

M.L. 2021 Minnesota Aquatic Invasive Species Research Center Subproject Abstract

For the Period Ending June 30, 2024

SUBPROJECT TITLE: MAISRC Subproject 24.2: Genetic method for control of invasive fish species

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ORGANIZATION: University of Minnesota

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FUNDING SOURCE: Environment and Natural Resources Trust Fund (ENRTF)

LEGAL CITATION: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 06e

SUBPROJECT BUDGET AMOUNT: \$432,208

AMOUNT SPENT: \$430,972

AMOUNT REMAINING: \$1,236

Sound bite of Project Outcomes and Results

On this MAISRC-funded project, we are leveraging the latest advances in precision genome editing to engineer population control in common carp. We are testing these approaches in a controlled laboratory to determine their feasibility for field trials.

Overall Subproject Outcome and Results

The goal of this project is to responsibly advance the technology development related to genetic biocontrol of AIS, specifically common carp. Common carp is a problematic invasive species throughout much of the world, and existing physical and chemical population management techniques have not been successful in effective and economic management of the species.

We made substantial progress on many fronts. We leveraged our unique capabilities to routinely spawn captive carp at the MAISRC Containment Lab to collect gametes for in vitro fertilization and transgenesis. We routinely inject hundreds of carp eggs every two weeks. The majority of genetic biocontrol transgenesis efforts have been geared towards making sex-ratio-biasing fish, with a lower number of transgenesis days used to advance gene drive or engineered genetic incapability agents. The first G0 fish injected with sex-ratio-biasing constructs are currently sexually mature and characterization is ongoing.

To accelerate the timeframes associated with engineering biocontrol agents in non-model fish species, we made progress towards developing a surrogate host species for carp. We generated recombinant DNA reporter systems that label primordial germ cells (PGCs) with fluorescent proteins. This enabled tracking the viability, trafficking, and development of PGCs non-invasively via fluorescence microscopy. We also developed protocols to genetically sterilize fathead minnow surrogates. While initial attempts at surrogacy were unsuccessful, we are performing one last control experiment (M.L. 2023, Subproject 24.3) before deciding on alternative approaches.

Lastly, we organized a series of stakeholder/rightsholder workshops to co-develop a shared language to describe the maturity of genetic biocontrol technologies using NASA's Technology Readiness Level framework as a guide.

Workshop attendees included social scientists, state- and federal-regulators, watershed district managers, technology developers, entrepreneurs, and tribal representatives. This work resulted in a draft manuscript that is currently under revision by the co-authors prior to submission for publication.

Cumulatively, these results bring genetic biocontrol closer to reality.

Subproject Results Use and Dissemination

Peer-Reviewed Publications

- Badger J, et al. (23 more coauthors), Smanski MJ (2024) "Coproducting a Technology Readiness Level framework for non-persistent genetic biocontrol agents of aquatic invasive species". *In preparation*.
- Pornschloegl L, Erickson S, Jacob N, Badger J, Johnson C, Smanski MJ (2024) "Towards engineering genetic incompatibility in fish". *In preparation*.
- Badger J, Jacob N, Erickson S, Pornschloegl L, Johnson C, Smanski MJ (2024) "Protocols for engineering the germline of common carp" *In preparation*.

Presentations/Videos

- 2022 MAISRC Research & Management Showcase: Genetic method for control of invasive fish species: Phase II
<https://z.umn.edu/2022ShowcaseGeneticControl>
- 2023 MAISRC Research & Management Showcase: Genetic Biocontrol in Common Carp
<https://z.umn.edu/2023ShowcaseGeneticControl>
- 23rd International Conference on Aquatic Invasive Species (Halifax, Canada) "Genetic Biocontrol of Common Carp", May 2024
- Invited EPSCORE program workshop keynote (Lincoln, NE) "Accelerating the translation of new technologies from the laboratory to the real world", May 2024
- 2023 Canadian National Department of Fisheries and Oceanography Genomics Conference (virtual) "Genetic biocontrol of invasive carp", April 2023
- CFANS Research Symposium (St. Paul, MN) "Attempt at Establishment of Germline Chimeras Between Common Carp and Fathead Minnows", March 2023
- Black Carp Working Group (virtual; covering Mississippi River basin) "Genetic biocontrol for invasive carp" January 2023
- Developmental Biology Center (DBC) Seminar. Minneapolis, MN "Genetic Biocontrol in Eurasian Carp and Directed Evolution of SpCas9 and Cas9-ABE for low-temperature catalysis" January 2023. (Julie Badger)
- Upper Midwest Invasive Species Conference (UMISC). Green Bay, WI "Progress in Genetic Biocontrol in Invasive Common Carp (*Cyprinus carpio*)" October 2022.
- Invited lecture at the Cold Spring Harbor Synthetic Biology Summer Course, remote, "Engineered Genetic Incompatibility for self-sustaining and self-limiting genetic biocontrol" August 2022
- MN DNR update meeting (St Paul, MN) "Gene drive technologies" September 2022
- University of Minnesota Organism Cryopreservation Conference, Minneapolis, MN. "The Utility of Primordial Germ Cells in Invasive Species Bioengineering" July 2022
- Gordon Conference: New Biological Platforms for Affecting Phenotype Changes for Control (Ventura, CA), "Combining female lethality and engineered genetic incompatibility for a potent biocontrol strategy". June 2022

- AGSx 2022 Conference (Virtual) “Engineering species-like barriers to reproduction for population control”. May 2022
- Conservation Sciences Seminar Series (St Paul, MN) “Engineering species-like barriers to reproduction for population control”. April 2022
- MN DNR Technology update (virtual): “Genetic biocontrol of aquatic invasive species”. January 2022