

Dreissenid Mussel Control Collaborative

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Great Lakes Commission, Great Lakes Fishery Commission, NOAA, and USGS September 30, 2014

U.S. Department of the Interior U.S. Geological Survey

Zequanox – Discovery



- Discovered by research team seeking replacement for oxidizing chemicals used to control zebra mussel in industrial systems
- Killed cells of the common soil microbe, *Pseudomonas fluorescens* strain CL145A (*Pf* CL145A)
- Highly selective for zebra/quagga mussels
 - Controls mussels in all life stages
- Effective in a broad range of water conditions and temperatures
- Produced by Marrone Bio Innovations
- <u>Approved by USEPA for open water use</u> <u>July, 2014</u>











Zequanox – Mode of Action

- Mussels perceive Zequanox as food and continue feeding during treatment
- Dead Pf CL145A cells contain compounds that destroy epithelial cells in the mussels' digestive system, causing hemorrhaging and



death





In healthy mussels, epithelial cells (arrows) appear as a thick layer lining the tubules of the digestive gland.



Following treatment, epithelial cells are destroyed. Blood cells are abundant as the digestive gland hemorrhages

Zequanox – Human Safety

- Composed of <u>dead</u> cells
 - Cannot grow, reproduce, mutate, etc.
- Not a human pathogen
 - American Type Culture Collection and American Biological Safety Association list as "Biosafety Level 1"
 - Lowest possible risk rating
- Food tolerance exempt
- Approved for use in manufacture of food grade and food contact materials
- No re-entry interval (REI)
 - Treated waters can be used for recreation (including swimming) immediately
 ISAN
 treatment







Zequanox – Environmental Safety

- Product activity degrades in approximately 24 hours
- Classified as "Readily biodegradable"
- Non-toxic, non-hazardous, and non-corrosive
- Demonstrated selectivity towards zebra and quagga mussels (*Dreissena* species)



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USGS – Zequanox research to date

USGS Zequanox research projects

- Great Lakes Restoration Initiative sponsored research to evaluate limited open-water use to support native mussel restoration activities
- Legislative-Citizen Commission on Minnesota Resources (LCCMR)-Environment and Natural Resources Trust Fund sponsored research to expand non-target animal database, application techniques, and limited open-water applications



Non-target studies 2011-2014

- Seven species of native mussels
 - No observed effect on survival
- Native mussels with adhering zebra mussels
 - No effect on survival of native mussels
- Nine species of freshwater fish
 - Impacts only observed at concentrations and exposure durations that exceed expected enivironmental levels and labelled use.
- Fathead minnow reproduction and development
 - Preliminary results indicate no effect on reproduction/development
- Two species of native aquatic invertebrates (Hexagenia & Gammarus)
 - Preliminary results indicate no effect on survival





Target animal studies 2012

- Zebra mussels exposed to expected environmental concentration (EEC) and durations using sub-surface and whole water column applications
 - Zequanox applied to 350-L tanks supplied with lake water
 - Applications conducted at Lake Carlos (MN) and Shawano Lake (WI)
 - ➢ Zebra mussel mortality ≥ 90% for treated groups
 - >90% mortality in all treatments regardless of application type or treatment duration





Dreissenid Mussel Control Collaborative

- Management Backbone:
 - Great Lakes Commission
 - Great Lakes Fishery Commission
- Proposed Membership:
 - Federal, Tribal, State, Local govt., Canadian
 - Academia, NGOs, Industry



- Focus: incubated in Great Lakes national/international approximation
- Common Agenda
 - Develop comprehensive IPM management approach
 - Adaptively manage/align science and research with management
 - Ultimately manage/control mussels in Great Lakes
- Communication
 - Continuous with a focus of vertical and horizontal communication to P³
 (participants, partners, and <u>public</u>)



Dreissenid Mussel Control Collaborative

- Science Role
- Develop IPM control tools & techniques
 - Assess Zequanox application methods
 - Assess impacts on GL-specific species
 - Develop additional controls
- Assess ecosystem response
 - Impacts on water quality (nutrients)
 - Benthic community restoration
 - Native mussel restoration
 - Recolonization
- Develop models and decision support tools
 - Develop quagga mussel population models
 - Model effect of dreissenid mussel control on ecosystem services



Adaptively align science to management objectives



Collaborative - Next Steps

- Continue to reach out to partners for buy in Does this approach make sense?
- Explanatory Webinar for potential members planned
- Further refine prospectus
- Begin to plan governance of collaborative
- Begin defining common agenda, management objectives and research needs
- Reach out beyond Great Lakes to other agencies



Lake Darling 2013

- Native mussels with adhering zebra mussels exposed in Lake Darling, MN to evaluate the use of Zequanox to aid in the control of dreissenid mussels adhering to native mussels
 - Zequanox applied within 2.25-m² enclosures positioned in the lake
 - Application concentrations 0, 50 & 100 mg/L;
 8-h exposure duration
 - Observation period shortened due to heavy filamentous algae bloom in the lake
- <u>Treatment reduced adhering zebra mussels by 53-68%</u>
- No effect on native mussel survival







Lake Minnetonka 2013

- Preliminary evaluation of subsurface versus whole water column application.
 - Zequanox applied to 2.25-m² enclosures in Lake Minnetonka
 - Zebra mussel survival and density reduction compared by application
 - Sub-surface application has the potential to significantly reduce the amount of product necessary to achieve control





Lake Minnetonka 2014 - in progress

Anticipated outcomes for this project include:

- Determine the suitability of using Zequanox as a management tool to control zebra mussels in open- water environments
- Determine Zequanox application strategies required for successful dreissenid mussel control
 - Zequanox concentration, application method
 - Assess any positive or negative exposure related impacts to native invertebrates





USGS Science Framework

SCIENCE FOCUS:

- Control tools and technologies
- Methods for early detection



- Assessing risk of Asian carp reproduction and survival.
- STRATEGY: Use an Integrated Pest Management approach to detect, aggregate, remove and exclude Asian carp. Foundational science:
 - Asian carp life history
 - Hydrologic dynamics



Life History and Habitat Use

Currently examining:

- Spawning requirements and early life history
- Feeding requirements at different life stages and overlap with native species
- Habitat use of different life stages
- Use of telemetry to obtain more detailed understanding of behavior and distribution

Knowledge of AC Life History characteristics is the foundation of our science!



Asian Carp Net Avoidance Behavior

USGS is using acoustic technology to examine Asian carp behaviors. Actions:

- Determined site locations
- Begun data collection with multiple gear types to compare gear types and catch efficiencies
- Developing testable hypotheses regarding net design improvement and design studies to test hypotheses



Asian Carp Feeding Attractants 2014

- Testing new automated feeding apparatus (MO River) to increase harvest success
- Evaluating response of AC and other species to attractant during IPM strategy at Morris, IL, Aug 2014
- Future strategy: Combine feeding attractant applications with microparticle technology





Targeted Microparticles

- Target bigheaded carps, minimize effects on native species
 - Multiple antimycin formulations prep'd & tested (UMESC, ABN, SWRI)
 - Additional UMESC formulations in dev. plus additional SWRI and ABN formulations
 - Leaching rates <<1% in some particles</p>
 - Multiple eugenol formulations prep'd/in dev.
- Formulations for other actives (e.g. pathogens)
- Adhesive particles SWRI

■ grass carp focus
■ USGS



Initial oral toxicity trials with antimycin microparticles

	Mortality (%)														
-	Largemouth														
	Silver carp			Bighead carp			Bluegill			bass			Paddlefish		
Dose	6 h	24h	48h	6 h	24h	48h	6 h	24h	48h	6 h	24h	48h	6 h	24h	48h
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	0	80	80	0	80	80	0	0	20	0	0	0	0	90	90
В	100	100	100	100	100	100	0	60	80	0	20	40	20	100	100
С	100	100	100	100	100	100	20	100	100	100	100	100	100	100	100





Registration of Control Technologies

Complete formulation review to determine data requirements of antimycin incorporated microparticles

- EPA registration review
- USFWS Section 7 ESA-consultation

Complete registration review of a CO₂ barrier or the use of CO₂ as a control agent in limited open-water application sites

- EPA registration data requirements
 - 30 data requirement waivers being prepared (coordinated w EPA OPP-RD)
- USFWS Section 7 ESA-consultation data requirements



Early Detection- eDNA and Microbial

USGS is examining:

- Distribution of Asian carp DNA in the environment
- How it degrades (i.e., how long DNA sequences are broken into shorter and shorter sequences)
 - Focus on transitioning cPCR to rtPCR analysis
- Its persistence in the environment
- Rate at which it is shed from fish



Hand-held Real-time DNA Detection Kit

- Target detections in fish distribution tank water
- CRADA developed between USGS and Lucigen
- Developing markers and optimizing LAMP assay
- Optimizing sample collection and preparation methods
- Validate LAMP assay performance
 - Assess concordance of LAMP assay w real-time PCR



Tributary Assessment Tool

- USGS data collection and analysis on 4 GL tribs led to new understanding egg development and survival in rivers
 - Lower velocities and shorter river lengths required than previously thought
- FluEgg Tributary Assessment Tool incorporates hydraulics, water-quality and egg characteristics to analyze rivers for Asian carp spawning suitability



Illinois River Data Collection



- Analyzing hydraulics and water-quality data to determine factors controlling the stalling of the AC population
- Mapping of water velocity and water quality- Upper IL R. Emphasis on boundary condition inflows/outflows (Brandon Rd L & D, Marseilles L & D) April-Sept 30, 2014
- Compute continuous water-quality data for 2 Illinois R. stations (main channel and backwater; 8 parameters)
- Working with SIU on database and visualization tools for AC movement data



Status of Grass Carp in Lake Erie

- Sandusky River demonstrated suitable for Asian carp spawning (Kocovsky et al. 2012 JGL 38:159-166; Murphy et al. 2013 USGS SIR 2013-5106)
- Grass Carp spawned successfully in Sandusky River in 2011 (Chapman et al. 2013 JGL 39:547-554)
- Large, mature, diploid female grass carp with > 4 kg of eggs (GSI 15%) captured near Sandusky Bay in June 2014
- = High potential for another successful spawning event





IPM Approach in Action



- 2013: IL DNR, SIU and USGS collaboration First integration of these techniques
 - Used algal attractants to lure carp to a location
 - Waterguns used to deter and move carp
 - Commercial fishing to remove carp –number of fish captured increased substantially
- 2014: IPM Field Effort Same as above plus:
 Tag fish and track using *acoustic telemetry* May test other sound techniques as deterrents



USGS Science Framework

SCIENCE FOCUS:



- Develop and assess control tools/technologies
- Assess ecosystem response to controls
- Develop models and decision support tools

STRATEGY:

Develop a dreissenid mussel control collaborative

- identify management objectives and align research goals
- adaptively manage development and application of integrated pest management to dreissenid mussels



Lake Minnetonka 2014 – In progress

- Background color is the RGB equivalent of "dark blue" from the USGS color palette (specified in PowerPoint)
- Identifiers on the title and content slides are specified to print black when printing to a B&W printer







