USGS
science for a changing world

Development of a Control Tool to Target Filter-Feeding Aquatic Invasive Species

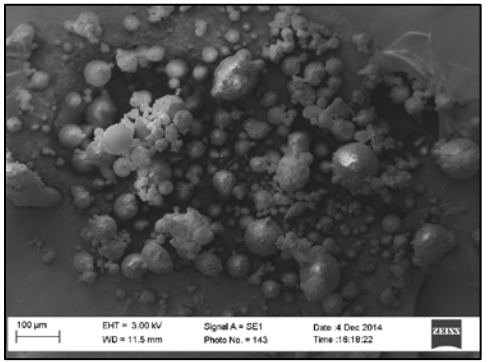
Jon Amberg and James Luoma*
United States Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin
Invasive Mussel Collaborative Webinar
June 21, 2016

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

*presenting author

Our Approach

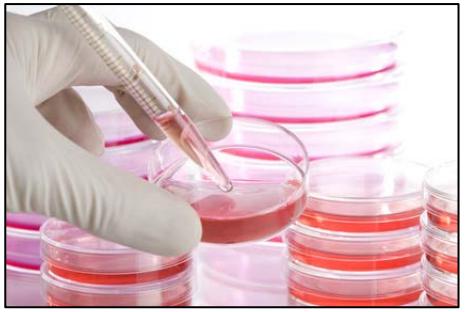
- Developing species-specific controls
- Two-pronged
  1. Chemistry
  2. Delivery



USGS

1. Chemistry

- Quantitative Structure Activity Relationship
  - Mathematical model to efficiently screen databases
- High-throughput screening with cellular assays
  - Establish cell lines for target and non-target species
  - Initiated work on development of zebra mussel cell lines
- In-life toxicity trials
  - Beginning 2016
- Initiate the registration



USGS

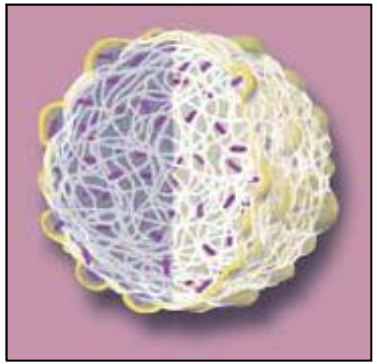
2. Delivery

- Take advantage of the filter-feeding strategy of the targeted organism
- Requires knowledge of the targets AND natives
- Our work has centered on:
  - Bigheaded carps (silver and bighead carps)
  - Dreissenid mussels

USGS

Goal

Develop an oral delivery formulation (ODF) to selectively deliver control agents (i.e. antimycin, niclosamide) to control filter feeding aquatic invasive species

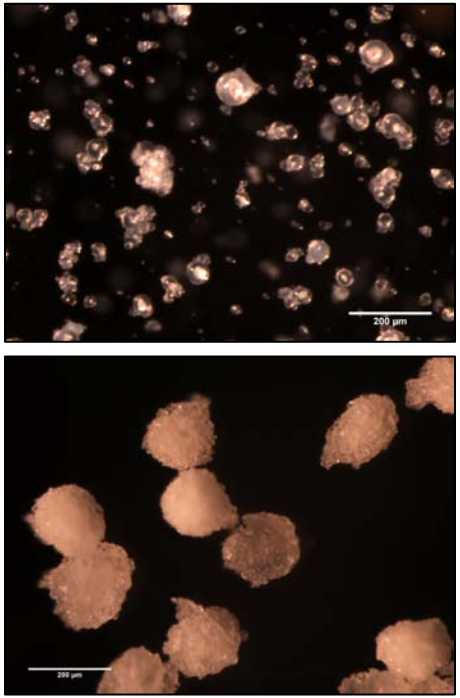


ODF

USGS

Requirements for an oral delivery formulation (ODF)

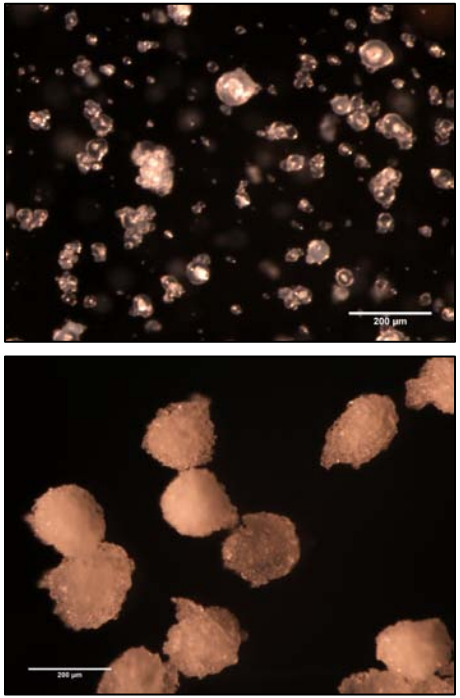
1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed



USGS

Requirements for an oral delivery formulation (ODF)

1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed



USGS

Microencapsulation

An industrial processes

- Pharma and personal care products
- Easily scaled
- Affordable
- Control size

Methods:

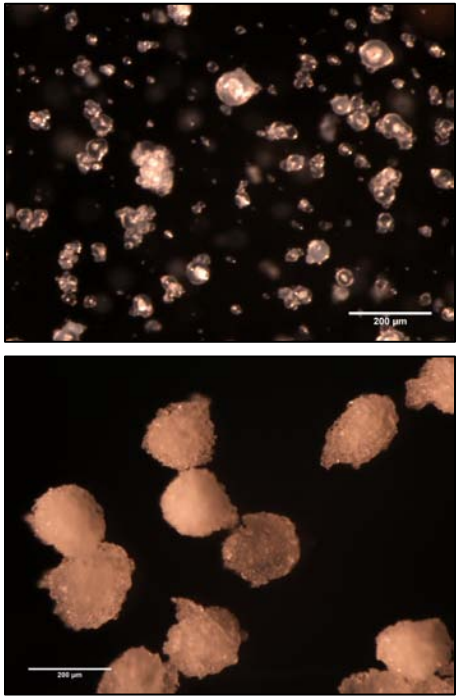
- Spray atomization
- Coacervation
- Co-extrusion
- Fluid bed coating

Photos source: SwRI

USGS

Requirements for an oral delivery formulation (ODF)

1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed



USGS

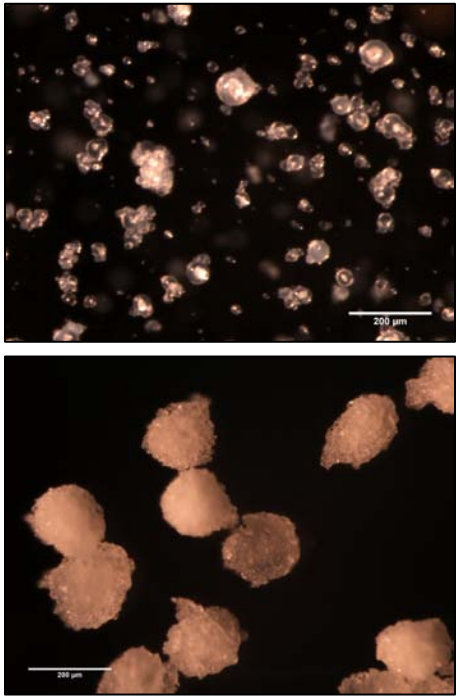
Ability to hold the control agent

Particle	% Leach
20% Antimycin A in beeswax core	0.02
Caster oil 0.09% Antimycin A palmitate core	1.41
Algae coated 0.18% Antimycin A palmitate core	1.28
Zein coated 0.18% Antimycin A palmitate core	1.33
Palmitate coated 4.11% Antimycin A beeswax core	0.05
Spirolina coated 20% Antimycin A in beeswax core	0.08
Zein coated 20% Antimycin A in beeswax core	0.04
Double coat - Zein on palmitate beeswax core	0.25

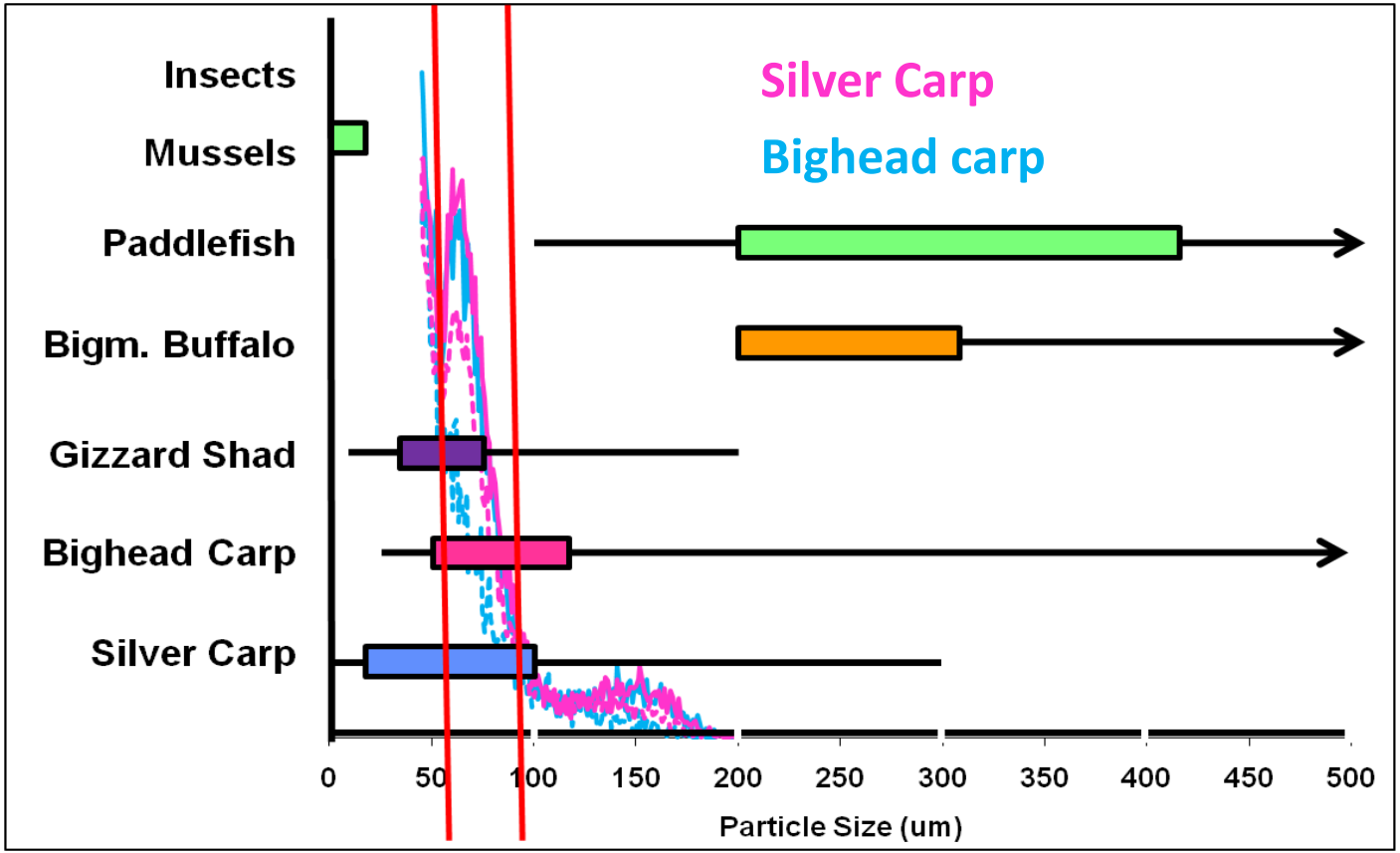
USGS

Requirements for an oral delivery formulation (ODF)

1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed



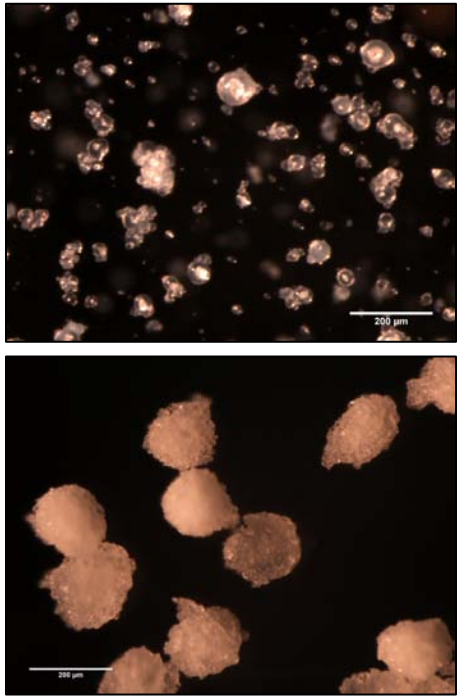
USGS


Insects
Mussels
Paddlefish
Bigm. Buffalo
Gizzard Shad
Bighead Carp
Silver Carp
Silver Carp
Bighead carp
0
50
100
150
200
250
300
350
400
450
500
Particle Size (um)

USGS

Requirements for an oral delivery formulation (ODF)

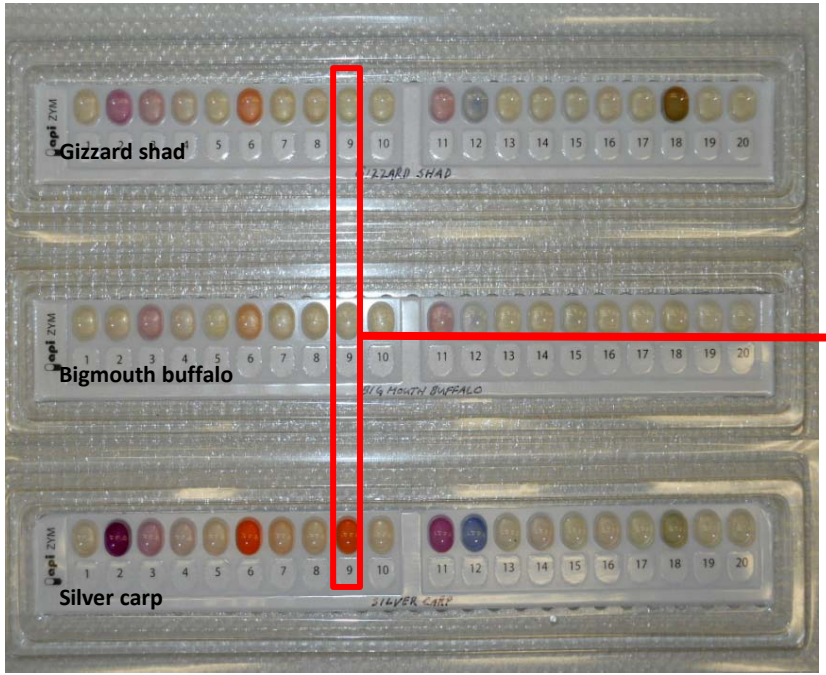
1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed

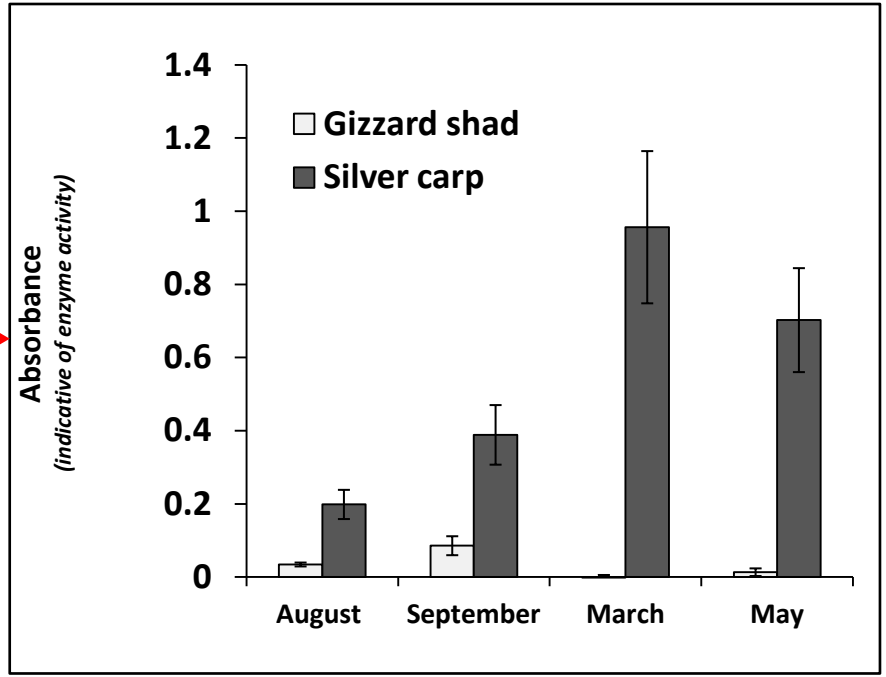


USGS

Identify a release

Differences in digestive enzymes

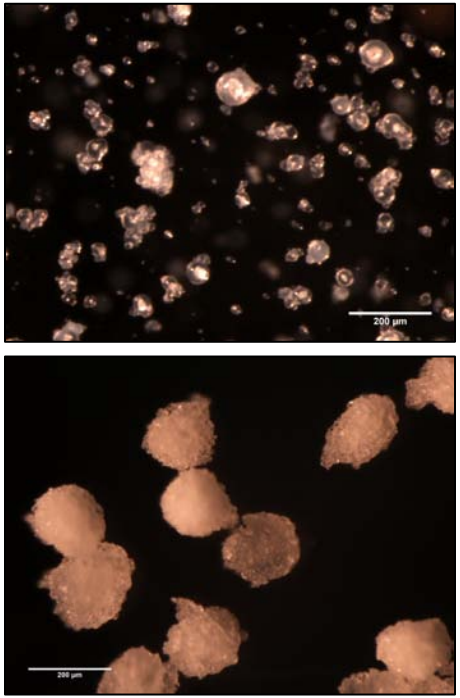




USGS

Requirements for an oral delivery formulation (ODF)

1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed



USGS

Specificity *(laboratory trials)*

- Mixed stock
- Each dose in triplicate
- Repeated 3 Xs

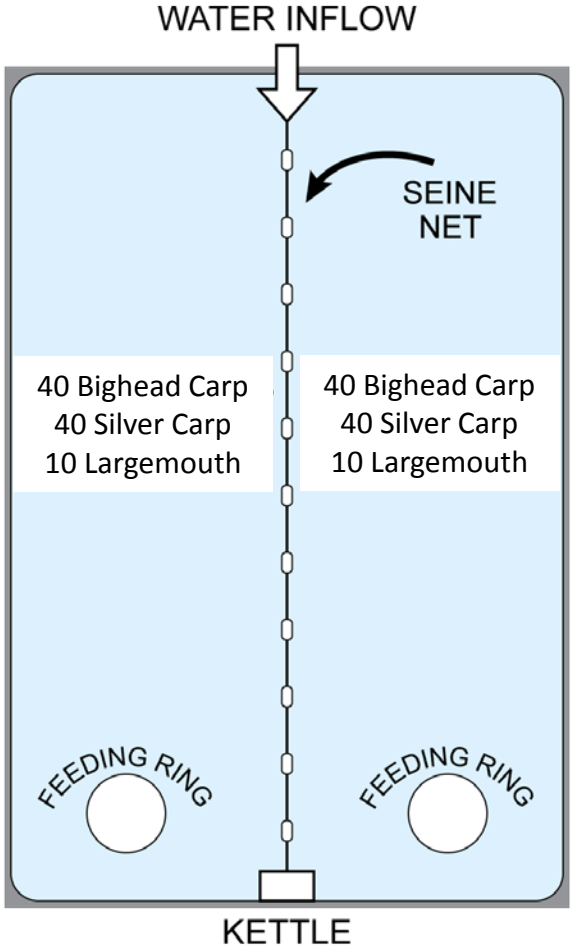
Dose*	SVC	BHC	LMB
0	0	0	0
10	0	0	0
20	**100**	**100**	0
40	100	100	100
LC50 (ppb)	**0.65**	**0.35**	**0.2**

*milligrams of antimycin

USGS

Specificity *(ponds trial)*

- Conducted at the USGS-CERC in Columbia, MO
- 0.25 acre pond split lengthwise
- 40 SVC, 40 BHC and 10 LMB on each side
  - 50 total fish *(and a couple of turtles)*
- Fish on one side were exposed to particle, while other side did not receive particle
- Survival monitored for 96 h



USGS

Specificity *(pond trial)*

- 50% of BC dead
  - All within 24 hours
- No mortality on non-targets
- Repeating pond trials
- Initiate field trials in IL

USGS

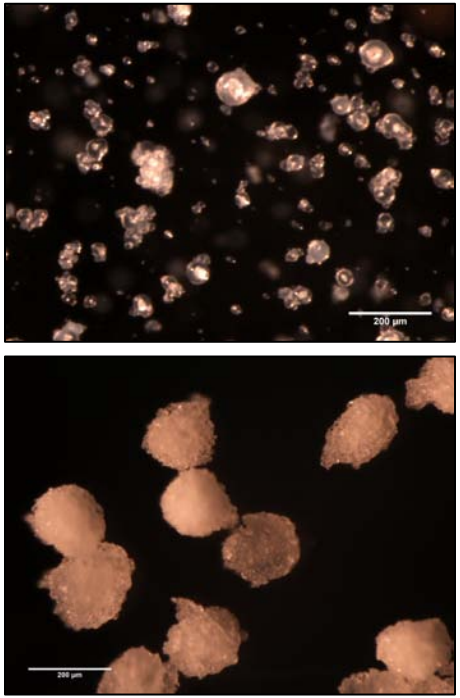
Movement toward a Dreissenid control

- Use BH approach as a template
  - Technologies for particle the same, they just need to be smaller
    - Modify orifice size and pressure
  - Incorporate molluscicide
    - Niclosamide

USGS

Requirements for an oral delivery formulation (ODF)

1. Scalable for mass production
2. Incorporate or “hold’ the toxicant
3. Size specific
4. Releases under “targeted” conditions
5. Readily consumed

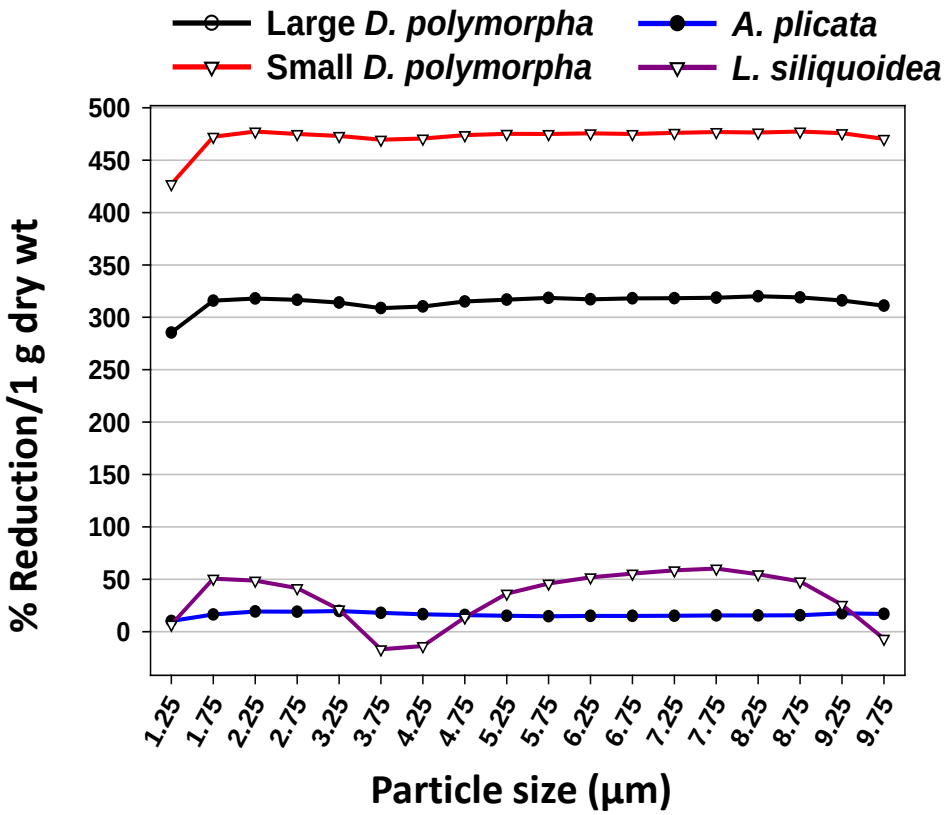


USGS

Size preference

Compared zebra mussel filtration with 2 native unionid species

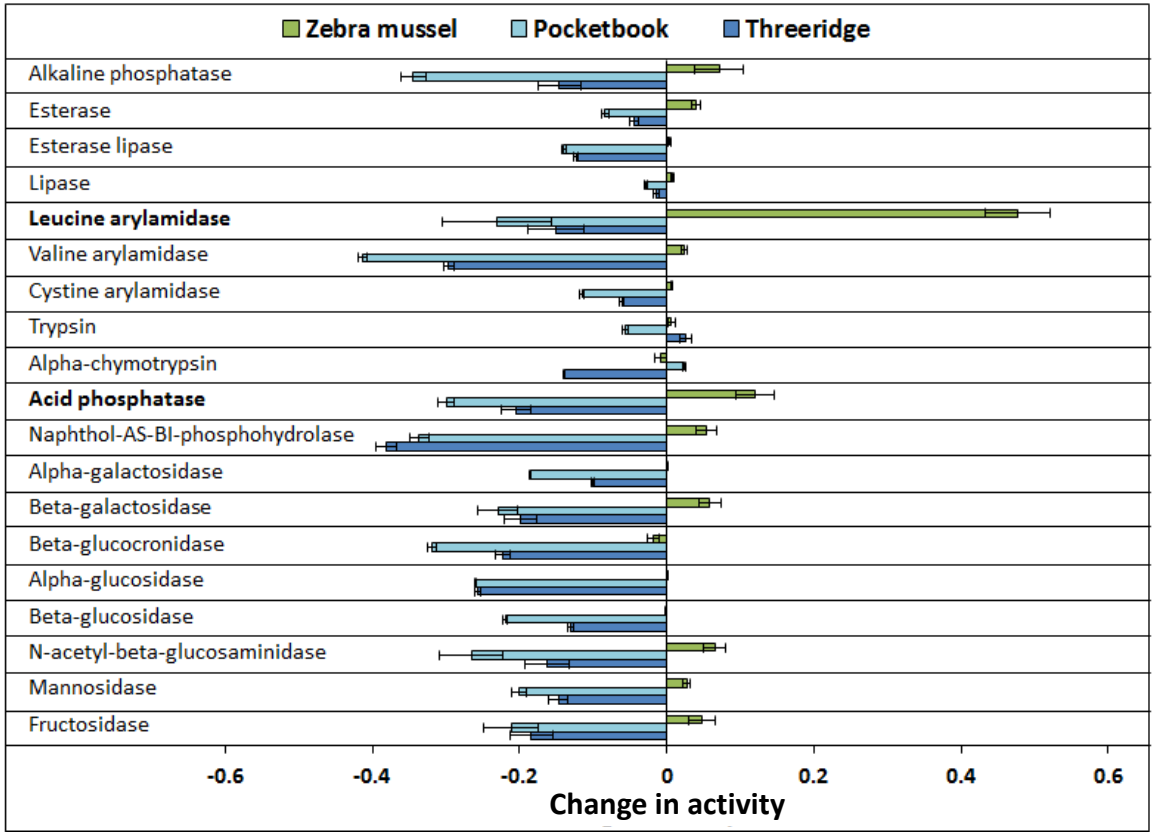
- Target size 1-10 µm
- ZM did not prefer a size
- ZM filter rate is much greater than natives



USGS

Potential release

- All had similar digestive enzyme profiles
- ZM digestion increased in colder water temperatures
- Native mussels began to shut down



USGS

Direction

- We have made a batch of niclosimide particles
  - Confirm the size of the particles
  - Test buoyancy
- Laboratory efficacy trials
- Site specific testing in field with mobile bioassay trailer

USGS

Summary

- Looking at control in two ways
  1. New chemicals
  2. New delivery tools
- We made a particle that can selectively deliver a control agent to bigheaded carps
- This approach is being used to develop a new tool to control dreissenids

USGS

Questions

USGS