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Uses (and Misuses) of Sodium Bicarbonate in Aquaculture

Craig Tucker and Sue Kingsbury

About twenty years ago, an article appeared in a major aquaculture trade magazine describing various uses of sodium bicarbonate in fish culture. The article stirred so much interest among fish farmers that the major manufacturer of the chemical sent three representatives to Mississippi and Arkansas to find out why sales of sodium bicarbonate to the aquaculture industry had suddenly spiked. As it turns out, most of the potential uses of sodium bicarbonate reported in that article had no basis in fact.

Since that time, the use of sodium bicarbonate in aquaculture has been discussed in textbooks and other technical literature, yet the chemical is still widely misused. In this article, we will review three common uses of sodium bicarbonate: 1) removing carbon dioxide, 2) decreasing high pH, and 3) removing off-flavors.

What is sodium bicarbonate?

Sodium bicarbonate—also called bicarbonate of soda and baking soda—is a naturally occurring material made from the mineral trona, which is sodium carbonate. Sodium bicarbonate is one of the most widely used industrial chemicals in the world and, second only to sodium chloride (table salt), it may be the most familiar "pure" chemical compound known to the public. Common household uses include baking (leavening), cleaning, deodorizing, as a toothpaste, and as an antacid to relieve heartburn. Some of these uses (such as tooth cleaning) depend on the gentle abrasive qualities of the compound, but the general usefulness of sodium bicarbonate stems from the unique ability of sodium bicarbonate to neutralize either acids or bases. Substances having this property are called "amphoteric."

Removing carbon dioxide

Perhaps the most common use of bicarbonate in aquaculture is to remove carbon dioxide from water. Carbon dioxide is the end product of respiration and accumulates naturally in ponds as part of the daily photosynthesis-respiration cycle. Carbon dioxide concentrations almost always vary inversely with dissolved oxygen; that is, carbon dioxide usually decreases during the day and increases at night. Highest concentrations occur near dawn, when dissolved oxygen concentrations are lowest. Very high concentrations can occur after phytoplankton die-offs because large amounts of carbon dioxide are produced as dead plant material decomposes.

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Uses (and Misuses) of Sodium Bicarbonate in Aquaculture
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Carbon dioxide interferes with oxygen use by fish. That is, if carbon dioxide concentrations are high, fish may suffocate at dissolved oxygen concentrations that are normally tolerated. The carbon dioxide tolerance level for catfish is not known with certainty, but concentrations in excess of 20 to 30 ppm are usually considered undesirable. When dissolved oxygen levels are low and carbon dioxide levels are high, catfish farmers sometimes try to relieve the stress on fish by removing some of the carbon dioxide. Sodium bicarbonate is often used for this purpose—often by throwing large quantities of the material into the current produced by aerators.

The basis for using sodium bicarbonate to remove carbon dioxide is a mystery because it does not work. When sodium bicarbonate is added to water containing carbon dioxide, it will cause a slight increase in pH, but it does not remove any of the carbon dioxide present.

Carbon dioxide can be removed from water by adding strong bases such as carbonates or hydroxides. Those bases react with carbon dioxide to form bicarbonate. The most common base used to remove carbon dioxide is hydrated lime (calcium hydroxide), although large amounts are needed if carbon dioxide concentrations are high.

About 1.6 ppm of hydrated lime is needed to quickly remove 1 ppm of carbon dioxide. So, for a typical 10-acre, 4-feet-deep catfish pond, about a ton of hydrated lime is needed to remove 20 ppm carbon dioxide. Using large quantities of a caustic chemical is inconvenient, especially under emergency conditions. Hydrated lime also affords only temporary relief because it removes only the carbon dioxide present at the time of application. Treatment does nothing to prevent subsequent problems (which may occur as soon as the next night).

Decreasing excessively high pH

Rapid photosynthesis by phytoplankton or other aquatic plants removes carbon dioxide from water and causes the pH to rise. On warm, sunny days in ponds with rapidly growing blooms, pH may increase to very high levels, which can be stressful to aquatic animals. Again, there are no precise guidelines for high pH tolerance, but pH values above 9.5 to 10 are considered undesirable.

Problems with high afternoon pH seem to be most common in fry nursery ponds and in ponds used to grow freshwater prawns, perhaps because the fertilization practices used to prepare ponds for stocking are designed to promote fast-growing phytoplankton blooms. Typically, high afternoon pH values abate in a few weeks after organic matter begins to accumulate in the ponds. As the organic matter decomposes, carbon dioxide is produced which reduces peak pH values.

When it is inconvenient or impossible to wait for pH values to stabilize naturally in ponds before stocking, a common recommendation for managing high pH problems is to add sodium bicarbonate. Does this recommendation work? The answer is “yes,” but with important qualifications.

In theory, the effect of bicarbonate on pH can be calculated from a simple chemical relationship if some simplifying assumptions are made. For readers interested in this process, the basic assumption is that pH over the range pH 8.5 to pH 11 is described mainly by the equilibrium condition for the second dissociation of carbonic acid. The equilibrium expression can be mathematically rearranged to solve for the hydrogen ion concentration, which can then be transformed to logarithms to give the Henderson-Hasselbach equation. This expression is solved for the proportion of bicarbonate and carbonate present at any pH over the range 8.5 to 11, and you can then calculate the impact on pH when certain amounts of bicarbonate are added.

We calculated the effect of adding bicarbonate to waters with three different initial total alkalinities (50, 100, and 200 ppm as calcium carbonate), all at an initial pH of 10.0. We also made actual measurements of pH changes when pond water samples with pH 10.0 were treated with sodium bicarbonate in the laboratory. Results in Table 1 show that the results predicted from the theory and the results from actual treatment agree closely, showing that the

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Table 1. Final pH values of waters with an initial pH of 10.0 treated with different amounts of sodium bicarbonate. Values were obtained either by calculation from the equilibrium expression or by treating actual pond water samples in the laboratory (in parentheses).

Initial alkalinity (ppm as $CaCO_3$)	Amount of sodium bicarbonate added (ppm) 25	50	100
50	9.85 (9.89)	9.73 (9.77)	9.56 (9.61)
100	9.92 (9.93)	9.85 (9.85)	9.73 (9.75)
200	9.96 (9.94)	9.92 (9.91)	9.85 (9.84)

simplifying assumption made in the calculation was valid.

The bottom line is that treatment with sodium bicarbonate reduces high pH values, and the results are almost immediate. However, results were not spectacular except when large amounts of sodium bicarbonate were added to waters with an initially low total alkalinity. For example, if the water has an initial total alkalinity of 200 ppm as calcium carbonate and a pH of 10.0, adding 100 ppm of sodium bicarbonate (about 270 pounds per acre-foot) will reduce the pH only to 9.85. The same amount of sodium bicarbonate added to water with an initial alkalinity of 50 ppm as calcium carbonate will reduce pH to about 9.6.

In addition to the relatively large amount of chemical needed to achieve a significant reduction in pH, there is another drawback to using sodium bicarbonate—adding bicarbonate does little to prevent subsequent increases in pH. The failure of bicarbonate to permanently prevent high pH values in ponds is rooted in some complex chemistry that is difficult to explain. Suffice to say that high pH problems are common in ponds with high total alkalinities and low total hardness, demonstrating that high concentrations of bicarbonate will not prevent high pH problems.

Treating off-flavors

This is the most inexplicable use of sodium bicarbonate because there is no chemical or biological basis whatsoever for the claim that adding the compound to water either removes or prevents off-flavors in fish. The misconception is perhaps related to the common household practice of placing an open package of baking soda inside refrigerators to remove food odors. Sodium bicarbonate actually does remove certain airborne odors, but only if the odors are caused by acidic or basic compounds. For example, two common odors in refrigerators are caused by lactic acid (spoiled milk) or acetic acid (from the vinegar in pickles, for example). When these acidic, airborne molecules contact baking soda inside your refrigerator, they react with bicarbonate and become neutralized to less odorous compounds. Similarly, odorous basic gases, such as ammonia, are neutralized to less odorous compounds when they contact baking soda. This is an example of the amphoteric nature of bicarbonate—it neutralizes both acidic and basic odors.

The major off-flavors in pond-raised catfish are caused by geosmin and 2-methylisoborneol. Both compounds are tertiary cyclic alcohols and are uncharged over the range of pH values encountered in nature. In other words, they are neither acidic nor basic, and do not react with bicarbonate.

Bottom line

Sodium bicarbonate has many industrial and household uses. And despite the discussion above, it does have meaningful applications in aquaculture. Sodium bicarbonate is, for example, an important component of most “hauling tank aids.” When fish are transported in tight quarters, adding sodium bicarbonate to the water provides sodium to help animals maintain internal salt balance and bicarbonate to help buffer the pH of the hauling water. Nevertheless, two common uses of sodium bicarbonate in aquaculture—to remove carbon dioxide and treat off-flavors do not work. The use of sodium bicarbonate to reduce high pH in culture waters is based on sound principles, but the results are not as spectacular as many people believe.

Welcome to New Personnel at NWAC

Sarah S. Harris

Dr. Attila Karsi recently joined the NWAC staff as a Postdoctoral Assistant working in conjunction with the USDA-Agricultural Research Service Catfish Genetics Research Unit. He received his B.S. degree in Fisheries and Aquaculture at Ankara University, Turkey (1994), and his M.S. (1998) and Ph.D. (2001) degrees in molecular biology from Auburn University under the direction of Dr. John Liu.

Dr. Karsi’s studies included a broad spectrum of research in molecular biology. During his M.S. studies, he was involved with genetic marker development (EST and microsatellite) for linkage mapping of catfish and gene cloning and expression of important catfish genes. His doctoral studies focused on evaluation and utilization of the SB transposon in transgenic fish research, EST development, cloning of a complete set of (79) ribosomal protein genes, and construction of a catfish AFLP map. One focus of his research will be on allelic association between immune related genes and disease resistance for the application of marker-assisted selection in catfish. Dr. Karsi can be contacted by phone at 662-686-3531.

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Optimizing Fry Pond Fertilization

Charles C. Mischke and Paul V. Zimba

Although channel catfish have been farmed in the United States for over 50 years, research on fertilization practices specific to channel catfish nursery ponds in the Delta has not been conducted. Recommendations for fertilization of channel catfish nursery ponds are the result of research done in Alabama during the 1930's and 1940's. A common recommendation is to fertilize with high phosphorus (10-34-0 or 13-38-0) inorganic fertilizer at 1/2 to 1 lb/acre every 2 days until a bloom develops. Also, some sources recommend organic fertilizer (rice bran, cottonseed meal, or alfalfa pellets) applications up to 250 lbs/acre followed by weekly applications of half the initial rate.

To determine if recommended fertilization practices are appropriate for the Delta, we evaluated phytoplankton and zooplankton responses to fertilization (addition of both organic and inorganic fertilizer) in channel catfish nursery ponds before fish stocking. We also evaluated responses to organic, inorganic, and a combination of both fertilizer types in newly constructed versus established catfish nursery ponds.

In 2001, three ponds were used as controls and did not receive fertilizer. Three additional ponds received an initial application of 200 lbs/acre cottonseed meal, 50 lbs/acre calcium nitrate (7.5 lbs/acre N), and 0.6 gal/acre triple superphosphate (1.8 lbs/acre P). After initial application, fertilized ponds received weekly applications of 25 lbs/acre cottonseed meal and twice-weekly applications of 25 lbs/acre calcium nitrate, and 0.2 gal/acre triple superphosphate for 4 weeks.

Few differences were apparent between fertilized and non-fertilized ponds. Phosphorus levels were higher in fertilized ponds, but nitrogen was unchanged. Although phosphorus levels were higher in fertilized ponds, algal populations were not different. Preferred zooplankton populations were also unchanged by fertilization.

In 2002, 26 ponds were studied. Sixteen ponds were newly constructed ponds; 10 ponds were previously used for fish production for several years. Within each pond age group, treatments of no fertilizer additions, organic fertilizer only, inorganic fertilizer only, or a combination of organic and inorganic fertilizers were assigned. Organically fertilized ponds received an initial application of 75 lbs/acre cottonseed meal followed 3 days later by 50 lbs/acre. Thereafter, 25 lbs/acre was added twice per week for 3 weeks. Inorganically fertilized ponds received an initial application of 40 lbs/acre urea (18 lbs/acre N), 0.6 gal/acre triple superphosphate (1.8 lbs/acre P), followed by twice weekly applications of 20 lbs/acre urea, and 0.3 gal/acre triple superphosphate for 3 weeks.

Nitrogen was higher in old ponds compared to new ponds. Nitrogen was also higher in the inorganic and in the inorganic plus organic fertilizer treatments compared to control ponds or organic only treatments. Phosphorus was higher in old ponds compared to new ponds and in all ponds receiving inorganic fertilizer.

Chlorophyll *a* was higher in the inorganic and in the inorganic plus organic treatments compared to control and organic only treatments. Control ponds and organically fertilized ponds – both old and new – were similar in chlorophyll *a* concentrations and decreased over the study. Chlorophyll *a* in new ponds fertilized with either inorganic only or both inorganic and organic fertilizers was low and remained constant throughout the study. Old ponds fertilized with either inorganic only or both inorganic and organic fertilizers increased initially in chlorophyll *a*, and then decreased throughout the second half of the study.

The three groups of zooplankton important for channel catfish are copepods, cladocerans, and ostracods. Copepod numbers were higher in old ponds compared to new ponds and higher in ponds fertilized with both organic and inorganic fertilizer compared to ponds fertilized only with organic fertilizer. In all fertilizer treatments, copepod numbers increased over the study with peak numbers being reached from 14 to 24 days after filling. Cladoceran numbers were not significantly different between old and new ponds but were higher in ponds fertilized with inorganic fertilizer as compared to all other treatments. In inorganically fertilized ponds, cladocerans reached peak numbers 17 days after filling in both new and old ponds. Ostracods were more numerous in old ponds compared to new ponds; however, no differences occurred among fertilizer treatments.

The fertilization rates used in 2001 had little affect on primary productivity and, consequently, little affect on zooplankton. Laboratory studies indicated that nitrogen may be limiting in the ponds; therefore, the nitrogen levels were increased for the 2002 study. After increasing the nitrogen rates, several significant differences in primary productivity were detected between fertilized and non-fertilized ponds. This result indicates these ponds are primarily nitrogen limited and not phosphorus limited. This is in contrast to previous thought that phosphorus is the key ingredient in fertilizer and the basis for

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Research on Catfish Harvesting and Grading

Craig Tucker and Sarah Harris
Southern Regional Aquaculture Center

Inefficient harvesting and size grading seriously affect the profitability of the catfish farming industry. Market-size fish that escape during harvest continue to grow, creating production inefficiencies and carry-over of large fish that are unacceptable to processing plants. Large fish also tend to dominate feeding hierarchies in ponds and can prevent smaller fish from fulfilling their genetic potential for growth. Inefficient harvest also exposes fish that should have been marketed to additional risks such as disease and predation.

Size grading is important both for fingerling and foodfish producers. Farmers purchasing fingerlings generally desire fish of relatively uniform size. If a group of fingerlings purchased has a high proportion of small fish relative to the average size, many of the fish will be too small to grow out in the desired time frame. Also, if the fingerling population has many exceptionally large fish, the number of head purchased may be significantly underestimated.

Foodfish grading is important because sending undersized fish to the market is a financial burden to the farmer and the processor. On a per-pound basis, undersized fish represent a higher cost of production than market-sized fish, so their sale to processors at regular market prices may constitute a significant financial loss to the farmer. On the other hand, undersized fish may either be unsuitable for processing or, at best, may have lower processing yield than fish of the desired market size. In either case, undersized fish are a significant economic burden to processors.

In 2000, the Industry Advisory Council of the Southern Regional Aquaculture Center (SRAC) requested that a project be developed to improve harvest technology. The co-chairs of the Industry Advisory Council at that time were Lester Myers of Isola, Mississippi and Jerry Williamson of Lake Village, Arkansas. The 3-year project that was subsequently developed by SRAC involves twelve scientists from six universities in the southeast.

For information on all SRAC projects, visit our website at:

http://www.msstate.edu/dept/srac

In addition to the wide variety of information offered, you can print copies of all SRAC publications, obtain the address of your state Aquaculture Extension Specialist, and link to many other useful aquaculture sites.

Dr. Ed Robinson and Jason Yarbrough led the effort at Mississippi State University. They used funds from the SRAC project to complete work on a novel design for catfish seines. The original design for the seine was developed in collaboration with the National Marine Fisheries Service Lab in Pascagoula, Mississippi. Work on the SRAC project showed that braided polyethylene mesh is a good choice for constructing seines and socks for harvesting and grading catfish. Also, mesh sizes of the braided material that retain fish of a certain size were determined. A prototype seine was used to harvest catfish from ponds ranging from 4 to 10 acres at the National Warmwater Aquaculture Center. Average catch was 20% better than with conventional seines and seining time was reduced by 45%.

In Arkansas, David Heikes used funds from the SRAC project to enhance an ongoing program to develop a floating platform grader. The device has adjustable grader-bar spacing and can easily be incorporated into standard harvest procedures to grade catfish in ponds. The grader can grade 10,000 pounds of food-sized catfish in 2 to 6 minutes. One series of tests showed that 5 to 11% more weight of sub-harvestable size fish can be graded compared to current technology, resulting in a 12.5% increase in average weight of fish available for processing. With certain modifications, the grader appears to be adaptable to other species such as striped bass. Though testing continues, several commercial catfish producers and one striped bass producer have adopted this technology.

The two activities mentioned above are only part of this project, which involves work related to harvest of catfish, baitfish, and hybrid striped bass. A complete summary of this work and other activities supported by SRAC are presented in SRAC's Fifteenth Annual Progress Report (available online at http://srac.msstate.edu/dept/srac/apr15.pdf).

Effect of Feeding Level and Dietary Protein on Catfish Production

Menghe Li, Edwin Robinson, and Bruce Manning

Catfish are typically fed all they will eat, called "satiation", based on observation or some other subjective measure. However, during periods of reduced cash flow caused by low fish prices, a tight budget, or other factors a restricted feeding regime may be used to cut costs. Since feed cost is the largest operating cost in catfish production it is important that fish be fed in a manner so that the feed is most efficiently utilized.

In the past few years we have conducted several feeding trials to examine effects of daily satiate or restricted feeding of different protein levels on catfish production and feed efficiency. We found that moderate daily feed restriction improved feed efficiency, but also decreased production. Both 28% and 32% protein diets provided satisfactory fish production if the feed is not severely restricted (below 90 lbs/acre/day).

We have also evaluated effects of feeding on a less than daily basis on catfish performance. For example, we compared feeding once daily, once every other day, or once every third day to satiation, or once daily to half satiation on catfish production. Results showed that fish fed every other day or every third day to satiation ate about 50% and 64% more feed, respectively on days fed, but these fish were smaller at harvest compared to fish fed daily. We recommend that if a restricted feeding regime is to be followed, catfish should be fed to satiation on days fed rather than limiting feed on a daily basis, so that smaller, less aggressive fish have a better opportunity to eat.

So, if producers choose to feed every other day what is the dietary protein level that will result in optimum fish production? In 2002 we conducted a feeding trial to look at the effects of different protein levels (28, 32, or 35%) and feeding daily or every other day to satiation on catfish production, feed conversion, and processing yield.

Stocker-size catfish averaging 206 lbs/1,000 fish were stocked into 24, 1-acre ponds at a density of 4,500 fish/acre. Four ponds were used for each dietary protein × feeding regime combination. We fed the fish all they would eat once daily or every other day with three commercial diets containing 28, 32, or 35% protein for 110 days (June to September). Typical pond management practices used on commercial catfish farms were followed.

Regardless of feeding regimes, dietary protein levels (from 28% to 35%) had no impact on net production or percentage of fish that were marketable. On average, fish fed every other day ate 22% (based on total amount of feed fed) to 29% (based on feed consumption per fish) more feed than fish fed daily on the days fish were fed. These results generally agreed with that of our earlier study, but fish fed every other day in the present study ate less feed than fish in the previous study relative to that of fish fed daily. The difference appears to be associated with different fish sizes used in the two studies. The fish were larger in the previous study than in the present study. Larger fish may be able to eat more feed than smaller fish when feed is restricted, so one would expect a greater percentage increase in feed consumption of the larger fish after a period of feed restriction as compared to smaller fish.

In this study, fish fed every other day had 31% lower net production per acre and gained 27% less weight per fish than fish fed daily. Fewer marketable-size fish were produced for fish fed every other day than for fish fed daily (21% vs. 51% in a 110-day feeding period). However, fish fed every other day had a 12% improvement in feed conversion than fish fed daily (2.35 vs. 2.66).

We also observed a significantly lower carcass dress-out yield and fillet yield in fish fed every other day compared to fish fed daily (64.8% and 35.5% vs. 65.9% and 36.4%). One would expect a lower processing yield in fish fed a restricted ration since feed restriction limits nutrient and energy intakes and thus reduces muscle growth and fat deposition.

In summary, based on results from this study it appears that dietary protein levels had no effect on fish growth and production whether catfish were fed once daily or every other day to satiation. Feeding the fish every other day may improve feed conversion efficiency and reduce feed cost, but will also reduce production and processing yield and extend the production cycle compared to feeding daily. Producers should weigh savings on feed cost against losses of production if fish are to be fed less than daily for an extended period.

Effect of Diet on Processing Yield of Channel Catfish

Edwin Robinson, Menghe Li, and Bruce Manning

Since fish size dramatically affects yield of processed catfish, factors that influence size such as stocking density, feeding rate, water quality, fish health, and diet inadvertently affect yield. Even though we know from research how each of these factors affect fish growth and yield, in practice it is difficult to separate their effects because they are interrelated. For example, as stocking densities increase feeding rates must be increased to provide sufficient nutrients for growth, and as more nutrients are added to the pond water quality may begin to deteriorate. This in turn will affect feeding rate either through management decisions to reduce or stop feeding to improve water quality or fish health, or the fish may decrease feeding activity voluntarily due to environmental stress or because of a disease outbreak. Thus the overall management strategy must be considered when evaluating factors that affect processing yield.

So where does diet composition fit into this scheme? It can affect processing yield, but formulating a diet to increase processing yield cannot in itself overcome the negative effects of poor management practices. The effect of diet on processing yield is dependent on the relationship between dietary energy and protein. There is an optimum digestible energy to protein ratio of about 8.5 to 9.0 kilocalorie per gram of protein in the diet. For a 32% protein diet this equates to about 1200 to 1300 kcal per pound of diet and for a 28% protein diet energy should be 1080 to 1150 kcal per pound of diet. If the digestible energy to protein ratio greatly exceeds the optimum an increase in fattiness is generally observed in fish fed to near satiety. This is because energy consumption exceeds need and the excess is deposited as fat, which may affect processing yield. From the example given above, it is apparent that as dietary protein is reduced less energy is needed in the diet. Unless something is done to adjust the energy concentration of the diet, dietary energy will become too high in relation to dietary protein and an increase in fattiness will occur. The level of dietary protein where excess energy becomes problematic is around 24% to 26%. That is, as dietary protein is reduced to this level or below, the increased fattiness may affect processing yield unless dietary energy is reduced accordingly. However, there are two main problems with reducing dietary energy to optimize the relationship between energy and protein. One is that there is no practical and economical way to reduce dietary energy without causing other potential problems. For example, soy hulls could be used to dilute the diet but this adds a considerable amount of fiber (indigestible material) of which the long term effects on the pond environment are not known. The second problem with this issue is that if dietary energy is lowered too much (to less than about 1000 to 1100 kcal/pound of diet) fish growth will be reduced because there will not be enough non-protein energy for maximum growth.

Although the issue of dietary protein and both live and processing yields seems to be fairly straight forward, it is complicated by several factors including management practices, feed price, fish price, and whether your income is derived from growing fish or processing fish. Here is what we know. Fattiness is an inherent characteristic of growing animals and there is a genetic component that diet or feeding practices will not overcome. That is, catfish will contain a certain level of fat. Further we know that catfish require no more than 24% to 26% dietary protein for maximum growth, but that as we reduce protein to these levels the energy to protein relationship of the diet becomes less than optimum resulting in increased fattiness which may lead to reduced processed yield. In addition, we know that we can increase dietary protein to 35% and improve processing yield but not live yield. Given the above and considering that catfish producers have typically been paid on live yield, but knowing that there are rumblings of basing fish prices on processing yield (the policy may be in effect in some areas), and given the current status of the catfish industry (increasing feed cost and decreasing fish prices), making a recommendation that is satisfactory to all those impacted is difficult. The choices go from the extreme of feeding a 24% protein diet and realizing considerable savings on feed and accepting that the fish will be fatter and processing yield may be reduced to feeding a 35% protein diet and reducing fat and increasing processing yield. What we think would be best for the catfish industry is to feed a 28% protein feed with low levels of fish meal or with no animal protein. This will result in significant savings on feed cost and will not increase fattiness or decrease yield significantly. Regardless of the choice, keep in mind that diet alone will not correct all the problems that contribute to decreased processing yield, and if fish prices do not recover one has to look for ways to reduce production costs to stay in business. Reducing feed cost is one of the easiest methods to reduce production costs.

2002 CVM Aquatic Diagnostic Laboratory Summary

Al Camus and Pat Gaunt

In 2002, the Aquatic Diagnostic Laboratory at Stoneville received a total of 1306 case submissions, 1057 diagnostic and 249 research. The number of producer submissions declined from 1602 in 2001 to 1057 in 2002, or a total of 34%. A major factor contributing to the lower case numbers was the relatively mild fall disease season believed to be associated with rapid decreases in pond temperatures following a succession of tropical storms and cold fronts in September and October. This rapid cooling appeared to result in a precipitous drop in the number of enteric septicemia of catfish (ESC) cases received in September and an atypically low number of proliferative gill disease (PGD) cases in October and November. Despite this fall cooling trend, average monthly water temperatures were remarkably similar to 2001. While the mild fall disease season provided welcome relief to producers, fingerlings with no previous exposure to ESC or PGD were at risk as temperatures began to moderate in the spring.

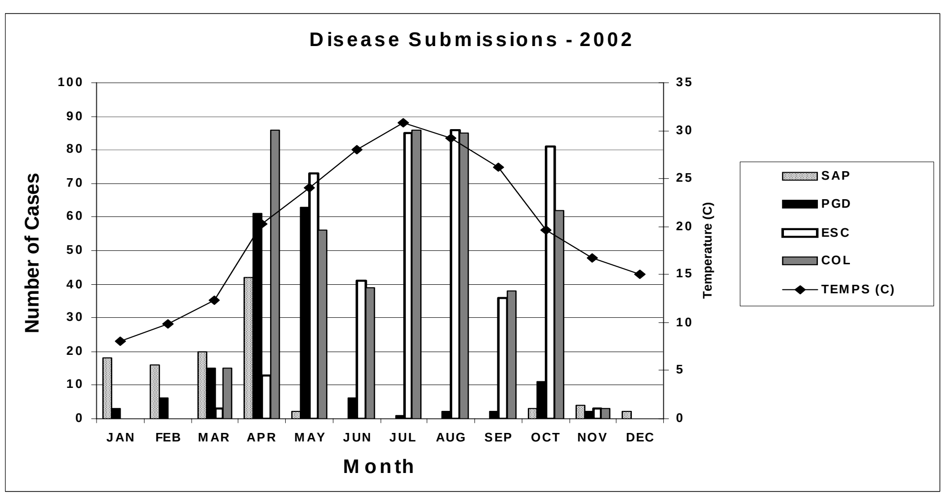
As in previous years, each individual case represents a composite of fish from a single submission collected from one pond. It should be mentioned that the numbers represented in this report are derived solely from submissions received by the laboratory and do not necessarily reflect actual disease incidence in the field. Routine diagnostic procedures include evaluation of gill clips, fin and skin scrapes, gross external and internal lesions, touch impressions of tissues, bacterial and viral cultures of various tissues, as well as histopathology.

The bacterial diseases ESC and columnaris disease continue to dominate the numbers of producer submitted cases. Examined as a single disease entity, ESC accounted for 13.6% of cases, but in combination with other disease agents was diagnosed in 39.8% of cases (36.4% in 2001). While columnaris has a lower tendency to occur alone, accounting for 9.9% of cases, in combination with other pathogens, columnaris was present in 44.5% of all cases (37.2% in 2001), making it the most frequently diagnosed cause of disease seen by the laboratory. ESC and columnaris were diagnosed together in 19.0% of case submissions. These numbers have remained relatively consistent over the past six years, where on average ESC was diagnosed in 37.6% and columnaris in 44.0% of all diagnostic cases. Of 432 ESC and 472 columnaris isolates tested, none showed resistance to the antibiotics Terramycin® and Romet®.

Proliferative gill disease (PGD) was the third most commonly diagnosed disease representing 16.3% of cases versus 19.2% in 2001. Saprolegnia, the cause of winter fungus, was present in 10.1% of cases, almost identical to the 10.4% seen in 2001. The number of channel catfish virus (CCV) disease cases declined from 7.3% in 2001 to 5.8% in 2002, but remained above the 6 year average of 3.9%. Numbers of channel catfish anemia (CCA) cases were minimally increased from 5.0 to 5.3%, but remain above the 6 year average of 3.9%. Similarly, the number of *Ichthyophthirius multifiliis* (Ich) cases increased slightly from 1.8 to 2.2%, and remain above the 6 year average of 1.4%.

Notably, the number of trematode cases, now identified as *Bolbophorus damnificus*, continued to decrease from a high of 5.6% in 2000, to 4.4% in 2001, and 2.0% in 2002. Decreased losses attributed to *Bolbophorus* trematodes are believed to be the result of greater awareness among producers, leading to increased surveillance and control of the ram's horn snail, intermediate host of the parasite. Cases of visceral toxicosis of catfish (VTC) declined slightly from 2.5 to 2.0% in 2002. Although a blue-green algal toxin is suspected, the cause of this enigmatic disease remains unknown.

The number of water quality samples received by the laboratory increased from 1037 in 2001 to 1191 in 2002. As in 2001, however, the total number of farms submitting declined. Raising pond chloride levels above 100 ppm is the most frequent recommendation made regarding water quality. Only two cases of brown blood disease were seen during 2002.



Spring Viremia of Carp

Al Camus

Spring viremia of carp (SVC) is a disease, primarily of the common carp (*Cyprinus carpio*), caused by the viral agent *Rhabdovirus carpio*. The disease is believed to have existed in Europe for centuries, where it causes significant losses in carp culture annually, although the virus was first described in 1971. The virus is also responsible for outbreaks in Russia, Asia, and the Middle East. The disease was diagnosed for the first time in the United States in 2002 from cultured koi (*Cyprinus carpio*) in West Virginia and in wild carp in Wisconsin. Signs of infection include lethargy, darkening, abdominal swelling, bulging eyes, pale gills, and hemorrhage in the skin. Internally, there is fluid in the abdominal cavity and extensive hemorrhage, particularly on the swim bladder. All ages are susceptible, but outbreaks occur most often in 1 to 2 year old fish, in the spring when water temperatures are 52 to 63°F. There are currently no vaccines available to prevent infection.

Natural infections of the disease have been reported in koi carp, grass carp (*Ctenopharyngodon idella)*, bighead carp (*Aristichthys nobilis*), silver carp, (*Hypophthalmichthys molitrix*), crucian carp (*Carassius carassius*), goldfish (*Carassius auratus*), tench (*Tinca tinca*), and the Eurpoean catfish (*Silurus glanis*). Experimental infections have been induced in roach (*Rutilus rutilus*), pike (*Esox lucius*), guppy (*Lebistes reticulates*), pumpkinseed (*Lepomis gibbosus*), zebra danio (*Brachydanio rerio*), and the golden shiner (*Notemigonus crysoleucas)*.

The potential danger posed by this disease to native, wild and cultured fish species, including the channel catfish, is unknown, but is under investigation by federal agencies. Carp producers are at risk for substantial losses. For this reason, and others, SVC is being treated by USDA-APHIS-Veterinary Services as a reportable foreign animal disease. If heavy unexplained mortalities are encountered, particularly in wild or cultured carp species, in association with rising spring water temperatures, accompanied by extensive external and internal hemorrhage, you are encouraged to contact the Aquatic Diagnostic Laboratory at the National Warmwater Aquaculture Center, in Stoneville, at 662-686-3305. For additional information a more detailed factsheet is available through the USDA-APHIS web site at www.aphis.usda.gov.

Welcome to New Personnel

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Dr. Michael J. Mauel recently joined the staff of the MSU College of Veterinary Medicine, Aquatic Diagnostic Laboratory at NWAC. He comes to us from the Tifton Veterinary Diagnostic and Investigational Laboratory of the University of Georgia where he was head of the Bacteriology Section. While in Tifton his research concentrated on the isolation and characterization of an agent causing epizootics in tilapia. Prior to UGA, Dr. Mauel was head of the Zoonotic Molecular Diagnostic Laboratory and Research Associate for the Center for Vector-borne Disease at the University of Rhode Island. At Rhode Island Dr. Mauel utilized molecular diagnostic techniques such as PCR and dot-blot hybridization to determine the presence of pathogens such as *Borrelia burgdorferi* (Lyme disease) and *Babesia microti* (Human Granulocytic Ehrlichiosis) in tick vectors. He was also responsible for developing and implementing procedures to detect EEE for the Rhode Island state surveillance program. In addition, he taught courses in basic microbiology and food microbiology plus graduate seminars in molecular techniques.

Dr. Mauel received his Ph.D. in Microbiology from Oregon State University on the molecular diversity within *Piscirickettsia salmonis*, a pathogen of fish. At NWAC,

Dr. Mauel will develop molecular diagnostics and research the pathobiology of catfish diseases.

Dr. Mauel can be contacted by phone at 662-686-3303.

Safer, Plastic Paddles for Hatching Channel Catfish Eggs

Jim Steeby

Although aluminum or steel paddles have been used successfully in egg hatching troughs, they pose a threat to worker's hands, arms, and even hair. Jerry Noble and Wayne Wright of Noble Fish Farm Hatchery may have found a safer alternative.

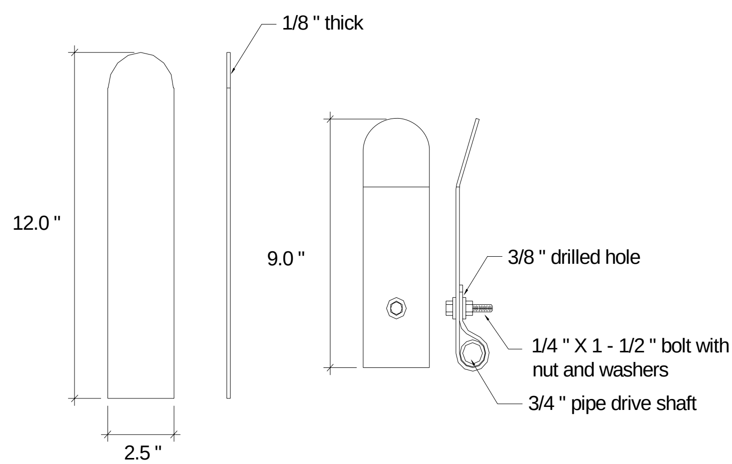
They have devised a new paddle that can be fabricated from FDA approved high-density polyethylene drums. New, food-grade 30-gallon drums (19 inches by 31 inches) can be purchased for about $30 and should make 30 to 35 paddles or enough to equip 5 to 6 hatching troughs.

Using a reciprocating saw, the 1/8 inch thick plastic is cut into 12 inch long by 2.5 inch wide strips (Figure 1). The plastic is then folded about 9 inches from one end and shaped to fit a 3/4-inch pipe by slightly heating the plastic with a small propane torch. The folded paddle is then drilled with a 3/8 inch bit and fitted with a 1/4 inch diameter bolt (1.5 inches long), nut, and washers. The edges and end of the paddle can be smoothed with a small knife or coarse stone grinding wheel.

The finished paddle can be bolted to the 3/4-inch pipe drive shaft and tightened to dig properly through the water. The paddle stops when it comes in contact with resistance, such as an arm or hand. Loosening the bolt allows the paddle to hang straight down if the trough is needed for rearing fry rather than hatching eggs.

Jerry Noble has been using this design for two years and has replaced all metal paddles. Converting paddles to this new safer material can make an excellent winter or off-season project.

Figure 1. Diagram of plastic paddles for hatching channel catfish eggs.



Optimizing Fry Pond Production

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recommending using a fertilizer with three times as much P_2O_5 as N. Delta soils historically have medium to high soil test levels of phosphorus. In this study we used four times as much N as P_2O_5. Although the 2002 protocol resulted in significant differences among treatments, even higher nitrogen application may be beneficial, especially in new, non-established ponds. Nitrogen and phosphorus concentrations increased in all ponds receiving inorganic fertilizer, although not as much in new ponds, indicating new ponds may require several times the amount of nitrogen and phosphorus required in old ponds.

The addition of cottonseed meal was expected to have a direct effect on zooplankton populations; organic fertilizer provides substrate for bacterial growth, can be consumed by zooplankton directly, and may provide nutrients for phytoplankton. However, organic fertilizer application had little affect on primary productivity or zooplankton populations. Using higher rates of organic fertilizer may eventually produce responses in phytoplankton or zooplankton, but may reduce water quality.

Although older, established ponds may be more problematic, we suggest using established ponds for fry culture, filling ponds 7 to 10 days before stocking, and applying inorganic fertilizer at an initial rate of ~18 lbs/acre N and 1 to 2 lbs/acre P, followed by subsequent applications (every 3 to 5 days) of half the initial rate for 3 to 4 weeks. If newly constructed ponds are used, higher fertilizer rates are probably necessary to achieve the same response. Also, continuing fertilization at lower rates until the fish begin eating commercial feeds may be helpful in sustaining zooplankton populations.

Comparison of Multiple-batch and "Modular" Catfish Production Systems

Terry Hanson and Jim Steeby

Under the traditional multiple-batch production system, 5-inch fingerlings are restocked annually resulting in a growout period of 18 to 24 months. This system is fairly efficient at producing an average yield of 4,000 to 5,000 lbs/acre of 1.0 to 1.5 lb fish. However, decreasing farm-bank prices and an increase in the size of catfish desired by processors strains the ability of this management scheme to produce fish at a consistently profitable level.

Studies by Carole Engle at UAPB found that stocking 7-inch fingerlings into growout pounds resulted in an estimated 99% probability of producing market size fish at less than $0.60/lb. Given that fingerlings larger than 6 inches are typically difficult to find and expensive to transport, a production system is needed that grows larger foodfish utilizing the 5-inch fingerlings readily available to most fish producers. An alternative is a three-step "modular" system (those operations that purchase 5-inch fingerlings would begin with step 2):

1. Fry are stocked at 120,000/acre to grow 4- to 5-inch fingerlings by the end of the first season. Fish may be fed at rates up to 120 lbs/acre/day.
2. At the end of the first season or by the start of the subsequent spring, the 4- to 5-inch fingerlings are placed in "stocker" ponds at 40,000 to 50,000 fish/acre. These fingerlings are fed to satiation daily and provided with 3 hp/acre of paddlewheel aeration. This phase will usually yield a standing crop of 7- to 8-inch stocker-size fish totaling 10,000 lbs/acre at the end of the second growing season.
3. At the end of the second season or by the subsequent spring, the 7- to 8-inch stockers are placed in the final growout ponds at 4,000 to 6,000 fish/acre depending on the production goal and size needed for market. In this final stage maximum feeding rates may approach 150 lbs/acre/day and 2 hp/acre of paddlewheel aeration is recommended.

The goal of this project was to evaluate and compare this modular production system to the traditional multiple-batch catfish production system currently in use in the Mississippi Delta.

Farm simulations can assist farmers in determining if another production system, such as the modular system, may be right for them. Production parameters used in this simulation come from enterprise budget preparations stemming from long-term analysis of catfish production systems in the Mississippi Delta, and modular production system results come from farmers presently using this system. For the economic and production analysis and comparisons between the two systems, farm size, production (fingerlings stocked, pounds harvested, feed fed, labor, chemicals, other variables) and fixed costs, machinery and equipment were taken into account. Enterprise budgets were constructed for each scenario and compared. Breakeven analysis was conducted to determine the cost of production for each system. The breakeven cost can be compared to current farm bank prices to determine profitability (Table 1).

Total farm acreage for the two compared systems did not vary, though

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Table 1. Comparison of Production System's Acreage, Revenue, Costs and Breakeven Costs of Production.

	Modular System		Multiple-batch System	
	Acres		Acres	
Required acres for:				
Growout to final harvest	900		1,050	
Fingerling to Stocker stage	200		0	
Fry to Fingerling stage	100		150	
Broodstock	50		50	
Total acres	1,250		1,250	
Major Revenue/Costs	Pounds/ Number	Cost ($/acre)	Pounds/ Number	Cost ($/acre)
Receipts	8.85 mill.	3,723	8.21 mill.	3,473
Costs:				
Feed		2,075		2,166
Fingerlings	7.88 mill.	375	10.00 mill.	455
Labor & Mgt.		411		362
Chemicals		739		659
Fixed costs		489		501
Net Returns		250		158
Breakeven cost of production to cover:				
All variable costs, $/lb		0.56		0.57
All variable & fixed costs, $/lb		0.65		0.67

Comparison of Multiple-batch and "Modular" Catfish Production Systems
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acreage usage by specific production phases did differ (Table 1). There were 1,050 growout acres in the multiple-batch system compared to 900 growout acres in the modular system, i.e., a 200-acre reduction in growout acres for the modular system. This poses the question whether the modular system can increase production to make up for this reduction in growout acreage. Additionally, all operating costs for 200-acres of 'fingerling-to-stocker' production were accounted for in the modular analysis.

Feed requirements for the two systems differed with the multiple-batch system requiring 5.96 tons/acre/year compared to 5.91 tons/acre/year for the modular system, a decrease of 0.05 tons and a $12/acre/year decrease in feed costs. The modular system required an additional four seining crew employees over the multiple-batch system, or an additional $72,000/year in labor and management costs. Reduced overall acreage resulted in fewer salt and diuron applications for the modular system. Copper sulfate was applied to 50 more acres in the modular system. Overall, chemical costs were $10/acre/year higher for the multiple-batch system over the modular system.

Equipment usage for the two systems followed the same rule, i.e., one tractor and PTO emergency aerator for every three ponds; two 10-hp electric aerators per 10-acre pond and the modular system required two boom-loading trucks whereas the multiple-batch system required only one. When all receipts and costs were totaled the modular system had a net return of $250/acre/year compared to the multiple-batch system's net return of $158/acre/year, a net increase of $92/acre. The breakeven price of production is presented in the bottom of Table 1. The modular production system had a $0.01/lb lower cost than the multiple-batch system when variable costs only are considered. When variable and fixed costs are included, the modular system had a $0.02/lb lower breakeven cost, but other 'non-cash' advantages of the modular system may be just as important.

Other 'non-cash' reasons to pursue the modular system include the additional control over catfish at all stages; the reduced risk of over- or under-stocked ponds; becoming aware of dead fish sooner in the production cycle; and a more efficient use of foodfish pond space and size control. Growth of 5-inch fingerlings to stockers in their second year takes advantage of the natural competitive nature of fish at this size.

Stocker size fish should be produced as close to the final growout ponds as possible to keep transport costs to a minimum. On many operations this distance can be kept to one mile or less. At the same time, fry-to-fingerling ponds may be located in areas where close observation is possible because these fish are highly susceptible to bird predation and require more attention to assure survival than stocker or growout ponds. Ponds are harvested on 2 or 3 occasions at various times during a year. For most of the growing period a single crop of fish is present in the final growout pond, but as restocking will typically occur each spring, a portion of the previous crop may still remain to be harvested for 2 to 4 months.

The modular catfish production system was proposed many years ago and is currently in use on a small number of farms. This type of system lends itself best to operations greater than 300 acres in size that have on-farm crews for harvesting. Given the current size of catfish fingerlings that are widely available and the needs of processors, the modular system has proven to work well for those that have adopted it. All growers contacted that use the system are very satisfied with the level of production realized when using this system. While the modular system does not entirely confront the current price of fish received by producers, it does decrease the potential variability in fish yields and allows for greater control of the pond production system.

Mississippi State University and U.S. Department of Agriculture Cooperating