



# Bio-based Control for Invasive Mussels

Prepared for Leelanau Clean Water



*Manufactured by Marrone Bio Innovations, Inc.*

© Marrone Bio Innovations, Inc. 2013-2014. All Rights Reserved. No part of this presentation or any of its contents may be reproduced, copied, modified or adapted, without the prior written consent of Marrone Bio Innovations. Distributing this content to other than the intended party or posting on a website is also prohibited.

# Forward Looking Statement



This presentation may include forward-looking statements. These statements reflect the current views of the Company's senior management with respect to future events and financial performance. These statements include forward-looking statements with respect to the Company's business and industry in general, including statements regarding potential market size of Company products, anticipated product launches, target geographic markets, factors for the barriers to entry into the market, and strategies for growth. Statements that include the words "expect," "intend," "plan," "believe," "project," "forecast," "estimate," "may," "should," "anticipate" and similar statements of a future or forward-looking nature identify forward-looking statements for purposes of the federal securities laws or otherwise. Forward-looking statements address matters that involve risks and uncertainties such as the timing of and costs associated with the launch of products, the difficulty in predicting the timing or outcome of product research and development efforts and regulatory approvals. Accordingly, there are or will be important factors that could cause the Company's actual results to differ materially from those indicated in these statements. The statements made herein speak only as of the date of this presentation.

# Topics of Discussion



- **About Marrone Bio and Our Mussel Team**
- **The Invasive Mussel Challenge**
- **About Zequanox**
- **Treatment Techniques and Management Programs**
- **Sample Case Studies**
- **Wrap Up / Next Steps**



# Marrone Bio Innovations: Delivering the Next Generation in Biopesticides



- Public Company
  - [NASDAQ – MBII]
- Founded April 2006 by Dr. Pamela Marrone
- Headquartered in Davis, CA
- 150+ employees
- Strategic investors: DSM, Syngenta, Mitsui
- Fermentation facility in Bangor, MI
- 21 issued patents and more than 200 patents pending



We discover, develop, and  
market effective and  
environmentally responsible  
bio-based pest management  
products for agriculture and  
water applications



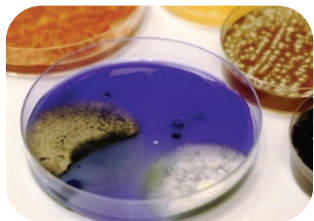
# Wide Breadth of Biopesticide Expertise



## In-house Discovery & In-licensed Technology

*Internally-discovered break-through products*

*Access to others' technology at earlier stage. Add IP to in-licensed technology*



## Biopesticide Company with the Broadest Screen

*18,000+ microorganisms*

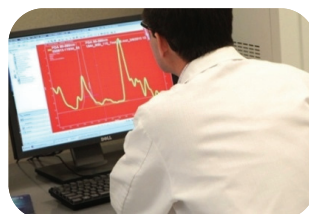
*350+ plant extracts*



## Natural Product Chemistry Advantage

*Identify and patent natural compounds*

*Proprietary compound analytics for higher efficacy and consistency*



## Rapid Development & Commercialization

*Targeted launch with key large growers*

*Highly specialized commercial team*

*Commercialized multiple products in record time*



## Formulation, Fermentation & Manufacturing

*Microbial formulation expertise*

*Fermentation optimization at scale*



***More than 200 patents and patent applications***

# Why Bio?



- Safer alternatives to standard chemicals to protect public health and the environment
- Well established technology in the pharmaceutical and agricultural industries
  - Currently about 11% of pesticides and >50% of human drugs are derived from natural products
  - *Bacillus thuringiensis (israelensis)* used to control black fly larva in open waters - globally
  - Other *Pseudomonas* species are registered for plant health and frost protection in the US and Canada

**Often highly selective/target specific**

**Safer for workers**

**Delayed onset of resistance**

**Better public perception**



# Invasive Mussels Cause Significant Environmental Damage



- Decreases fish populations
  - Zebra mussels strip the food web of plankton
  - “Causes populations of alewives, salmon, & whitefish to plummet.”\*
- Impacts native mussel populations
- Causes proliferation of toxic blue-green algae
  - “Fouls beaches & causes botulism which has killed countless fish and more than 70,000 aquatic birds in the last ten years.”\*



\*<http://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species/Invasive-Mussels.aspx>

# Invasive Mussels Populations Result Significant Recreational Impacts



## Recreational Impact

- Injuries during recreational events
- Limited use of recreational areas

PALOS VERDES PENINSULA NEWS

SATURDAY, MARCH 13, 2004

## ZEBRA MUSSEL NEWS

Norris Center for the Performing Arts, 27570 Crossfield Drive in RHE, on Saturday, March 20 at 2 and 4 p.m. Tickets are \$38 for adults and \$19 for students for the evening performance and \$30 for adults and \$15 for students at the matinee performance. For reservations, call 544-0401.

• **UPCOMING** — The Palos Verdes Peninsula Unified School District and Friends of School Music host the 15th Palos Verdes Elementary Choral Festival on March 23, 24 and 25 at the Norris Center for the Performing Arts, 27570 Crossfield Drive in RHE. All shows begin at 7:30 p.m. For tickets, call the Norris box office at 544-0401.

• **ONGOING** — The Distinctive Edge, 29050 S. Western Ave., Suite 113 in NPV, continues "Third Time's a Charm," an exhibit of 8-D collages by artist Steve Jacobson, through March 30. For gallery hours, call 833-3613.

• **ONGOING** — "Natural Treasures" exhibition contin-

### Fond du Lac-area teen seriously injures knee in 'Cold Water Challenge'

Two years ago, U.S. Navy personnel and their families assigned to the Arangi Navy base, home of the U.S.S. Kittyhawk, were treated to a rare experience when Terry Fleming and his local Irish/American band, Innisfree, traveled to the base to entertain them on St. Patrick's Day. Fleming and the other five members of Innisfree were delighted and honored to be able to go to Japan and lift the spirits, if only for a few hours, of the Navy personnel and their families.

For the third year in a row, Fleming — a local insurance broker in Rolling Hills by day and an entertainer by night — and the band travel to entertain the Navy men, women and families at various bases throughout Japan.

Fleming, the leader of the band on accordion and harmonica, actually is the only member of the band from Ireland. Other members include lead singer Julie Delaney, a civil engineer in Newport Beach; Terry Doyle, guitarist, a news director with CBS news; Denis Doyle, Celtic harpist, a professor at Glendale College; Kevin Wood, keyboards and bagpipes, music

teacher and assistant director of the Orange County Symphony; and Mike Tiffany, bass, a computer engineer. The band has been playing the length and breadth of California for the past 25 years. They have played at pubs, wakes, weddings, birthdays and on occasions where there was little excuse for throwing a party.

Fleming says it was by coincidence the band got the opportunity to travel to Japan. Another band was unable to travel at the last minute and so he and his band were offered the opportunity to go in their place.

With some trepidation they made their first trip and with the overwhelming response they received at Arangi, any fears they had were quickly allayed. On a damp St. Patrick's Day, hundreds of families, clad in many shades of green, whooped it up, sang their hearts out and danced up a storm. As the evening wore on, many in the audience were emboldened to try their hand or foot at the Irish jig, with much encouragement from the band.

Even though far from home, the Arangi base — situated a few hours

south of Tokyo — felt like home away from home, with its lush green rolling landscape and its multitude of cherry blossom trees. "Yes," Fleming says, "one was struck by the commitment and dedication of our men and women in uniform as they played their part in protecting and serving in an ever-challenging and hostile world."

A couple of the families even took time out from their busy schedule to host Terry and the band members. They treated them to a guided tour of the base and accompanied them on a few exciting trips off the base, visiting beautiful ancient temples, monuments and revered giant Buddas.

On a visit to downtown Tokyo, the band came across what they assumed was a very rare sight, a place called "Scruffy Murphy's," an Irish pub located in the heart of a bustling downtown. Upon checking the establishment out, they discovered a real authentic Irish Pub with excellent Guinness and good pub grub. It also happened to be open one night, so the band members took over the stage

and entertained the locals for a few fun-filled hours. It turned out that it was just one of many establishments in the city.

A special bond developed between the band members and these families and already exchange visits have occurred when the same families were on leave in the United States.

For more information about the band, log on to [www.innisfreeband.com](http://www.innisfreeband.com).

**thebridge**

**THE BRIDGE** is the premier live performance venue in the Palos Verdes Peninsula. It is the only venue in the area that offers a full range of live entertainment. Full stage, full house, full band, full sound. For more information, call 291-0401 or visit us online at [www.thebridgepalosverdes.com](http://www.thebridgepalosverdes.com). Opened in 1997, we have 250-300 seats.

**SPECIAL SEATING PRICES WITHIN AREAS:**

• **FRONT ROW** (10 seats) \$150  
**MEZZANINE** (20 seats) \$100  
**BOX SEAT** (10 seats) \$50  
**GENERAL ADMISSION** (10 seats) \$25

**AGENT: CSOY MUSIC & ENTERTAINMENT**  
 12345 6789 1011 1213 1415 1617 1819 2021 2223 2425 2627 2829 3031 3233 3435 3637 3839 4041 4243 4445 4647 4849 5051 5253 5455 5657 5859 6061 6263 6465 6667 6869 7071 7273 7475 7677 7879 8081 8283 8485 8687 8889 9091 9293 9495 9697 9899 10000

**STREET AND OFFICE PHONES:**  
 1234567890 10111213141516171819202122232425262728293031323334353637383940414243444546474849505152535455565758596061626364656667686970717273747576777879808182838485868788899091929394959697989910000





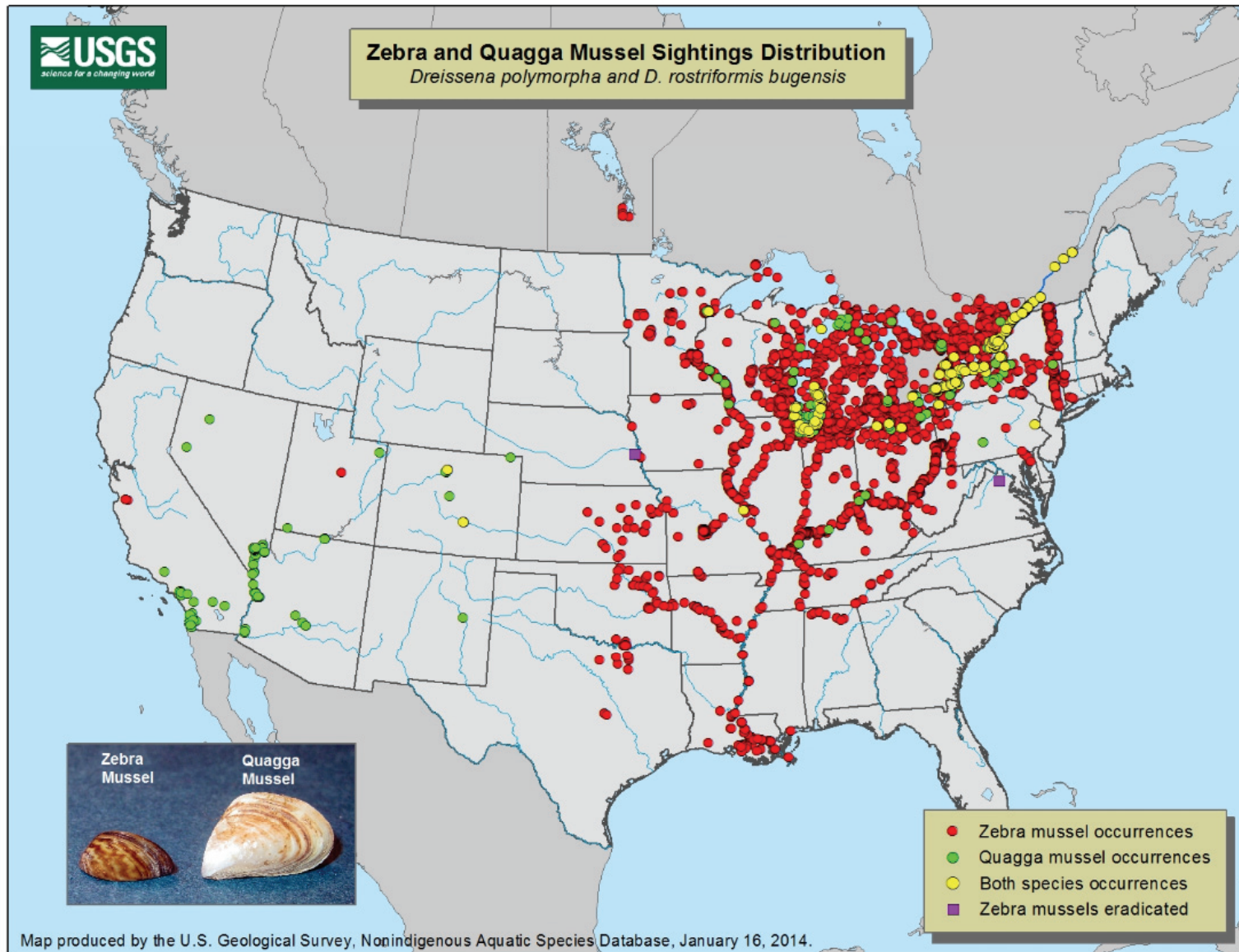
# Invasive Mussels Cause \$ Billions in Economic Damage



- Risk of decreased lakefront property values
- Community revenue loss due to reservoir closers and reduced recreation
- Cost of management /removal
- Additional costs to municipalities / industry



# Zebra and Quagga Mussels are Spreading Throughout US and Canada





# Traditional Chemical Solutions Treat Mussels, but Result in Lasting Environmental Impacts



- Toxic to other organisms
- Persistence in the environment results in pro-longed ecosystem recovery times
- Restricted use of copper in drinking water reservoirs due to public health concerns
- Potash (potassium chloride, KCl) treatments also kill endangered and threatened native mussel species (same concentrations)
- Long treatment times and entry periods



**ZEQUANOX**<sup>®</sup>  
Invasive Mussel Control

# Zequanox: The Environmentally Compatible Alternative to Chemicals

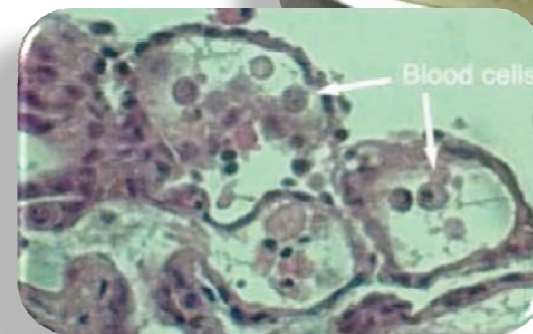
# Zequanox: The Only Biopesticide for Invasive Mussel Control



- Environmentally friendly
  - Derived from soil microbe (*Pseudomonas fluorescens*)
  - Composed of 100% dead cells
- Controls mussels in all life stages
- Highly selective toward zebra/quagga mussels
- Effective in a broad range of water conditions and temperatures
- Noncorrosive to infrastructure and equipment
- Nonvolatile



NEW YORK State Museum

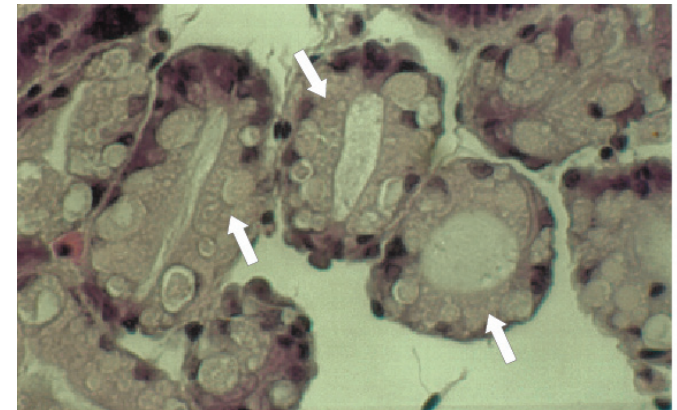
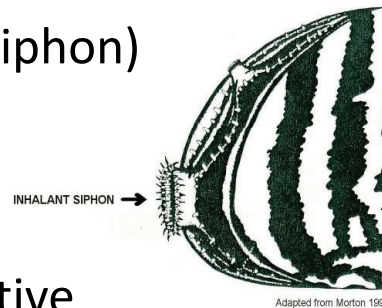


**ZEQUANOX**<sup>®</sup>  
Invasive Mussel Control

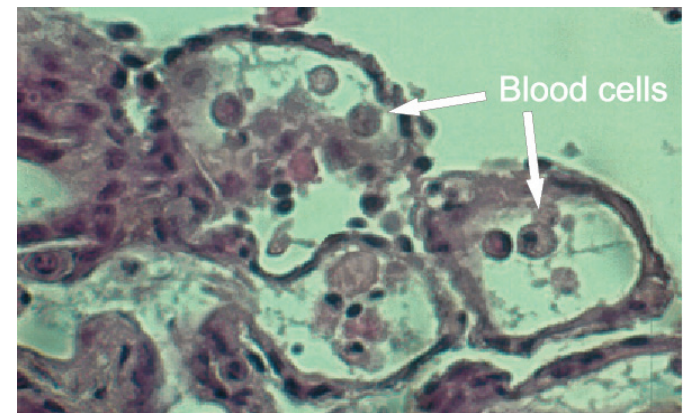
# Zequanox Mode of Action



- Dead *Pseudomonas fluorescens* cells contain compounds that destroy epithelial cells in the mussel's digestive system, causing hemorrhaging and death
- Mussels perceive Zequanox as food and readily feed (i.e., actively siphon)
- Zequanox (*Pseudomonas fluorescens*) is highly selective to zebra and quagga mussels (*Dreissena* species)



*Digestive gland before ingesting Zequanox:  
Healthy epithelial cells (arrows) surround the  
tubules in the digestive gland*



*Following ingestion of Zequanox:  
Blood cells are abundant inside the hemorrhaging  
digestive gland*



# Extensive Ecotox Studies Show No Impact to Other Aquatic Species



## FISH

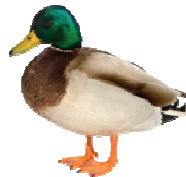


Bluegill sunfish (*Lepomis macrochirus*)  
 Channel catfish (*Ictalurus punctatus*) †  
 Chinook Salmon (*Oncorhynchus tshawytscha*)  
 Coaster brook trout (*Salvelinus fontinalis*)  
 Common Carp (*Cyprinus carpio*)  
 Fathead Minnow (*Pimephales promelas*) \*  
 Klamath Suckers (*Catostomus sucker spp*)  
 Lake sturgeon (*Acipenser fulvescens*) †  
 Largemouth bass (*Micropterus salmoides*) †  
 Rainbow Trout (*Oncorhynchus mykiss*) \*  
 Sacramento Splittail (*Pogonichthys macrolepidotus*)  
 Smallmouth bass (*Micropterus dolomieu*) †  
 Striped Bass (*Morone saxatilis*)  
 Walleye (*Sander vitreus*) †  
 Yellow perch (*Perca flavescens*) †



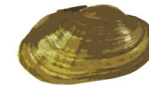
## OTHERS

Mallard Duck \*  
 Midge (*Chironomidae*)  
 Mayfly (*Baetis*)  
 Amphipod (*Hyalella azteca*) \*  
 European Freshwater Crayfish (*Austropotamobius pallipes*)  
 Freshwater Crustacean (*Asellus aquaticus*)  
 Freshwater Water Flea (*Daphnia magna*) \*



## MOLLUSCS

Blue Mussel (*Mytilus edulis*) \*  
 Freshwater Mussel - Duck Mussel (*Anadonta*)  
 Freshwater Mussel - Black Sandshell (*Ligumia recta*) †  
 Freshwater Mussel - Fatmucket (*Lampsilis siliquoidea*)  
 Freshwater Mussel - Pink mucket (*Lampsilis abrupta*)  
 Freshwater Mussel - Hickorynut (*Obovaria olivaria*) †  
 Freshwater Mussel - Higgins Eye (*Lampsilis higginsii*) †  
 Freshwater Mussel - Mucket (*Actinonaias ligamentina*) †  
 Freshwater Mussel - Paper Pond Shell (*Utterbackia imbecillis*) †  
 Freshwater Mussel - Plain Pocketbook (*Lampsilis cardium*) †  
 Freshwater Mussel - Washboard (*Megaloniais nervosa*)  
 Freshwater Snail (*Lymnaea peregra*)



## PLANTS AND ALGAE

Algae \*  
 Bindweed (*Convolvulaceae*)  
 Common Water Plantain (*Alisma subcordatum*)  
 Curly Dock (*Rumex crispus*)  
 Mallow (*Malvaceae*)  
 Nightshade (*Solanaceae*)  
 Smallflower Umbrella Sedge (*Cyperus difformis*)



\* EPA required

† Final report expected in 2014.

Studies conducted by Institute of Technology, Sligo, Ireland; New York State Museum and USGS; U.S. Bureau of Reclamation; Certified Good Laboratory Practices (GLP) Lab; Missouri State University; and MBI lab

# Treatments Address the Invasive Mussel Control Problems Without Treating the Entire Lake



- Recreational rehabilitation
  - Beaches and boat launches
- Marinas
  - Docks, submerged ladders, navigational buoys, deicing equipment
- Submerged infrastructure
  - Intakes for irrigation, fire suppression, or drinking water
- Restoration and protection of critical habitat
  - Fish spawning beds
  - Native mussel beds
- Rapid response approach
  - Prevent or postpone large scale infestations





# Techniques and Management Programs Delivery

## Targeted Control



### Whole Water Column Treatments

Applied using wand, sprayer, or trailing hose to evenly disperse product through entire treatment area

High mortality achieved on both veligers and adults

### Benthic Layer Treatments

Create grid of injection points across the treatment area

Product injected at the location where mussel control is desired

High mortality on adult mussels or recently settled mussels

### Annual/Adult Control

Targets adult infestation to kill and manage adult breeding population

Typically late summer/early fall

### Rapid Response

Treatment at discovery of first mussels or known potential introduction

Prevents infestation from taking hold

### Bi-Weekly Lakefront Property Maintenance

Low concentration 2-hr treatments every other week designed for new settlement prevention

Achieves moderate adult mussel control

# Product Delivered with Expertise in Invasive Mussel Control



- Barrier curtains used to maintain treatment concentrations within desired area
- Treatments completed within hours and normal use can be resumed immediately
- Mortality typically monitored by placing locally-collected mussels in mesh or net containers
- Product concentration measured using turbidity

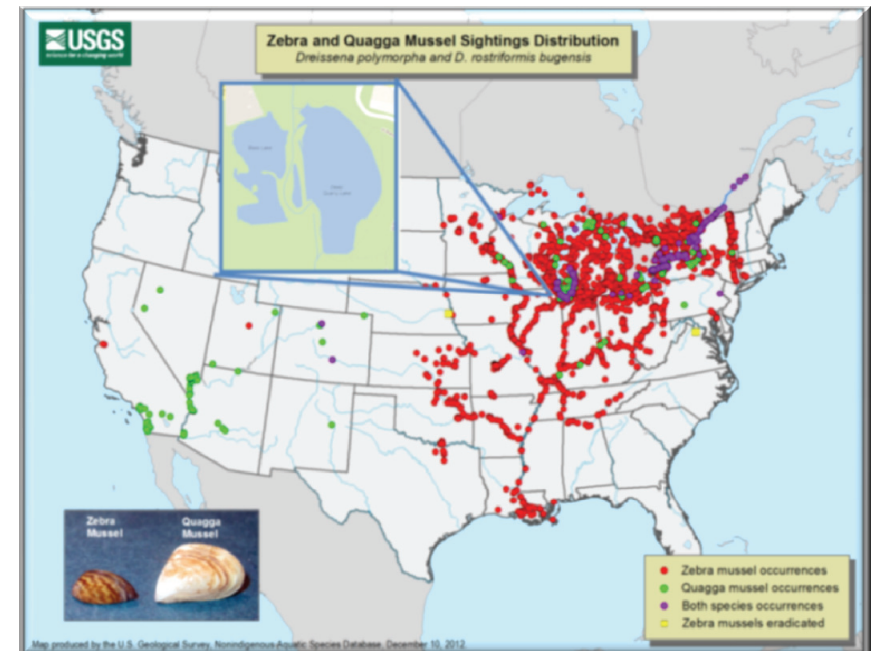


# Zequanox Open Water Case Studies

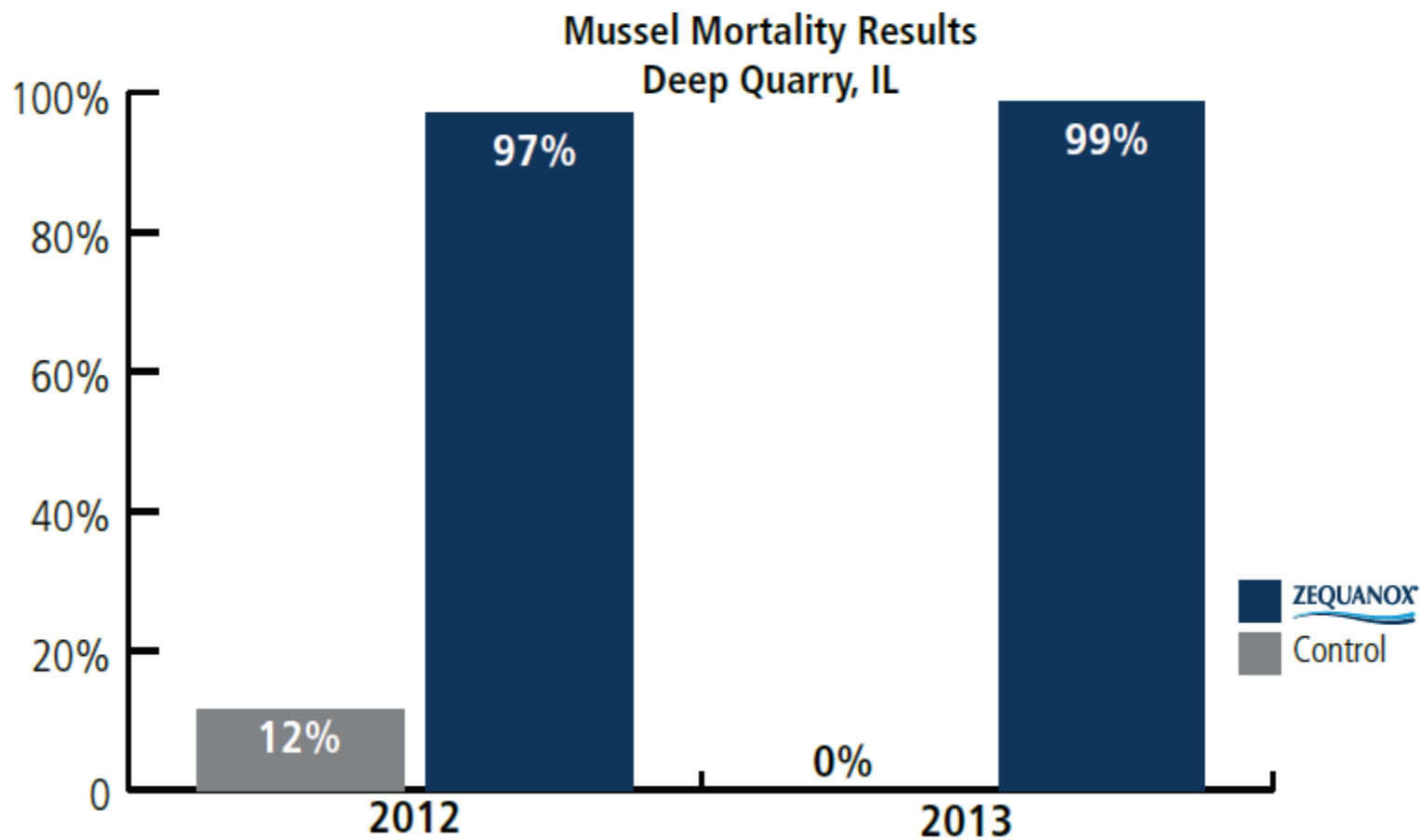
# Deep Quarry Lake, IL



- Collaborative project with Southern Illinois University, Forest Preserve District of DuPage County, and Dept. of Natural Resources
- Replicated trials achieved high efficacy
  - 2012 - Efficacy & water quality testing
  - 2013 - Application methods, adult & veliger efficacy, commercial scale treatment
- Size of mussel does not impact level of control
- No lasting impacts to water quality

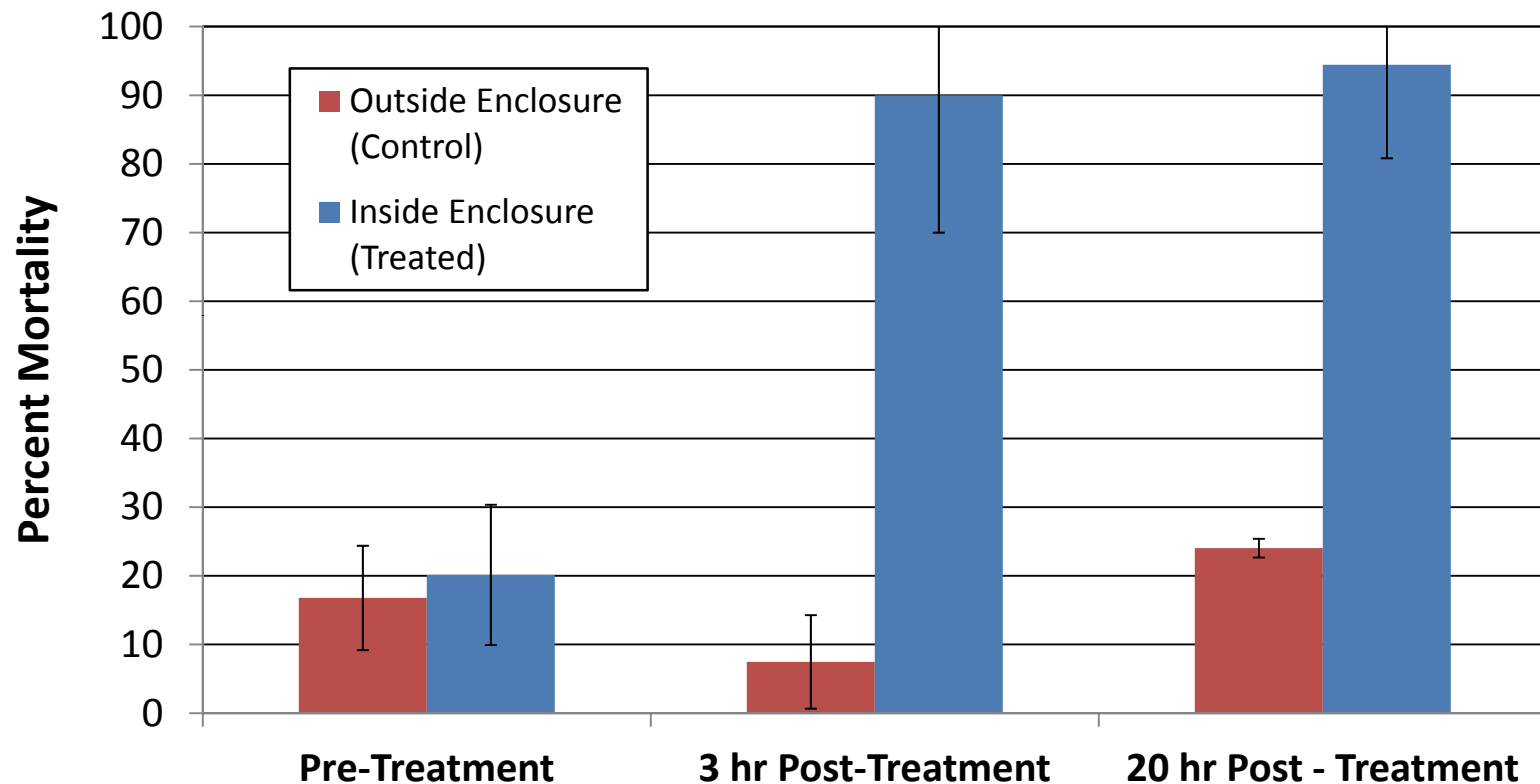


# Adult Morality in Replicated Deep Quarry Lake Treatments



*Open water trials conducted at Deep Quarry Lake in Illinois,  
summer of 2012 and 2013*

# 2013 Deep Quarry Lake, IL Veliger Control



*Full water column treatment treated both adult mussels and veligers (free floating larval stage)*



# Lake Minnetonka, MN



- CRADA research with United States Geological Survey, Upper Midwest Environmental Services Center (USGS UMESC)
  - Comparison of application techniques found targeted benthic applications are effective, and significantly reduce amount of product needed
  - Found no difference in mussel size class between live and dead treated mussels



# Working Together

# Consulting and Services for Successful Mussel Control



## EXPERIENCED SCIENTISTS

Expert team of biologists

Multiple PhDs on staff

Deep knowledge of invasive mussels—metabolic activity, spawning behavior, etc.

Internal wet lab facilities



## REGULATORY GUIDANCE

Extensive experience with federal and state regulators

Ensure compliance at every level

Provide assistance for securing necessary permits (e.g., NPDES permits, NEPA/CEQA compliance, etc.)



## TREATMENT PROGRAM MANAGEMENT

Onsite assessment of site and infestation

Specific treatment recommendation and management program

Treatment and monitoring of results

# Regulatory Items to Consider Prior to Treatment



- Licensed aquatic pesticide applicator required
- Invasive species collection/handling permit
  - May be needed to collect/handle mussels for monitoring
  - Requirements vary by state, check with local regulators
- Other community or local permits and outreach





# Zequanox Delivers the Lowest Risk with the highest Environmental Compatibility



- **Promote Environmental Stewardship**

- *Eliminate the use of harsh chemicals for mussel control*

- **Postpone or Prevent Large-Scale Infestation**

- *Eliminate isolated adult colonies in newly infested water bodies*

- **Manage Existing Infestations**

- *Reduce adverse impacts of mussels to recreational areas and sensitive aquatic habitats*

# Questions?



## Heath Phillips

Marrone Bio Innovations

[hphillips@marronebio.com](mailto:hphillips@marronebio.com)

(303) 378 – 3141

[www.zequanox.com](http://www.zequanox.com)







# ZEQUANOX<sup>®</sup>

Invasive Mussel Control

[www.zequanox.com](http://www.zequanox.com)

