation average percentage of fish harvested and percentage of pounds of fish harvested, by production practice:

	Operation Average Percent Harvested*							
	Catfish 2003				Catfish 2010			
Production Practice	**Operation Average**	**Std. Error**	**Percent Fish by Weight**	**Std. Error**	**Operation Average**	**Std. Error**	**Percent Fish by Weight**	**Std. Error**
Multibatch	81.4	(0.7)	88.0	(1.7)	82.4	(0.5)	77.5	(5.0)
Single batch	14.6	(0.7)	11.7	(1.7)	13.8	(0.4)	22.5	(5.0)
Other	4.0	(0.3)	0.3	(0.1)	3.8	(0.2)	0.0	(0.0)
Total	100.0		100.0		100.0		100.0	

*Catfish 2003 data represent all foodsize fish harvested in 2002, whereas Catfish 2010 data represent channel and channel x blue hybrid foodsize catfish harvested during 2009.

4. Primary harvesters

For both studies, the highest percentage of operations used custom harvest crews as the primary harvester of foodsize fish. This percentage declined between studies, however, from 55.1 to 42.9 percent of operations. For Catfish 2010, processing plant harvest crew and fee fishing were added as harvester options, based on responses in the "other" category for Catfish 2003; this change at least partially explains the decline in use of "other" methods and perhaps some of the decline in custom harvest, because some producers might have included processing plant crews in custom harvest.

Percentage of foodsize-fish operations by primary harvester of foodsize fish:

	Percent Foodsize-fish Operations			
	Catfish 2003		Catfish 2010	
Harvester	Percent	Std. Error	Percent	Std. Error
Employees of this operation	24.1	(0.8)	21.7	(0.4)
Custom harvest crew	55.1	(0.9)	42.9	(0.6)
Processing plant harvest crew			27.0	(0.6)
Fee fishing (angling)			8.2	(0.3)
Other	20.8	(0.6)	0.2	(0.1)
Total	100.0		100.0	

J. Management of Off-flavor Issues

1. Delayed harvest

From Catfish 2003 to Catfish 2010, the percentage of all operations that experienced harvest delays because of off-flavor problems increased from 69.6 to 80.7 percent of operations. The percentage of ponds (on all operations) that were affected by harvest delays was similar for the studies, however. This pattern held for most of the size categories, with the percentage of operations experiencing harvest delays increasing for all sizes except the largest operations (150 or more surface acres for foodsize fish). Similarly, the percentage of ponds affected remained the same between studies, with the exception of operations with 20 to 49 surface acres, which had an increase in the percentage of ponds affected between studies.

Percentage of operations and percentage of ponds on operations from which foodsize fish were harvested that experienced any harvest delays in the year preceding the study because of off-flavor problems, and by size of operation:

	Percent							
	Catfish 2003				Catfish 2010			
Operation Size (surface acres for foodsize fish)	**Pct. Operations**	**Std. Error**	**Pct. Ponds**	**Std. Error**	**Pct. Operations**	**Std. Error**	**Pct. Ponds**	**Std. Error**
1 to 19	21.7	(2.1)	26.8	(4.1)	55.3	(2.4)	34.9	(2.1)
20 to 49	61.9	(2.1)	48.2	(2.4)	75.2	(1.3)	68.9	(1.2)
50 to 149	78.0	(1.3)	55.7	(1.6)	83.0	(0.7)	54.4	(0.9)
150 or more	86.3	(1.2)	53.9	(2.6)	88.6	(0.5)	45.8	(1.9)
All operations	69.6	(0.8)	53.3	(1.9)	80.7	(0.5)	48.1	(1.6)

2. Duration of off-flavor episodes

There were no clear trends in the duration of delays caused by off-flavor problems between Catfish 2003 and Catfish 2010. The average harvest delay appeared to increase slightly, with the percentages of operations having an average delay of 61 to 100 days or 500 or more days (ongoing) increasing between the two studies. The percentages of operations with an average delay of 1 to 6 or 101 to 499 days decreased, and the percentages of operations with an average delay of 7 to 14, 15 to 30, or 31 to 60 days were similar for Catfish 2003 and Catfish 2010. For both studies, the highest percentage of operations had an average delay of 15 to 30 days.

For the pond with the longest delay, the percentages of operations with a delay of 1 to 6, 101 to 499, or 500 or more days (ongoing) decreased, while the percentages of operations that had ponds with a longest delay of 7 to 14, 15 to 30, or 31 to 60 days increased. For Catfish 2003, the highest percentage of operations had a delay of 500 or more days (ongoing) on the pond with the longest delay; for Catfish 2010, the highest percentage of operations had a longest delay of 31 to 60 days.

For the pond with the shortest delay, the percentage of operations with a delay of 1 to 6 days decreased, while the percentage of operations with a delay of 31 to 60 days increased. The percentages of operations for the other delay categories were similar for the studies. For both studies, the highest percentages of operations had a delay of 7 to 14 days on the pond with the shortest delay.

For operations with ponds that had delayed harvests in the year preceding the study, percentage of operations by ponds with the shortest or longest delay, and the average delay:

	Percent Operations											
	Catfish 2003						**Catfish 2010**					
	Pond with Shortest Delay		**Pond with Longest Delay**		**Average Delay**		**Pond with Shortest Delay**		**Pond with Longest Delay**		**Average Delay**	
Days Harvest Delayed	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**	**Pct.**	**Std. Error**
1 to 6	8.2	(0.6)	1.0	(0.2)	4.0	(0.4)	3.8	(0.3)	0.0	(—)	0.4	(0.1)
7 to 14	43.2	(1.3)	2.1	(0.3)	11.2	(0.8)	43.0	(0.8)	4.1	(0.3)	9.6	(0.4)
15 to 30	35.1	(1.2)	14.1	(0.9)	40.1	(1.3)	34.5	(0.8)	17.9	(0.6)	37.9	(0.8)
31 to 60	8.9	(0.7)	21.4	(1.0)	28.2	(1.2)	14.6	(0.6)	26.8	(0.7)	31.8	(0.8)
61 to 100	2.5	(0.4)	10.5	(0.8)	9.3	(0.7)	1.7	(0.2)	11.7	(0.5)	13.2	(0.6)
101 to 499	1.3	(0.3)	24.1	(1.1)	6.2	(0.6)	2.0	(0.2)	18.4	(0.6)	4.1	(0.3)
500 or more (or ongoing)	0.8	(0.2)	26.8	(1.1)	1.0	(0.2)	0.4	(0.1)	21.1	(0.6)	3.0	(0.3)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

3. Treatment of harvest-delayed ponds

Because off-flavor problems in catfish often are caused by metabolites from algae, treatments are commonly related to algae control, such as chemical treatments using Diuron and copper sulfate.

For Catfish 2003 and Catfish 2010, the highest percentage of ponds with delayed harvest received both Diuron and copper sulfate treatment. The percentage of ponds treated with copper sulfate only declined between the studies, while the percentages of ponds that received the other chemical treatments or no treatment were similar for the two studies.

For ponds with delayed harvests because of off-flavor problems, percentage of ponds that were treated with the following chemicals:

	Percent Ponds			
	Catfish 2003		Catfish 2010	
Chemical	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Diuron only	27.2	(2.3)	23.7	(2.1)
Copper sulfate only	12.1	(1.3)	6.7	(0.3)
Both Diuron and copper sulfate	32.6	(2.9)	36.5	(1.5)
No treatment	28.1	(1.7)	33.1	(1.5)
Total	100.0		100.0	

K. General

1. Record-keeping practices

Records are a very important tool in production management. Producers with thorough records can measure the differences associated with management or other changes and maximize the operation's profitability.

Although the percentage of operations that kept any records was similar for Catfish 2003 and Catfish 2010, the percentages of operations that kept records on stocking, feeding, and "other" topics decreased slightly between studies. The percentage of operations that kept records related to disease increased. In both studies, the highest percentages of operations kept records on harvesting, feeding, or stocking

Percentage of operations that kept the following types of written or computerized records:

	Percent Operations			
	Catfish 2003		Catfish 2010	
Record Type	**Percent**	**Std. Error**	**Percent**	**Std. Error**
Stocking	78.5	(0.8)	73.1	(0.7)
Harvesting	80.9	(0.8)	81.1	(0.6)
Disease	26.5	(0.9)	30.1	(0.7)
Feeding	79.0	(0.8)	75.0	(0.6)
Water quality	48.4	(1.0)	48.5	(0.8)
Breeding	10.2	(0.6)	12.1	(0.5)
Other	5.5	(0.4)	1.7	(0.2)
Any	86.6	(0.7)	84.9	(0.5)

Appendix I: Sample Profile

A. Responding Operations

1. Responding operations by pond size

Size of Growout Pond (acres)	Catfish 2003*	Catfish 2010**
1 to 19	83	71
20 to 49	115	84
50 to 149	196	124
150 or more	175	120
Size not known	1	
Total	560	399

* Thirty responding producers did not raise foodsize fish.
* Twenty-five responding producers did not raise foodsize fish.

2. Responding operations by region

Region	Catfish 2003	Catfish 2010
East	322	252
West	278	172
Total	600	424

3. Responding operations by State

State	Catfish 2003	Catfish 2010
Alabama	172	127
Arkansas	123	77
Louisiana	46	13
Mississippi	259	207
Total	600	424

4. Responding operations by operation type

Operation Type	Catfish 2003	Catfish 2010
Breed catfish	82	37
Operate hatchery	74	31
Raise fry to fingerlings	176	54
Growout foodsize fish	570	399

Sum for each study is greater than total participating operations for that study because a number of operations are of multiple types.

Appendix II: U.S. Catfish Acreage Inventory and Operations

A. Regional Summary for 2003

Source: NASS Catfish Production report, February 5, 2004.

	Number Surface Acres Intended for Use January 1–June 30, 2003				
State	**Foodsize**	**Fingerlings**	**Broodfish**	**2002 Total Sales** (x$1,000)	**January 1, 2003, Number of Operations**
Alabama*	22,900	1,500	630	76,045	231
Arkansas*	28,500	4,200	650	56,380	155
California	1,810	360	90	7,875	38
Florida	590	45	15	756	34
Georgia	700	115	60	1,411	43
Illinois	65	45	10	226	12
Kentucky	460	95	15	1,180	60
Louisiana*	8,600	1,050	170	15,812	57
Mississippi*	86,000	16,800	3,000	243,226	405
Missouri	690	590	55	1,070	31
North Carolina	1,480	140	60	3,143	46
South Carolina	70	25	20	617	13
Texas	570	105	55	3,672	36
Total for Study States* (Percent of U.S.)	146,000 (95.8%)	23,550 (93.9%)	4,450 (92.1%)	391,463 (95.2%)	848 (73.0%)
Total U.S. (13 States)	152,435	25,070	4,830	411,413	1,161

* Study States (Alabama, Arkansas, Louisiana, and Mississippi).

B. Regional Summary for 2010

Source: NASS Catfish Production report, January 28, 2011.

State	Number Surface Acres Intended for Use January 1–June 30, 2010			Water Surface Acres Used/Intended for Production Jan 1–Jun 30		2009 Total Sales (x$1,000)	January 1, 2008, Number of Operations[4]
	Foodsize	Fingerlings	Broodfish	2009	2010		
Alabama[1]	19,200	380	120	22,100	19,800	90,688	252
Arkansas[1]	16,600	2,200	250	25,000	19,200	44,914	155
California	1,400[5]	190	80	2,400	1,800[5]	8,074	55
Louisiana[1]	1,700	50	0	6,300	1,800	8,395	31
Mississippi[1]	52,000	9,700	1,300	80,200	64,000	196,787	427
North Carolina	1,600	200	50	2,200	1,900	5,495	53
Texas	2,600	190	70	3,800	2,900	12,644	149
Other States[2]	1,900	1,300	370	4,900	3,700	5,570	495
Total for study states[1] (Percent of U.S.)	89,500 (92.3%)[5]	12,330 (86.8%)	1,670 (74.6%)[3]	133,600 (90.9%)	104,800 (91.1%)[5]	340,784 (91.5%)	865 (53.5%)
Total U.S.	97,000[5]	14,210	2,240	146,900	115,100[5]	372,567	1,617

[1] Study States (Alabama, Arkansas, Louisiana, and Mississippi).
[2] States whose estimates are not shown and States suppressed because of disclosure concerns.
[3] Excluding Louisiana.
[4] Source: NASS Catfish Production report, January 30, 2009 (most recent State-level publication for number of operations).
[5] Numbers updated from those presented in Catfish 2010 Parts I and II, which were obtained from NASS Catfish Production report, January 29, 2010.

January 1, 2009, U.S. operations equaled 1,306; January 1, 2010, U.S. operations equaled 994.

C. Number of Operations and Water Surface Acres used for Production, 2003–11

Year	Water Surface Acres Used for Production Jan 1–Jun 30	Total Sales (x$1,000)	Number of Operations (on January 1)
2003	187,200	409,918	1,161
2004	183,190	463,413	1,149
2005	175,940	482,295	1,124
2006	170,370	484,005	1,035
2007	163,676	454,593	1,240
2008	163,100	409,998	1,617
2009	146,900	372,567	1,306
2010	115,100	402,584	994
2011	99,600	Not available	909

Source: NASS Catfish Production reports.

D. Number of Water Surface Acres used for Production by Operations in the Four Study States, 2003 and 2010

State	Number of Operations (on January 1)		Water Surface Acres Used for Production Jan 1–Jun 30	
	2003	2010*	2003	2010
Alabama	231	NA	25,500	19,800
Arkansas	155	NA	34,000	19,200
Louisiana	57	NA	9,900	1,800
Mississippi	405	NA	109,000	64,000

* In 2009, NASS began publishing State-level number of operations only every five years, in conjunction with the Census of Agriculture.
Source: NASS Catfish Production reports.