SNAIL MANAGEMENT/GRUB CONTROL[1]

Project Component ***Termination Report*** for the Period
September 1, 2007 to August 31, 2010

NCRAC FUNDING: $191,995 (September 1, 2007 to August 31, 2010)

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REASON FOR TERMINATION

Project objective completed.

PROJECT OBJECTIVE

Investigate one or more methods of potentially useful approaches to snail population management and/or grub control. The methods of greatest interest include those that will be effective, economical, and approvable by state and federal regulators at commercial production scale. These methods will include reviewing what has been done elsewhere and designing studies that will address the NCRAC conditions, especially in pond systems for the production of economically important food fish for the region. Attempts will be made to investigate and refine these methods.

PRINCIPAL ACCOMPLISHMENTS

<u>University of Wisconsin-Stevens Point (UW-Stevens Point)</u>

Northern fantail crayfish (*Orconectes virilis*) were collected from lakes in Portage and Vilas Counties, Wisconsin in summer 2007. Baited wire (minnow) traps proved to be the most successful capture method with 455 crayfish (65.2% male, 34.7% female) collected. Additional crayfish were collected in summer 2008 from lakes in Vilas County, Wisconsin, bringing the total number of crayfish collected to 1,255.

The three, original, commercial fish farms, where the field study was to occur in Years 1 and 2 withdrew from the study amid concerns about Viral Hemorrhagic Septicemia (VHS) and because one of the farms implemented a winter draw-down program to control aquatic plants. The study locations were moved to AquaPoint Fish

[1]This Project Component Termination Report is for the first of two objectives of this project. A progress report for the second objective is contained elsewhere in this report. This is a project that had two years of funding and is chaired by Gregory W. Whitledge. It began September 1, 2007.

Farm, Stevens Point, Wisconsin, and Zelinski's Fish Farm, Antigo, Wisconsin. Both are commercial yellow perch (*Perca flavescens*) farms that have four, 0.022 ha (0.05 acre) ponds each that are fed with groundwater and are aerated. Ponds at both facilities had yellow perch that were previously infected with yellow grubs.

Because the total number of crayfish collected in Year 1 was less than the number required for pond stocking, both male and female crayfish were stocked into the treatment ponds in July 2008. Two treatment ponds at AquaPoint were stocked with 361 crayfish each (density = 1.66 crayfish/m^2 [0.15 crayfish/f^2]; 15% female), and two treatment ponds at Zelinski's were stocked with 267 crayfish each (density = 1.20 crayfish/m^2 [0.11 crayfish/ft^2]; 25% female). Each fish farm also had two control ponds that did not receive crayfish. Relatively small (< 25 mm [<1 in] total length) juvenile crayfish were recovered during the summer trapping at treatment ponds at both facilities, implying that successful crayfish reproduction and recruitment had occurred in all treatment ponds after the 2008 crayfish stocking.

Using an Eckmann grab sampler for benthic sampling, *Planorbella* (=*Helisoma*) and *Physa* snails were recovered from both treatment (crayfish added) and control ponds at both fish farms. Densities of *Planorbella* at the study ponds were generally low during spring sampling and increased through the summer. Notably, while *Planorbella* densities increased at both control and treatment ponds, the relative increase in densities was significantly greater in the control ponds without crayfish. Densities of *Physa* were always lower than *Planorbella* at all ponds sampled, and unlike *Planorbella*, *Physa* densities were generally static or even experienced a marginal decline during the summer. In terms of average snail size, both *Planorbella* and *Physa* snails exhibited declines through the summer.

None of the snails collected in any sampled pond were infected with *Clinostomum*, the trematode causing "yellow grub" metacercarial infections in yellow perch stocked into these facilities. Similarly, no *Uvulifer* (causing "black spot") or *Posthodiplostomum* were found in any of the snails examined. However, other non-grub causing digenean species were present in *Planorbella*.

Planorbella snails from both fish farms were also infected with the digenean trematode, *Echinostoma* sp. (likely *Echinostoma trivolvis*). *Planorbella* were infected with *Echinostoma* stages, and these snails served both as first intermediate hosts (possessing redial stages inside the ovotestis), and as second intermediate hosts (with metacercarial stages in the snail pericardial region).

All ponds at AquaPoint were stocked with approximately 640 yellow perch, of which 66% were initially infected with yellow grub with an average grub infection of 18.6 grubs/fish. Ponds at Zelinski's were stocked with approximately 1,000 fish, of which 75% were initially infected with yellow grub with an average infection of 2.3 grubs/fish. After two months, average grub infection rates in fish at AquaPoint and Zelinski's were 69% (14.28 grubs/fish) and 68% (4.1 grubs/fish), respectively. Specifically, averaged over May through September, yellow grub prevalence in perch at AquaPoint was 53.7% at treatment ponds while it measured 61.6% at control ponds. Average intensity of yellow grub infections in perch over the same time period was 7.67 grubs/infected fish at AquaPoint treatment ponds and 9.25 grubs/infected fish at the AquaPoint control ponds. At Zelinski's, yellow grub prevalence, averaged over May through September, was 68.0% in treatment ponds while it measured 74.4% in control ponds. Similarly, average intensity of yellow grub infections in perch over the same time period was 3.71 grubs/infected fish at Zelinski's treatment ponds and 4.03 grubs/infected fish at the Zelinski's control ponds. At the completion of the 2-year study, treatment ponds at AquaPoint that received crayfish contained yellow perch that showed 43.9% fewer grub infections than the yellow perch in control ponds. Treatment ponds at Zelinski's contained yellow perch that showed 18.4% fewer grub infections than yellow perch in control ponds after two years.

During 2009 the efficacy of the competitively dominant digenean trematode, *Echinostoma*, at reducing grub infections in other snails and ultimately in fish in the treatment ponds was attempted, i.e., echinostome egg introduction on prevalence of infections in first intermediate host snails (*Planorbella*), and the intensity of echinostome metacercarial infections in snails (*Planorbella*) at both treatment ponds (receiving echinostome eggs) and control ponds (no eggs). Eight 0.02-ha (0.046 acre) study ponds at the Hess fish farm facility in New London, Wisconsin were each stocked with 500 yellow perch. A total of 25 fish from each of the eight ponds (i.e., 200 total fish) were sampled monthly and assessed for grub infections as described above.

In an attempt to culture echinostome worms for the production of eggs, *Planorbella* snails naturally infected with echinostome metacercarial cysts were dissected. Echinostome metacercarial cysts from these snails were removed and the isolated cysts were then introduced by oral gavage (~25 cysts/animal) to hamsters (15 animals), mice (12 animals), and grasshopper mice (12 animals). Fecal material was then monitored for echinostome eggs using standard ova sedimentation protocols beginning at two weeks post-exposure. Unfortunately, while patent infections were achieved in hamsters in 2007, no patent infections (i.e., eggs appearing in feces) were achieved in attempts to infect the above described mammals in 2009. Marginal success was achieved using mallard ducklings. All eggs produced were distributed equally among the treatment ponds, with each pond receiving roughly 420 echinostome eggs between August 5 and August 17, 2009. Comparisons of snail infections between treatment and control ponds showed no significant differences in echinostome-infected snails in treatment versus control ponds.

<u>Southern Illinois University-Carbondale (SIUC)</u>

Laboratory trials were conducted in 2007-2008 to evaluate the potential of freshwater prawn (*Macrobrachium rosenbergii*) and two hybrid sunfishes (redear sunfish × green sunfish [*Lepomis micolophus* × *L. cyanellus*] and redear sunfish × warmouth [*L. gulosus*]) to serve as biological control agents for *Physa* spp. and *Planorbella* spp. Maximum consumption rates and maximum handling sizes for each of these taxa feeding on *Physa* and *Planorbella* were compared to those of redear sunfish, one of the most common molluscivores native to the North Central Region (NCR). Laboratory trials followed methods developed by Wang et al. that were published in the Journal of the World Aquaculture Society in 2003.

Redear × warmouth hybrids consumed larger snails than redear sunfish of equivalent body length, but consumed 25% fewer snails on average than redear sunfish.

While redear × warmouth hybrids have a larger mouth gape than redear sunfish for a given body size, they do not appear to be sufficiently voracious at consuming snails to represent a significant improvement over redear sunfish as a biological control agent.

Freshwater prawn (65.0–85.0 mm [2.6–3.3 in] carapace length) consumed *Physa* up to 12.0 mm (0.5 in) total length and *Planorbella* up to 16.0 mm (0.6 in) total length. However, freshwater prawns showed a strong preference for consuming *Physa* over *Planorbella*; prawns consumed 77% of *Physa* offered in maximum consumption trials but consumed only 20% of *Planorbella* offered. Consumption rates for smaller freshwater prawn feeding on snails were not determined but would likely be considerably lower than those of the harvest-size prawns that were used in laboratory trials.

Redear × green sunfish hybrids (120.0–140.0 mm [4.7–5.5 in] total length) consumed *Physa* and *Planorbella* up to 12.0 mm (0.5 in) total length; redear sunfish in this size range only consumed snails <10.0 mm (<0.4 in) total length. Maximum consumption rates of redear × green sunfish hybrids were equivalent to those of similar-size redear sunfish.

Laboratory trials were conducted in 2008 to determine the effectiveness of various concentrations of copper sulfate, hydrated lime, and salt (sodium chloride) for controlling snails given the characteristics (alkalinity, pH, hardness) of ponds at SIUC's pond research facility. All concentrations of hydrated lime (0.19–0.47 kg/m^2 [0.17–0.42 lb/ft^2] of water surface; *N* = 3 replicate tanks/treatment) yielded 100% snail mortality; mean snail survival rate in control tanks was 71%. Mean survival rate of snails exposed to copper sulfate applied at a rate of 0.09 g/m^2 [0.03 oz/ft^2] was 2% (range 0–6%). Salt concentrations up to 3 mg/L were ineffective at controlling snails in laboratory tanks. Based on laboratory trial results and application costs, hydrated lime was chosen as the chemical treatment to be used in subsequent snail control trials in ponds at SIUC.

Pond trials were conducted in 2008 to evaluate the effectiveness of hydrated lime ($Ca[OH]_2$) for controlling snails in research ponds at SIUC. Enclosures were placed in shallow water (0.3m [1.0 ft] depth) in four ponds and stocked with snails (*N* = 35 each) obtained from ponds at SIUC. Two ponds contained three enclosures each that served as controls. Two other ponds were treated with hydrated lime (0.25 kg/ha^2 [0.22 lb/ft^2]) along the pond edge, including enclosures containing known numbers of snails. Mean snail survival rate in control ponds was 89%, but was only 2% in ponds treated with hydrated lime.

Pond trials were also conducted beginning in July 2008 to assess the effectiveness of redear sunfish and redear × green sunfish hybrids for controlling snail populations in ponds. Three ponds at SIUC were stocked with redear sunfish at a rate of 250 fish/ha (100 fish/acre), three ponds were stocked with redear sunfish at a rate of 500 fish/ha (200 fish/acre), and three ponds were stocked with redear × green sunfish hybrids at a rate of 500 fish/ha (200 fish/acre); three ponds were not stocked and served as controls. Grass carp were stocked into each pond to provide control of aquatic macrophytes. Snail population densities and size structure were determined prior to stocking fish and at monthly intervals thereafter. Snail densities increased or did not significantly change in control ponds or in ponds stocked with redear × green sunfish hybrids; snail densities in ponds stocked with redear sunfish declined significantly over time. Few snails >7.0 mm (0.3 in) total length were present in ponds stocked with redear sunfish following stocking, whereas snails ranging from 3.0–16.0 mm (0.1–0.6 in) total length were relatively abundant in control ponds and ponds stocked with redear × green sunfish hybrids.

Pond trials evaluating the relative effectiveness of biological, chemical, and integrated biological/chemical controls of snail populations were conducted during June through October 2009. Redear sunfish and redear × green sunfish were used as biological control agents and hydrated lime was used as the chemical treatment based on the results of laboratory and pond trials conducted during Year 1. Sixteen ponds at SIUC were used for these pond trials ($N = 4$ ponds each for biological, chemical, biological and chemical combined, and control treatments). Triploid grass carp (*Ctenopharyngodon idella*) were stocked to provide vegetation control. Effectiveness of the snail control treatments (including controls) was assessed under production conditions using hybrid striped bass as a sentinel species. Snail population densities and size structure were determined prior to stocking fish and at monthly intervals thereafter. Prevalence of grub infestation in hybrid striped bass was assessed for each treatment.

Hydrated lime slurry applied at a rate of 31.7 kg/30.5 m (70.0 lb/100.0 ft) of linear shoreline in a 1.0-m wide(3.3-ft) swath produced a 99% reduction in estimated snail densities during 2009 pond trials. However, estimated snail densities in several ponds rebounded within two months of application. Ponds stocked with redear sunfish redear × green sunfish hybrids at 494 fish/ha (200 fish/acre) experienced a gradual decline in snail densities over four months, resulting in a 95% overall reduction at the end of the trial period. Ponds treated with both hydrated lime and predator sunfish experienced an abrupt decrease in snail densities, with a less appreciable rebound relative to the hydrated lime treatment group. Lowest abundances of encysted trematodes in hybrid striped bass reared in ponds coincided with low densities of *Planorbella* spp. Estimated *Planorbella* densities during the month in which hybrid striped bass were stocked were most strongly correlated to trematode abundance in crop fish. All three treatment methods reduced snail densities relative to the control. A combination of chemical and biological treatments may produce a rapid reduction of snail densities and maintain low snail numbers over the growing season.

IMPACTS

These results have provided valuable information regarding the effectiveness and efficiency of several approaches for controlling snail populations and associated grub infestations in aquaculture ponds in the NCR. Previously untested treatments for snail control in ponds (the crayfish *Orconectes virilis*, freshwater prawn, hybrid sunfishes, biocontrol with natural dominant trematodes, and integrated chemical and biological controls) were evaluated.

Work completed by UW-Stevens Point researchers has demonstrated that by utilizing locally available biological control species, e.g., crayfish, significant reductions in the snail populations can be achieved. Consequently, with a reduced snail population grub infections in fish contained within the ponds also decreased. Infections in yellow perch reared in ponds along with crayfish showed between 18–43% fewer grub infections after two years. However, it appears that more time is needed to completely eliminate snail populations and associated grub infections in fish culture ponds. This is most likely due to the low number of snails that actually harbor *Clinostomum*, the trematode causing "yellow grub" metacercaria. Snail density results showed that between 2–12% of snails actually harbored the yellow grub parasite; however, snails infected with the parasite were capable of releasing tens of thousands of cercaria. It might take time for the crayfish to eliminate all the infected snails especially when snail densities are high.

Crayfish may represent an economically viable, adaptable, and universally applied method of snail and grub management given enough time for the crayfish to be effective. The culturing and introduction of a competitively dominant echinostome trematode proved more difficult and laborious than predicted. Additionally, given the very low average prevalence of *Clinostomum* in snail first intermediate hosts, to possibly achieve measurably effects, the echinostome egg introduction to affected ponds would likely have to be maintained at a level of 10–100× greater than researchers were able to achieve in the field test. In short, this option is likely to be less effective as a biocontrol option compared to the crayfish manipulation.

Work completed at SIUC demonstrated that a combination of chemical (hydrated lime) and biological (native sunfish) treatments was effective for controlling snail abundance in ponds and limiting trematode abundance in cultured fish. Results also indicated that timing of treatment application is important for limiting grub infections. Integrated chemical and biological treatments yielded a rapid reduction in snail density that was maintained over the growing season. Application of a combination of snail control treatments may be a generally effective strategy for consistently limiting snail abundance in ponds over time, thus reducing the potential for grub infestations in cultured fish.

RECOMMENDED FOLLOW-UP ACTIVITIES

<u>Crayfish as a Biological Control Agent for Snails</u>

Four years after the start of this investigation, producers associated with Zelinski's fish farm indicated that there are thriving crayfish populations in the treatment ponds, along with crops of yellow perch, and that yellow perch harvested from these ponds have reduced or no grub infections. Control ponds that did not receive crayfish still do not have crayfish and yellow perch harvested from the control ponds continue to have grub infections. Based on the initial results at the completion of the 2-year study and the observations at Zelinksi's fish farm after four years, it appears that using crayfish as a biocontrol mechanism for snails and, ultimately, grubs may require longer than two years to be completely effective. Longer-term funding and further projects are needed to confirm these observations, but data show that crayfish are having an impact on the snail populations in the ponds. Understanding the extent of the crayfish impact and the duration and density of crayfish needed in fish culture ponds to reduce or eliminate grub infections should be further explored.

<u>Integrated Approaches to Snail Management and Grub Control</u>

While a combination of hydrated lime, native sunfish, and triploid grass carp (for vegetation control) was effective in limiting snail abundance and trematode infestation in hybrid striped bass in ponds at SIUC, other combinations of treatment methods may be more effective in ponds with different characteristics or in other geographic locations in the NCR. Additional evaluation of integrated pest management approaches (using various combinations of chemical, native biological, and/or physical treatment methods) are recommended to develop snail management and grub control methods tailored to particular settings given the variety of pond systems used for production of food fish across the NCR. Additional studies to assess the degree of snail population control required to limit grub prevalence in cultured fishes are also recommended.

SUPPORT

NCRAC has provided $191,995 which is the total amount allocated for this objective.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Snail Management/Grub Control activities.

APPENDIX

SNAIL MANAGEMENT/GRUB CONTROL

Publication in Print

Noatch, M.R. 2010. An evaluation of chemical, biological, and combined chemical-biological approaches for controlling snails in aquaculture ponds. Master's thesis, Southern Illinois University-Carbondale.

Manuscript

Noatch, M.R. and G.W. Whitledge. In press. An evaluation of hydrated lime and predator sunfish as a combined chemical-biological approach for controlling snails in aquaculture ponds. North American Journal of Aquaculture.

Papers Presented

Whitledge, G.W. 2008. Research on biological control of aquaculture pond snails at Southern Illinois University. Missouri Aquaculture Association Annual Meeting, Jefferson City, Missouri, January 12, 2008.

Timmons, B.A., C.C. Green, and A.M. Kelly. 2008. Snail consumption and preference by redear sunfish (*Lepomis microlophus*) and redear sunfish × warmouth (*Lepomis gulosus)* hybrid. Aquaculture America 2008, Lake Buena Vista, Florida, February 9-12, 2008.

West, A.J., T. Huspeni, and C. Hartleb. 2008. Biological control of snails and associated parasites of fish in culture ponds. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 14-17, 2008.

West, A.J., T. Huspeni, and C. Hartleb. 2009. Biological control of snails and associated parasites of fish in culture ponds. Wisconsin Aquaculture Association Annual Conference, Hayward, Wisconsin, March 13-14, 2009.

Noatch, M.R. and G.W. Whitledge. 2009. Comparison of biological, chemical, and integrated biological-chemical approaches for controlling aquaculture pond snails. Poster, 70th Midwest Fish and Wildlife Conference, Springfield, Illinois, December 6-9, 2009.

Noatch, M.R. and G.W. Whitledge. 2010. Comparison of biological, chemical, and integrated biological-chemical approaches for controlling aquaculture pond snails. 48th Annual Meeting, Illinois Chapter of the American Fisheries Society, Whittington, Illinois, February 23-25, 2010.