BAITFISH[1]

Project ***Progress Report*** for the Period
September 1, 2006 to August 31, 2009

NCRAC FUNDING: $200,000 (September 1, 2006 to August 31, 2008)

PARTICIPANTS:

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Industry Advisory Council Liaison:		
Phil Goeden	Goeden Fisheries, Alexandria	Minnesota
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Jeffrey L. Gunderson	University of Minnesota-Duluth	Minnesota
Non-Funded Collaborators:		
Barkhausen Waterfowl Reserve	Brown County	Wisconsin

PROJECT OBJECTIVES

(1) Determine what techniques and strategies for early season, indoor spawning of golden shiners and subsequent stocking into ponds will result in growth to 76 mm (3 in) by November 1 of that year.

(2) Develop economically viable culture techniques and strategies for growing spotfin shiners to a market size (greater than 51 mm [2 in]).

(3) Provide regular research updates related to this project to the baitfish industry through Web-based technologies, newsletters, fact sheets, workshops, and/or technical bulletins.

ANTICIPATED BENEFITS

This project addresses priority needs identified by the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council (IAC). In a survey conducted in late 2006, the NCRAC IAC members ranked "Baitfish" as being "Very Important," second only to disease and health issues. The development of techniques for producing fry earlier in the growing season so that they can be stocked into ponds concurrent with the onset of natural spawning cycles will allow for grow out to market size within one growing season. This research explores a potentially economically viable solution to advance baitfish culture in the NCR.

[1]NCRAC has funded two Baitfish projects. The Termination Report for the first project is contained in the 1989-1996 Compendium Report. This Progress Report is for the second project which is chaired by Joseph E. Morris. It is a 2-year project that began September 1, 2006.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Iowa State University (ISU) staff were successful at developing a strategy for early season spawning of golden shiners. Age-0 and -1 golden shiners brood stock were obtained from the University of Pine Bluff-Arkansas in the fall of 2006. Initially, fish were held indoors under "winter" conditions, i.e., 10°C (50°F) water temperature and a photoperiod of 8 h light/16 h dark. Fish were fed a 32% protein diet at 2% body weight twice weekly. Brood stock were held under these conditions for 10 weeks. Following this "winter" period, temperature and photoperiod were gradually increased over a 2 week transition period to "spring" conditions, i.e., 22°C (72°F) and a photoperiod of 16 h light/8 h dark. Once the tanks were under "spring" conditions, commercial spawning mats were placed into the tanks, just under the water surface. After spawning, the egg-covered mats were then transferred to hatching tanks. Once the eggs had hatched, one of nine commercially available diets were used to feed the newly hatched fry. At this stage, ISU staff determined that too many eggs and fry were not surviving due to the presence of fungus on the mats; cool water temperatures combined with excess feed caused excessive fungal growth. In addition, it was difficult to obtain reliable egg and fry counts using this technique. To overcome this problem, ISU staff began utilizing a technique in which the egg-covered spawning mats were immersed for 2–2½ min in a 1.5% sodium sulfite solution bath. This caused the eggs to drop out of the mat after which they were placed in hatching jars. This method allowed for enumeration of the eggs as well as the culture of the fry in tanks without spawning mats, thus eliminating fungal growth.

In 2007 six additional diets were evaluated and in 2008 three more diets were evaluated against the best performing diet from the 2007 trials. Stocking rates ranged from 8–40 fry/L (30–151 fry/gal). In 2007, only one diet, Zeigler AP100™, resulted in any survival of fry. That diet was then used in 2008 as the control for additional pair-wise comparisons of the three additional diets. Results from the 2008 culture season showed the Zeigler AP100™ diet again yielded the best survival; mean survival ranged from 1–28%, while the other three diets had mean survival that ranged from 4–6%. Results from this study show that more effort needs to be put into developing a more nutritionally complete diet for golden shiners. In addition, there is need to refine better culture techniques for growth and survival in indoor tank systems. Both better feeds and improved culture methods are needed to support the growth of the golden shiner industry in indoor systems.

In a related project not funded by NCRAC, the efficacy of hydrogen peroxide (H_2O_2) to control fungal (Saprolegniasis) infections of golden shiner eggs was evaluated in two experiments. Golden shiner eggs were exposed in a 15-min static bath (21°C; 70°F) to 0, 50, 100, and 200 mg/L in the first experiment, and 0, 200, 400, and 800 mg/L in the second experiment. All treatments were based on amount of active ingredient (30% active ingredient concentration of H_2O_2) in a single treatment. Three replicates of each concentration were used in both experiments. The objective was to determine the H_2O_2 concentration that would result in optimum hatching successes. The hatching rate significantly increased in each treatment level until 800 mg/L. The mean percent egg hatchability (± S.E.) at 400 and 800 mg/L was 72.3 ± 8.55 and 68.2 ± 5.03, respectively. Regression

analysis revealed the peak treatment level to be between 400 and 800 mg/L.

Because of the low fry survival in both 2007 and 2008, ISU researchers were not able to complete the original project objectives, i.e., use of out-of-season fry in ponds. Instead the objectives of the pond portion of ISU's studies were modified to (1) evaluate the growth of golden shiner fry in ponds using two fertilization regimes, one a combination of organic and inorganic fertilizers and the other organic fertilizer only, and (2) evaluate diet selection of fry in ponds using those two fertilization regimes.

To accomplish these objectives, six 0.08 ha (0.20 acre) ponds were each stocked with 360 golden shiner brood stock, total weight of 4.2 kg (9.3 lb) per pond. The fish were then allowed to spawn naturally on spawning mats that were staked on the edge of the pond slightly below the water surface. After the spawning activity concluded, the brood stock were left in the pond with the resulting fry and cultured for 180 days. All ponds received organic fertilization which consisted of one application of soybean meal at a rate of 9.1 kg (20.1 lb)/pond/week followed by weekly applications at a rate of 4.5 kg (9.9 lb)/pond/week for 5 weeks. Three of the six ponds also received inorganic nitrogen (36-0-0) fertilizer for 4 weeks at a rate which gave a nitrate-nitrogen to total phosphorus ratio (NO_3-N:TP) of 7:1. Water temperature, dissolved oxygen, and pH were all within acceptable ranges for golden shiner pond culture throughout the study period. Nitrite levels were low in both treatments throughout the culture period. Ammonia-nitrogen (TAN) had the largest difference between treatments with the inorganic-organic (mixed) fertilization treatment having elevated TAN levels compared to the organic only fertilizer treatment. Golden shiner fry collected at harvest in the organic only fertilization treatment averaged 71.2 ± 8.8 mm (2.8 ± 0.3 in) in length and 4.6 ± 2.6 g (0.16 ± 0.09 oz) in weight while those harvested in the mixed fertilization treatment averaged 82.2 ± 4.0 mm (3.2 ± 0.2 in) and 4.9 ± 0.8 (0.17 ± 0.03 oz). Both treatments yielded fish in excess of the target size (76 mm; 3 in) for this objective. The average total weight of age-0 golden shiners harvested from the organic only treatment ponds was 43.0 ± 11.9 kg (94.8 ± 26.2 lb) and 43.8 ± 5.1 kg (96.6 ± 11.2 lb) in the mixed fertilization treatment. Production from this experiment in total weight ranged from 239.7–690.2 kg/ha (213.9–615.8 lb/acre) in the organic only treatment and 429.1–646.2 kg/ha (382.8–576.5 lb/acre) in the mixed fertilization treatment. The average length, weight, total weight, and fish numbers were not significantly different ($P < 0.1$) between treatments and the preferred food item in both treatments were cyclopoid copepods and the cladoceran, *Chydorus*.

Age-0 and -1 fish from the 2007 culture season were collected from the ponds and placed in the indoor spawning tanks to repeat the earlier tank rearing study using different commercial diets. Results from the 2007 and 2008 feeding trials have been previously noted in this report. As there was again limited fry survival in the spring 2008 feeding trials, the decision was made to stock the ponds with either adults (similar stocking rate used in 2007) or with eggs obtained from out-of season spawning. The objective was to investigate if the use of eggs alone (600,000 eggs/ha; 242,820 eggs/acre) would yield fish that were of a more consistent size distribution compared to the use of brood stock. All ponds in 2008 were fertilized with the combination of organic and inorganic fertilizers that was used in the 2007 study; ponds were then managed for the same time period as 2007.

Fish were harvested from all ponds in October 2008. The ponds that were stocked with only eggs yielded larger fish (mean 122 mm [4.8 in]) than ponds stocked with adults (mean 69.2 mm [2.72 in]). However, the ponds stocked with the eggs had a total mean production of 194 kg/ha (1,057 lb/acre) compared to 612 kg/ha (3,333 lb/acre). Both treatments resulted in fish larger than the targeted 76 mm (3 in) size.

OBJECTIVE 2

University of Wisconsin-Milwaukee

Wild adult brood stock were collected during the summer of 2005 from rivers and streams in southeastern Wisconsin. Wild fish were acclimated to 23–25°C (73–77°F) under laboratory conditions. The wild fish accepted standard commercial feeds after several days of feed training. One group of adults was maintained at seasonal (normal) temperatures and a second group was kept at a constant temperature of 23–25°C (73–77°F).

Wild brood stock that were maintained at constant temperatures of 23–25°C (73–77°F) from August 2005 to August 2007 spawned out-of-cycle from March–May and produced progeny in the tens of thousands. The F_1 generation (older fish) produced in 2006 (domesticated brood stock) kept at a constant temperature exhibited spawning behavior but gamete production was poor.

Wild brood stock kept at a seasonal temperature from August 2005 to August 2007 exhibited spawning behavior and produced progeny from May through September resulting in an F_1 generation of 2006. The F_1 generation exhibited spawning behavior and produced numerous 2007 F_1 generations.

Culture techniques for early life stage feeding included: Green Tank Water (GTW), Brine Shrimp Nauplii (BSN), and commercial larval diets. F_1 generations reached an estimated size of 51 mm (2 in) in 12–14 months. Survival was poor throughout the entire post-larvae stage even though tens of thousands were spawned; only several hundred fish survived from each group.

The 2008–2009 work plan focused on improving early life stage survival. However, this research resulted in limited success. At this time, the limiting factor associated with post-larvae survival is providing an appropriate nutritional diet. Also, these experimental results indicate that the spotfin shiner elicited a positive response to temperature manipulation to control reproduction. However, growth and survival remain a question regarding the commercial production of these fish.

University of Wisconsin-Stevens Point (UW-Stevens Point) Northern Aquaculture Demonstration Facility (NADF) and the University of Wisconsin-Madison (UW-Madison)

Researchers could not conduct their studies as originally planned because of issues regarding the interstate transport of fish that arose subsequent to the outbreak of viral hemorrhagic septicemia (VHS) in the Great Lakes. Because of these issues, the number of adult-sized fish that could be obtained for the 2007 and 2008 studies were limited. The limitation on brood fish, in turn, led to a reduction in number and a delay in time at which fry became available. Additionally, in 2008 the extreme flooding in the region precluded the conduct of any meaningful pond-based studies.

In the spring of 2007, NADF staff set up multiple 227- and 1,514-L (60- and 400-gal)

tanks for holding, spawning, and incubation of spotfin shiners and eggs. These tanks were plumbed for both flow through and recirculating aquaculture system capabilities. NADF staff collected adult spotfin shiners in April 2007 from the Wapsipicon River, Iowa with the assistance of ISU researchers. These fish were examined at the collection site by Dr. Dave Starling, Aqueterinary Services, Ames, Iowa. Additional adult spotfin shiners were obtained from a private Minnesota bait supplier with the assistance of Gunderson in June 2007. These fish were examined in Minnesota by Dr. Glen Zebarth, Douglas County Animal Hospital, Alexandria, Minnesota. All Wisconsin fish import regulations and permits were followed. The Iowa fish were kept separate from the Minnesota fish and both groups were successfully feed trained to a commercial trout diet. Despite the fact that both fish groups were subject to a veterinary fish health inspection, some disease issues have arisen with both groups of fish at NADF.

The fish accepted a commercial trout diet and were kept in temperatures of 18–21°C (64–70°F) during spawning. Water quality parameters were maintained at adequate levels to provide a good rearing environment. Several types of spawning substrates were placed into rearing tanks during the spring of 2008. Adult fish (52.0–112.0 mm; 2.0–4.4 in) responded to substrates immediately with active spawning behavior and swarming around the substrates. This behavior was captured with an underwater video camera. Four different types of substrates were utilized for collecting gametes in the tanks:

(1) flat style 483.0 × 101.0 × 64.0 mm (19.0 × 4.0 × 2.5 in) with cedar shingles horizontally layered with 2.0–5.0 mm (0.08–0.20 in) crevices suspended in the tank on rope and brick;
(2) square vertical 152 × 152 × 127 mm (6 × 6 × 5 in) cedar shingles layered on a threaded rod that was hung on the side of tank with crevices 5.0–10.0 mm (0.20–0.40 in);
(3) cinder blocks 25 × 25 × 381 mm (1 × 1 × 15 in) with smaller blocks placed inside with crevices between 3.0–8.0 mm (0.12–0.31 in); and
(4) aluminum siding layered and suspended on a rope and brick in the tank.

The flat style substrate performed the best for collecting gametes and protecting them from being consumed by fish in the tank. Substrates were removed from tanks within 3–5 days after eggs were deposited on over 50% of available surface to reduce loss to eggs being consumed. Substrates were placed into prepared multiple 227-L (60-gal) tanks connected to the recirculating system for incubation and hatching. NADF staff also utilized some agricultural “horse tanks” set up as a small pond for hatching eggs. Eggs hatched within 5–7 days at 18–21°C (64–70°F), resulting in thousands of <5.0 mm (0.2 in) fry. Newly hatched fry were initially lethargic and non swimming but became photopositive and strong swimming within a few days. Fry were fed commercial starter diets of several types supplemented with pond water and 24 h lighting. Biomarine Artemac produced the best results with fry at NADF. Fry were observed with feed in stomachs after a few days. Survival of fry to fingerling size was <10%. Average growth rate from fingerlings examined was 0.4 mm/day (0.016 in/day) at 19–21°C (66–70°F) in the recirculating system on a commercial trout diet.

NADF staff also utilized a 1.5% sodium sulfite solution bath and immersed substrates containing eggs for 2–3 min,

which caused eggs to drop off the substrates. These eggs were placed into a hatching jar for incubation with no formalin treatment. Within 3 days these eggs were covered in fungus and died.

The primary problem that has been faced in this project is not being able to produce enough fry at any one time to fully stock production ponds. Despite holding over 2,000 mature brood stock in tanks, staff have not been able to collect more than 5,000 fry in any single week. This has made the conduct of the proposed studies problematic. The researcher's opinion is that this is a major problem that will impede the development of this species as a viable commercial baitfish produced in ponds.

Strong swimming, photopositive fry were collected and delivered to the UW-Madison facilities at the Lake Mills State Fish Hatchery at three times during the spawning time frame. These fry were stocked into two fertilized outdoor rearing ponds at approximately 25,000 fish/ha (61,774 fish/acre). When the fish in one pond reached 15.0–25.0 mm (0.6–1.0 in), staff began regularly feeding them a formulated food, which they readily accepted. In the autumn both ponds were harvested, but only 10% of the stocked fish were recovered. The fish had a mean size of 35.0 mm (1.4 in). The intent was to continue growing these fish in tanks, but the failure of a water heater resulted in all of the fish being killed.

In 2009, a successful attempt was made to conduct the pond-base study onsite at NADF. In May, banked brood stock at NADF and additional brood stock from Minnesota were introduced into the warmwater recirculating aquaculture system at NADF and spawned utilizing equipment and techniques described below from 2007–2008. Using fry garnered from the indoor spawning operations, a nursery pond was stocked in June–August 2009. Prior to being stocked, the pond was fertilized with alfalfa meal and urea. Fry survival in the outdoor pond trial appeared much better than in previous attempts indoors. In two harvest operations in September and October an estimated 20,600 fingerlings (13.0–44.0 mm [0.5-1.7 in]) were harvested and placed into a 20–22°C (68–72°F) recirculating aquaculture system at NADF for further grow out. Fingerling spotfins were fed commercial trout starter diet (Nelson Silvercup Inc., Utah) utilizing 24-h feeders. Monthly growth and condition data was collected on these fish. Spotfins reached >51 mm (2 in) within 60 days in the recirculating aquaculture system. Fish were >51mm (2 in) within 7–8 months by using a combination of indoor spawning in a recirculating aquaculture system, outdoor fry rearing, and final grow out in an indoor recirculating aquaculture system on commercial diets. The combination of recirculating aquaculture systems for brood stock holding and spawning with pond culture for fry and winter grow out back in a recirculating aquaculture system has resulted in the most promising results to date for NADF.

In 2009, newly hatched fry were also utilized for a short term diet study at NADF using three commercial diets (Otohime B1 [Aquasonic PTY, LTD, Wauchope, NSW 2446, Australia]; Inve Proton 2 [INVE Aquaculture, Inc., Salt Lake City, Utah]; and Marisource Artemac [Aquafauna Bio-marine, Inc., Hawthorne, California]). In a 45-day culture period, the first diet resulted in 0% survival but the latter two diets resulted in 19 and 21% survival for Inve Proton 2 and Marisource Artemac, respectively.

OBJECTIVE 3
Gunderson, in his role as extension liaison for this project, has presented the results of the baitfish project at the NCRAC Annual Program Planning Meetings in both 2007 and 2008. As stated in the proposal, he was to assist in the procurement of spotfin shiner brood stock. This proved to be difficult in that only one producer was able to provide 7.6-L (2.0-gal) of spotfin shiner brood stock to NADF in June 2007. Gunderson also facilitated one conference call among the researchers to discuss the status of their research efforts and delivered an underwater video camera and recorder to NADF to allow video recording of spotfin shiner spawning activities. Several hours of video have been taken. The primary activities related to this objective will occur once the research has provided results at which point outreach connection with the industry can begin.

WORK PLANNED
OBJECTIVES 1 & 2
Data collected to date will be further analyzed with the intent to develop protocols for future research into developing golden shiners and spotfin shiners as potential aquaculture species for the NCR.

OBJECTIVE 3
The University of Minnesota-Duluth staff will review the video footage of the spawning of spotfin shiners captured at the NADF for a possible video to demonstrate the crevice spawning behavior of spotfin shiners so potential culturists can fully understand the unique spawning requirements of this species.

IMPACTS
OBJECTIVE 1
Results from this study show that more effort needs to be put into developing a more nutritionally complete diet for golden shiners. In addition, there is a need to refine better culture techniques for growth and survival in indoor tank systems.

The potential of using eggs collected from indoor culture operations did result in fish larger than the targeted 76 mm (3 in) size albeit at smaller production levels than ponds stocked with brood stock. It is possible to reach a market size in one growing season using a combination of pond fertilizers, a feeding program, and use of eggs spawned earlier in the season under indoor conditions. This study also showed that even though fish were fed a prepared diet, they still searched for natural prey.

OBJECTIVE 2
Studies demonstrating combined pond and indoor recirculation aquaculture system grow out may provide baitfish producers with an opportunity to produce a new baitfish species, spotfin shiners, for the large and expanding market in the NCR.

However, UW-Stevens Point NADF and UW-Madison studies to date suggest that the limited capacity for producing fry from brood stock may preclude the development of this species as a viable commercial baitfish raised in ponds.

The results from this research do provide some insight to the future direction of research, especially as it relates to nutrition as a function of growth and survival. Additionally, the spawning and egg incubation apparatus developed during this study contributed to improved spawning behavior, egg incubation, and hatching success.

OBJECTIVE 3
The ability to locate and transfer spotfin brood stock to the NADF has helped and will continue to help facilitate this project.

This outreach effort will help coordinate the reporting of research results and make this information available to industry representatives who can base business decisions regarding the culture of spotfin shiners and early spawning of golden shiners in the NCR on it.

SUPPORT

NCRAC has provided $200,000 which is the entire amount allocated for this 2-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Baitfish activities.

APPENDIX

BAITFISH

Publications in Print

Meronek, T.G. 1994. Status of the bait industry in the North Central Region of the United States. Master's thesis. University of Wisconsin, Stevens Point.

Meronek, T.G., F.A. Copes, and D.W. Coble. 1995. A summary of bait regulations in the north central United States. Fisheries 20(11):16-23.

Papers Presented

Copes, F.A. 1993. Aquaculture shortcourse. Sponsored by University of Wisconsin-Sea Grant and Wisconsin Department of Agriculture, Greenwood, Wisconsin, March 1993.

Copes, F.A. 1995. Baitfish aquaculture. North Central Regional Aquaculture Conference/Ninth Annual Minnesota Aquaculture Conference, Minneapolis, Minnesota, February 1995.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Annual Meeting of the Michigan Fish Farmers Association, Cadillac, Michigan, February 1993.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Seventh Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 1993.

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Meronek, T.G. 1994. Baitfish aquaculture and production. Governor's Conference: Wisconsin Aquaculture '94. University of Wisconsin, Stevens Point, February 1994.

Morris, J.E. and T. Kent. 2008. New investigations into golden shiner culture. U.S. Trout Farmers/Midwest Aquaculture. Milwaukee, Wisconsin, September 18-20, 2008.

Kent, T., J.E. Morris, and R.D. Clayton. 2009. Feeding golden shiner fry commercial diets. World Aquaculture Society Meeting, Seattle, Washington, February 15-18, 2009.