



USGS – Upper Midwest Environmental Sciences Center Update on Aquatic Nuisance Species Research

Great Lakes Panel on Aquatic Nuisance Species Meeting
November 15, 2023

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

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Projects Encompass EDRR framework

- Forecasting (Erickson)
- Detection (Spears)
- Response (Control methods)
 - Sea Lamprey (Luoma, Carmosini)
 - Invasive Carp
 - Acoustic deterrance (Brey, Fritts)
 - Genetic control (Merkes)
 - Toxicants (Saari)
 - Invasive Crayfish (Cupp)
 - Invasive Mussels (Waller)



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Horizon scanning and climate matching

Goal:


Determine invasion risk by looking at climate match for species

Approach:

Implemented the CLIMATCH algorithm into an R package, climatchR for rapid calculation of climate scores


Environmental Modelling and Software 157 (2022) 105510

Contents lists available at [ScienceDirect](#)


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Position Paper



Climate matching with the climatchR R package

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Detection: eDNA, occupancy models and sampling design

Goal:

Refine eDNA sampling protocols as an early detection tool

Why:

There are uncertainties about how many and when and where to take samples for detection of species and how to understand unexpected.

Approach:

Use occurrence modeling to predict optimal sampling methods for detection of common versus rare species

Ecological Applications, 29(6), 2019, e01951
Published 2019. This article is a U.S. Government work and is in the public domain in the USA.

Refinement of eDNA as an early monitoring tool at the landscape-level: study design considerations

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Trace amount of invasive silver carp DNA detected in Lake Erie

Updated: Jul 25, 2018, 7:02 p.m. | Published: Jul 25, 2012, 7:02 p.m.



Lake Erie's Presque Isle Bay in Erie, Penn., Jan. 26, 2012 (Garret Elson) | WQRC

Detection: Point-of-use eDNA

Goal:

Develop and optimize protocols for rapid, field-based eDNA detection.



Why:

Laboratory eDNA processing is time and resource constrained. Point of use tools can provide results on site.



Approach:

- Evaluate methods for rapid DNA extraction and stability of reagents
- Assays currently developed for Invasive Carp, Dreissenid mussels, & Spiny water flea
- Initiated field testing of protocols for dreissenid mussels at NPS and FWS sites

Detection: Automated eDNA collection

Goal:

Develop and optimize automated eDNA sampling for early detection and more comprehensive monitoring of populations

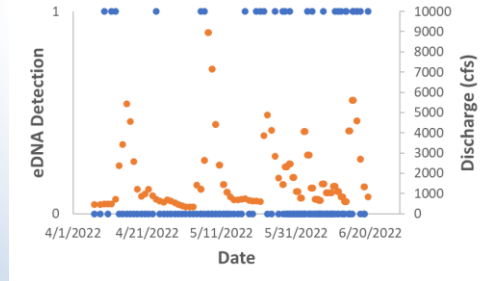


Why:

Automated sampling reduces resources required for field sampling and provides more comprehensive monitoring of invasive species

Approach:

- Deployed MBARI autonomous eDNA samplers (in 2022; planned in 2024)
- Pilot to assess ability of continuous eDNA to detect onset of grass carp spawning in Lake Erie tribs
- Initial results: Correlation of eDNA with GC spawning events



Control: Great Lakes Fishery Commission Sea Lamprey Control Technical Assistance Program



Goals:

- Conduct and maintain the lampricides and pheromone pesticides registrations in the U.S. and Canada.
- Develop, evaluate, and register new lampricide formulations
- Evaluate the effects of the lampricides on nontarget species of concern.
- Improve pesticide application/delivery techniques



Control: Sea Lamprey Technical Assistance Program



Approach:

Species of concern (identified by partners, FWS, DFO, Tribal entities, etc.) are tested

Use lab and field toxicity tests to simulate stream treatments



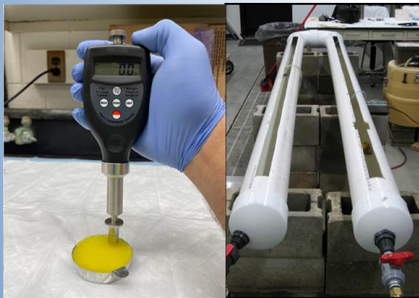
Control: Sea Lamprey Technical Assistance Program



Approach:

Develop an improved TFM bar formulation for treating low-discharge tributaries

Develop and evaluate an improved replacement for the emulsifiable concentrate formulation of Bayluscide



Measuring hardness of TFM bar

Test system to evaluate prototype TFM bar dissolution



Bayluscide Emulsifiable concentrate formulation



Bayluscide suspension concentrate formulation



Replicated flow-through toxicity test system for comparative toxicity tests with target and nontarget animals

Control: Next Generation Lampricide Project

Goal:

Identify new chemicals to control the invasive sea lamprey in the Great Lakes.



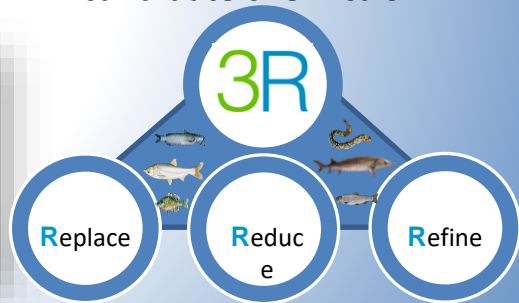
Why:

Reliance on 2 chemical lampricides for > 60 yrs has raised concerns over the potential for lamprey to develop resistance.



Approach:

Cell lines for sea lamprey and non-target species, along with *in vitro* assays, are being developed for screening candidate chemicals.



Control: Invasive Carp - Underwater Acoustic Deterrent System (UADS)

Goal:

Prevent movement of invasive carp into the Great Lakes

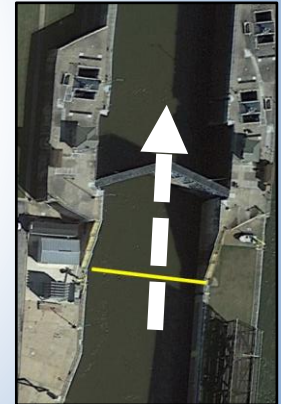
Approach:

Series of 16 speakers in Lock 19 approach
Operate for 4 years – 2021 to 2024)



Counts of full upstream passage by UADS operational status

	2021		2022		2021 - 22 Off vs On
	Off	On	Off	On	
Invasive carps	21	7	29	21	
Silver Carp	12	6	18	9	2 : 1
Bighead Carp	8	1	11	12	
Grass Carp	1	0	0	2	
Native species	34	29	40	35	
Bigmouth Buffalo	22	17	28	26	1.2 : 1
Flathead Catfish	--	--	--	1	
Freshwater Drum	6	8	4	--	
Northern Pike	--	--	--	1	
Paddlefish	4	3	1	1	
White Bass	2	1	7	6	



Brey, M.K., Woodley, C.M., Stanton, J.C., Fritts, A.K., Sholtis, M., Castro-Santos, T., Vallazza, J.M., and Albers, J.L., 2023, Lock 19 underwater acoustic deterrent system study—Interim project update, through 2022: U.S. Geological Survey Open-File Report 2023–1058, 11 p., <https://doi.org/10.3133/ofr20231058>

Control: Invasive Carp - BioAcoustic Fish Fence (BAFF)

Goal:

Prevent movement of invasive carp into the Great Lakes using multiple deterrents

Approach:

3-year study of BAFF (sound, bubbles, lights) at Barkley L&D

- Silver Carp passage reduced ~50%

- Native fish movements are similar when BAFF is On or OFF
- Currently evaluating Grass carp response

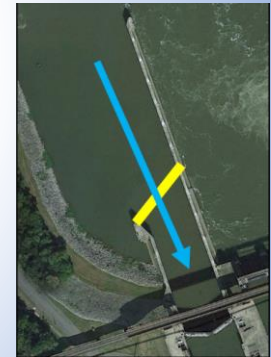


Upstream passage across BAFF and into Lake Barkley

Silver Carp full upstream passages	Counts BAFF OFF	Counts BAFF ON	Change
69 kHz tags	96	41	56% decrease
307 kHz tags	228	113	50% decrease

BAFF crossings by individual Silver Carp

Period	Individuals BAFF OFF	Individuals BAFF ON	Change
2020-2022	446	174	61% decrease



Control: Invasive Carp - RNA interference

Goal:

Develop molecular control tools for invasive carps as part of an IPM strategy

Why:

Molecular tools can be more selective than piscicides



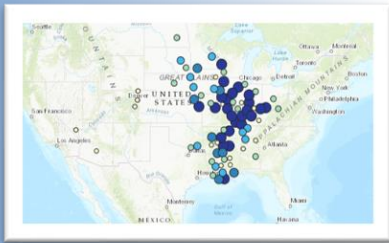
Approach:

- Transcriptome sequencing (completed)
- Develop cell cultures (completed)
- Identify target genes (completed, ongoing)
- Design candidate siRNAs (completed, ongoing)
- Optimize siRNA transfection (completed)
- Efficacy testing (ongoing)
- Specificity testing (initiated)
- Clone siRNA into expression construct (initiated)
- Incorporate algae into grass carp bait
- Feeding trials
- Registration as a biopesticide

GRC	SVC	BHC	BLC
✓	✓	✓	✓
✓	✓	✓	
✓	✓		
✓			
✓			
✓			
X			
X			

Control: Invasive Carp-Toxicant development

Goal: Register a historical pesticide for nuisance fish removal, identify and screen new chemicals, and develop formulations to control invasive carp.



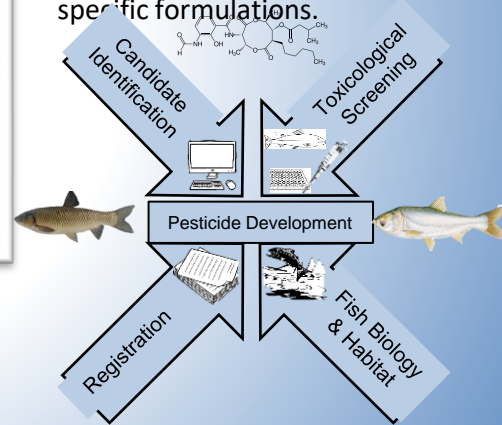
Silver Carp in the Mississippi River watershed and other waterbodies.

Why: Bighead, Silver, Grass, and Black Carp are detrimental to aquatic ecosystems and impact local recreation and economic opportunities.



Grass carp from the Sandusky River, a tributary of Lake Erie in Ohio.

Approach: Pesticide registration dossier preparation, *in vitro* (gill cell) fish assays are part of a multi-tiered approach used to identify/screen pesticides for controlling invasive carp. Use fish physiology to develop species-specific formulations.



Control - Invasive Crayfish

Goal:

Develop and apply invasive red swamp crayfish control techniques to support Integrated Pest Management

Approach:

- Lethal population controls
- Lethal burrow controls
- Behavioral controls



Control: Invasive Crayfish - Recent efforts

Approaches:

- Intensive trapping and removal (ongoing)
 - CO₂ (lab, pond trials, field treatment in 2018)
 - Pyrethrin (lab testing in 2019 and field treatment in 2021-2023)
 - Telemetry to understand behavior at infested ponds in Michigan (2021)
 - Burrow control strategies (ongoing)
 - Neofemales (planned 2024)
-
- Invasive Crayfish Collaborative webinars to communicate the science

USGS contacts: Ann Allert (CERC), Aaron Cupp (UMESC)



Control: Invasive Mussels – Develop & Refine Tools

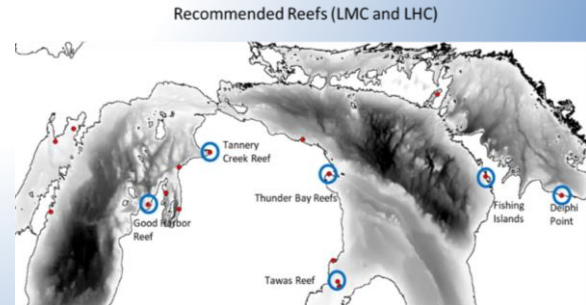
Goal:

Develop new tools to eradicate and reduce established populations of invasive mussels and prevent mussel biofouling in water use facilities and high value habitats

Approach:

- Low dose copper régimes
 - Open water application
 - Seasonal changes
 - Hydropower facilities dosing (BOR, ACOE, FWS)
- CO₂ application systems
 - Water use facilities – speece cone system (BOR)
 - Open water – bubble curtains and tarps

Goal: Conduct a multi-year project to assess whether experimental, site-specific invasive mussel control on a spawning reef can improve fish production.



Thank you!

Address questions to:

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- Invasive Carp Acoustic deterrence: MaryBeth Brey, mbrey@usgs.gov; Andrea Fritts, afritts@usgs.gov
- Invasive Crayfish: Aaron Cupp, acupp@usgs.gov
- Invasive Mussels: Diane Waller, dwaller@usgs.gov