Evaluating the Efficacy of Quaternary Ammonium Compounds for Wildland Firefighting Equipment Exposed to Dreissenid Adults and Veligers

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Overview

- Introduction
- Vectors of dreissenid spread
- Wildland fire fighting equipment
- Quaternary ammonium compounds
- Study and results
- Conclusions and implications

Introduction

- The further spread of quagga and zebra mussels west of the 100th Meridian may lead to more severe environmental degradation and economic damage
- Control and prevention of fouling caused by these mussels are a major concern of managers of all types of water delivery systems
  - Hydropower
  - Water treatment
  - Irrigation
  - Fire-suppression

Mussel Vectors

- Human activities
  - Overland dispersal
    - Most common and quickest way quagga and zebra mussels spread from water-body to water-body
      - Attach with byssal threads to boat hulls, engines, trailers, and other equipment
      - Inside bilge and live-bait compartments (anything that can be wet)
        - Decontamination protocols
    - Fish stocking
    - Wildland fire fighting equipment

Wildland Firefighting Equipment

- Vectors for dreissenid transport
  - Water tanks, pumps on fire engines, portable pumps, backpack sprayers, water tenders, portable tanks, helicopter buckets

Wildland Firefighting Equipment

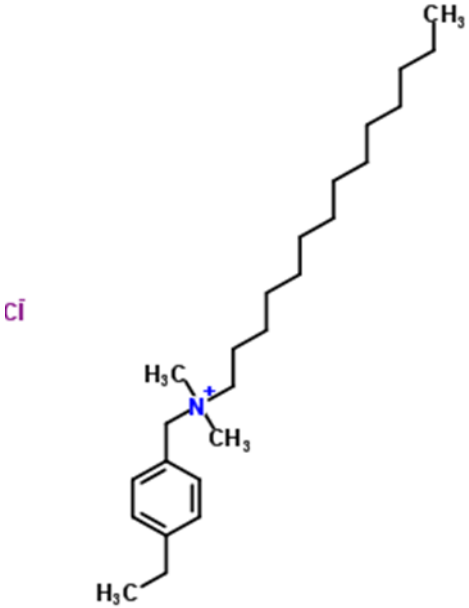
- Highly mobile
  - Equipment contaminated at one fire location may be dispatched immediately to another fire incident in another state within hours
    - Lower Colorado River to Columbia River Basin
- Contaminated equipment can act as vectors moving contaminated water around the landscape
- All equipment needs to be dried or treated to avoid an introduction to an uninfested water-body

Dreissenid Control Methods

- **Mechanical**
  - Scrubbing external structures and piping
- **Thermal**
  - Hot water sprays
- **Desiccation**
  - Costly and time consuming
- **Biological alternatives**
  - Low environmental impact
- **Chemical protocols**
  - Effective in closed systems

Quaternary Ammonium Compounds (Quats)

- Positively charged nitrogen covalently bonded to 4 alkyl or benzyl groups with the nitrogen cation balanced by an anion
- Quats 128 and 256
  - Blend of Didecyl Dimethyl and n-Alkyl Dimethyl Benzyl Ammonium Chlorides



Quats

- Favorable over chlorine
  - Non-corrosive
    - Will not damage fabric, metal, or gaskets
  - Do not form toxic byproducts
  - Bivalves generally do not detect quats and so do not exhibit avoidance through valve closure
- Mode of action
  - Protein denaturation, membrane damage, and cell death

Quats

- Common cleaning agents
  - Homes, gyms, swimming pools, and hospitals
- Firefighting agencies have been prescribing the use of quats to prevent the spread of aquatic invasive species (AIS)
  - Whirling disease, chytrid fungus, didymo, and New Zealand mud snail

Purpose of the Study

- Investigate the lethal concentrations of Quat 128 and 256 on quagga and zebra mussel veligers and adults at different treatment concentrations and varying water temperatures

Methods

- Quagga mussels were collected from Lake Mead, NRA and zebra mussels were collected from Lake Wilson, KS (summer 2011)
- Ice and hot water baths were used to regulate water temperature (35, 60 and 85°F)

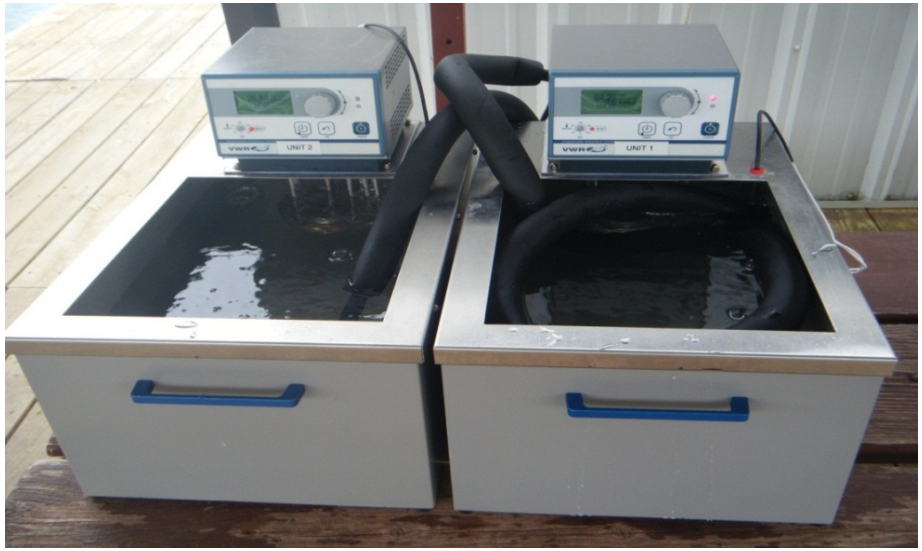


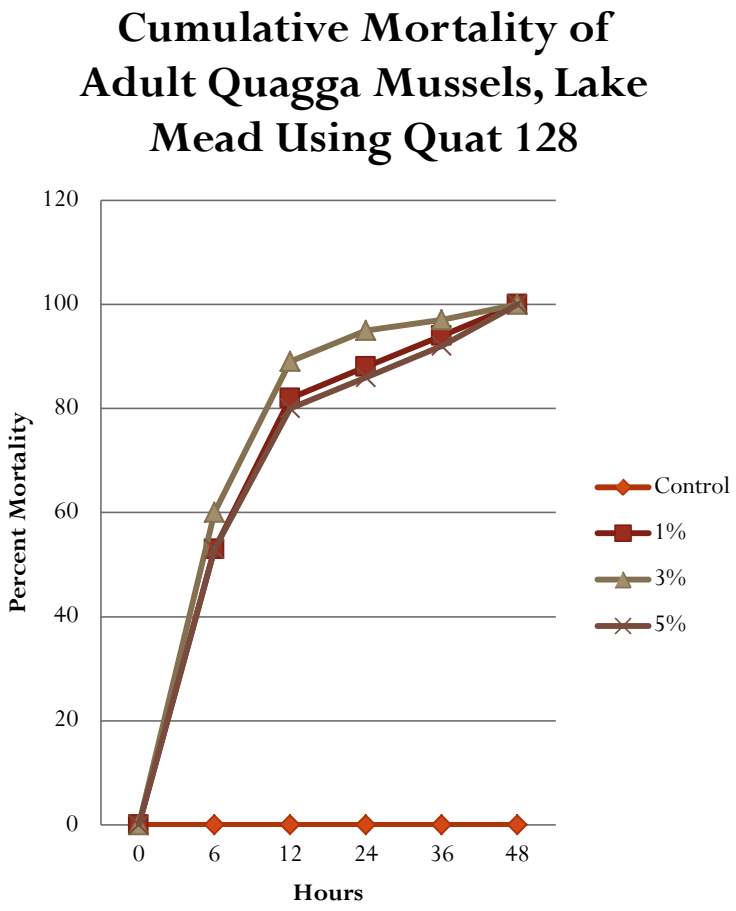
Table 1. Toxicity test of different concentrations of Quats 128 and 256 on dreissenid adults and veligers

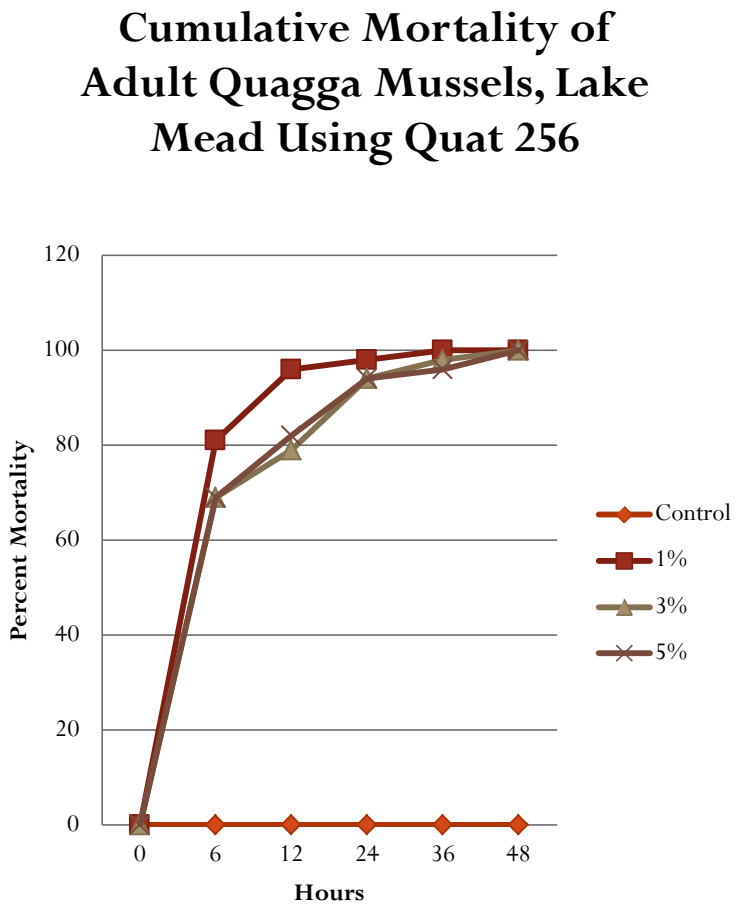
Chemical	Dreissenid Adult	Dreissenid Veliger
Quat 128	0, 1, 3 and 5%	0, .25, .5 and .75%
Quat 256	0, 1, 3 and 5%	0, .1, .25 and .5%

Methods

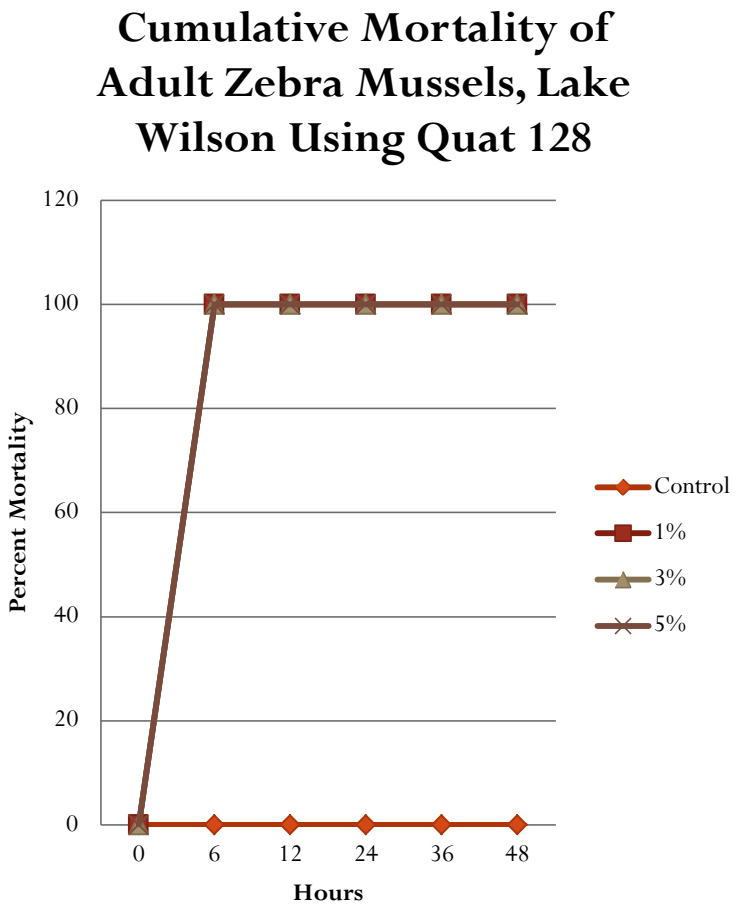
- Mortality assessment
  - Adult dreissenid mussels: Every 6 h
    - Via gaping valves
  - Veliger dreissenid mussels: 1, 5 and 10 min
    - Via ciliary movement of body or observations of internal organs moving

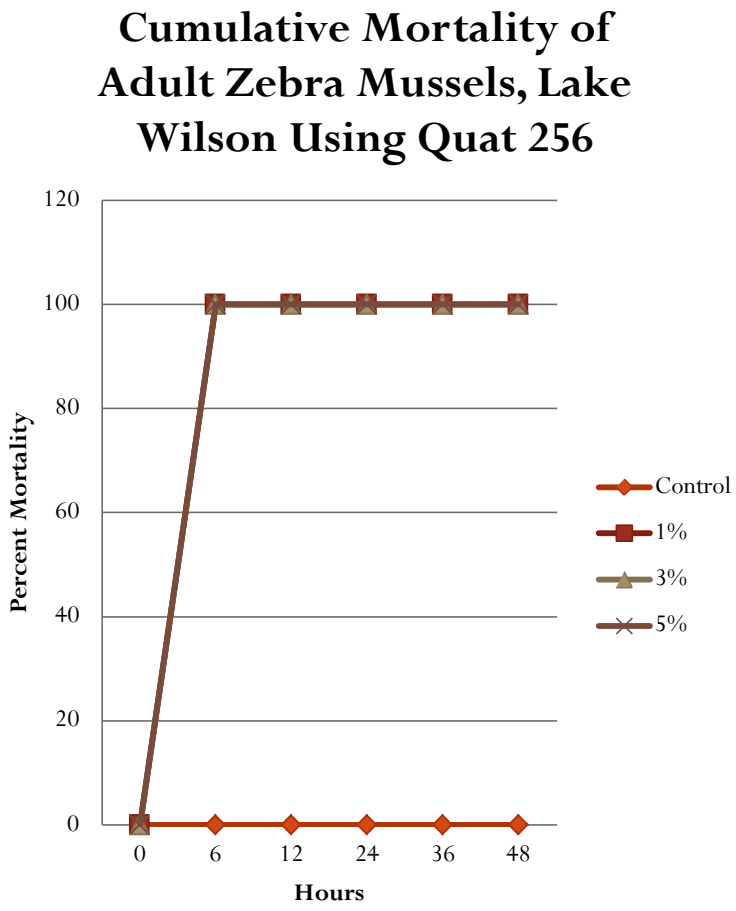
Results: Adult Quagga Mussels Using Quats 128 and 256





Results: Adult Zebra Mussels Using Quats 128 and 256



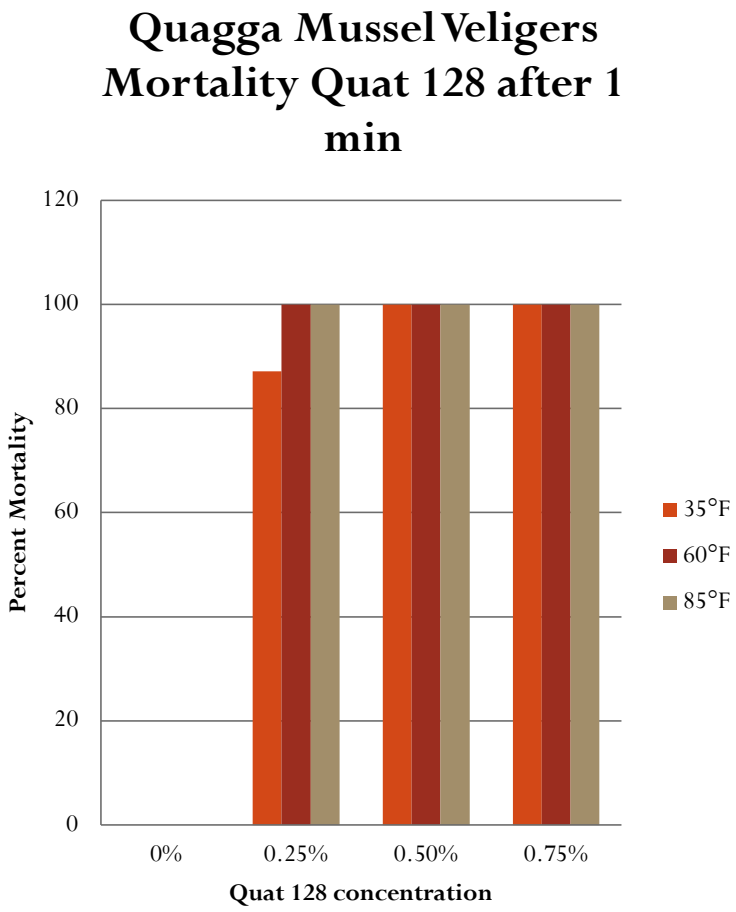


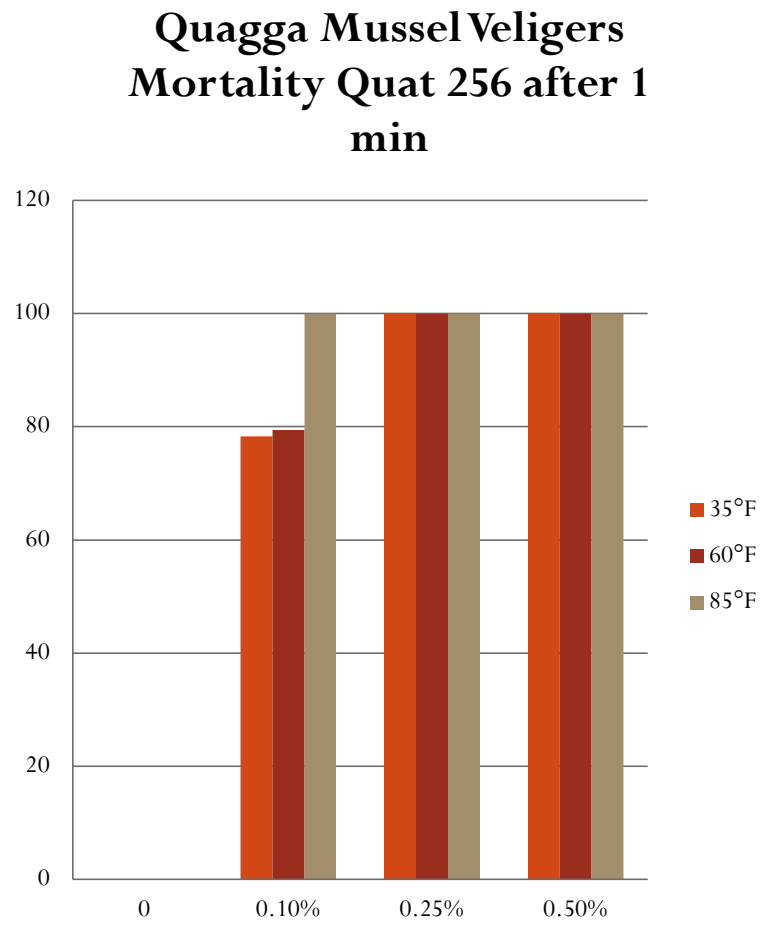
Results: Adult Quagga and Zebra Mussels

- Table 2. Results of ANOVA testing of adult quagga and zebra mussels using Quats 128 and 256; alpha set at 0.05

Variable	F	Significance
Mussel (quagga or zebra)	185.2	.000
Agent (Quat 128 or 256)	9.8	.002
Agent Concentration	4527.7	.000
Hour to Mortality	47.7	.000

Results: Quagga Mussel Veligers



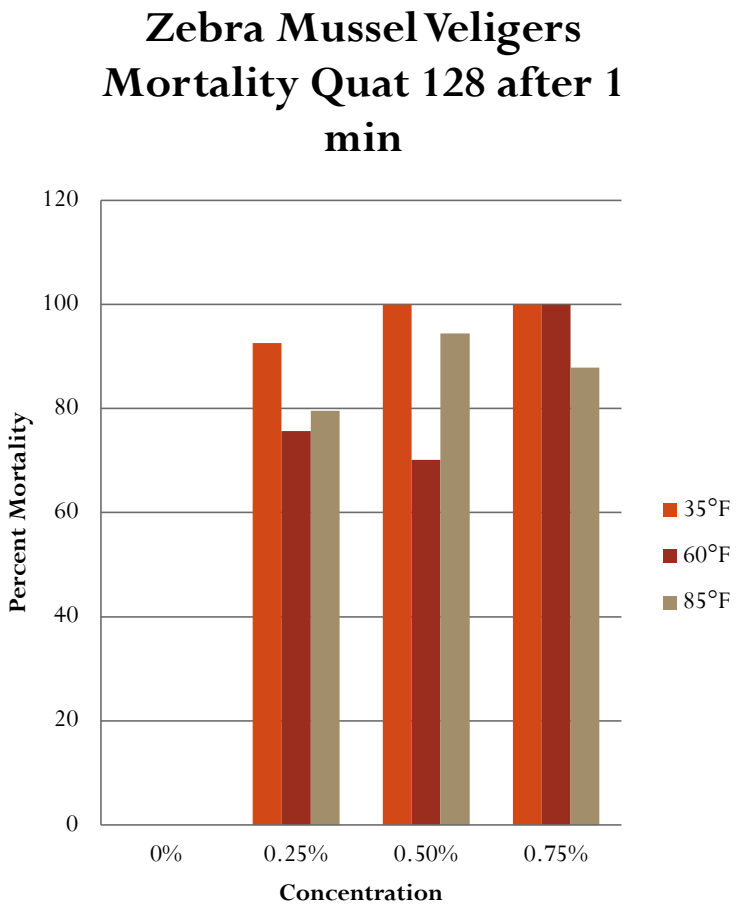


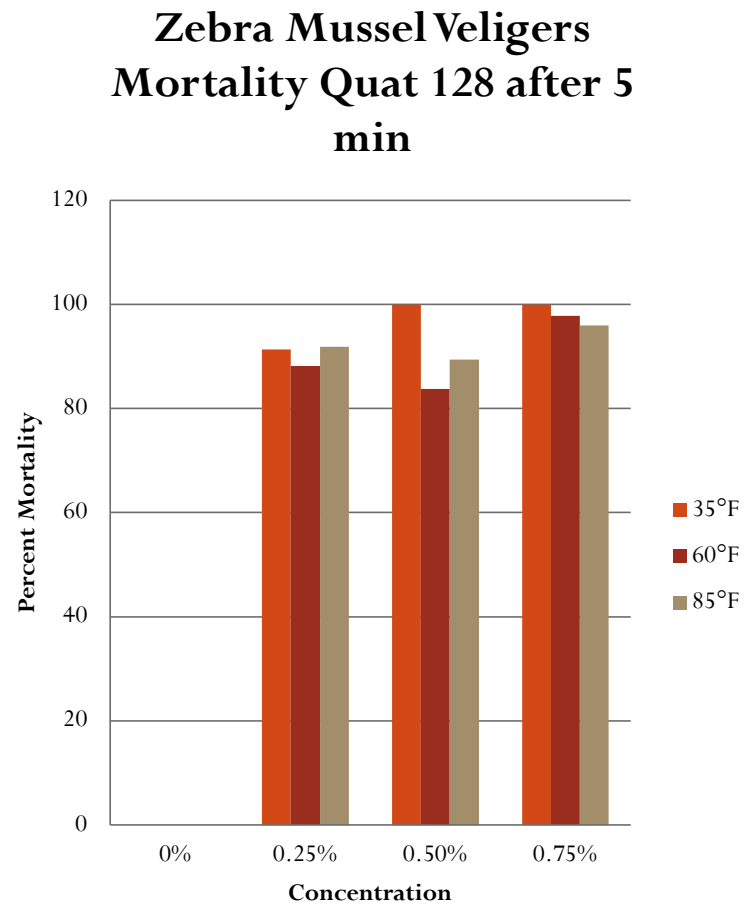
Results: Quagga Mussel Veligers

- Table 3. Results of ANOVA testing of quagga mussel veligers using Quats 128 and 256 with temperature as an added variable; alpha set at 0.05

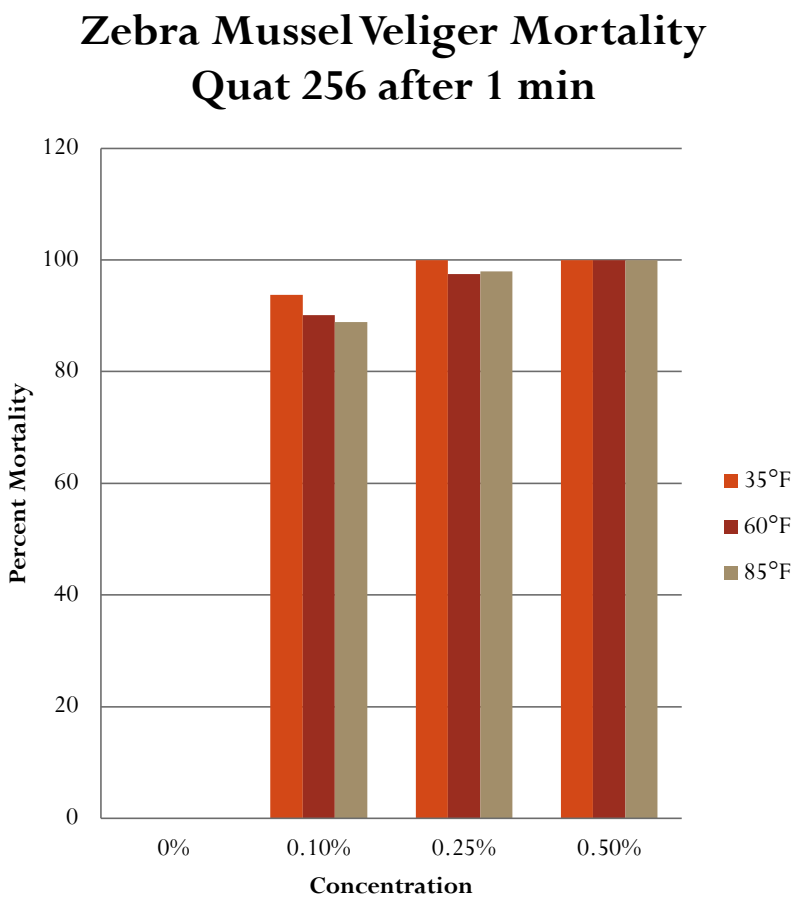
Variable	F	Significance
Agent Concentration	3578.9	.000
Temperature (°F)	5.7	.005

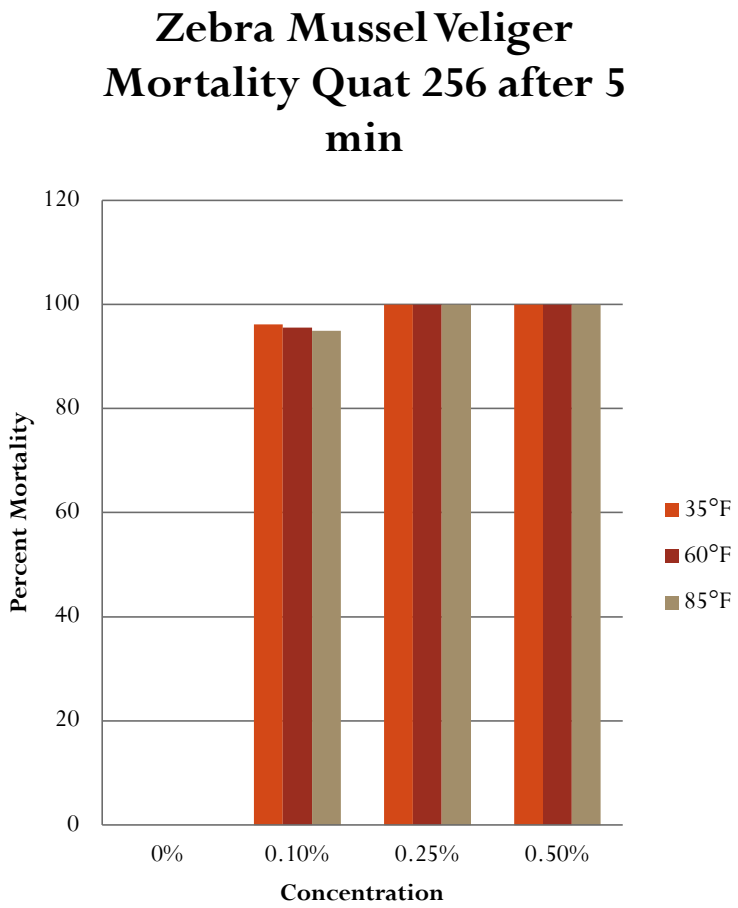
Results: Zebra Mussel Veligers (Quat 128)





Results: Zebra Mussel Veligers (Quat 256)





Results: Zebra Mussel Veligers

- Table 4. Results of ANOVA testing of zebra mussel veligers using Quats 128 and 256 with temperature as an added variable; alpha set at 0.05

Variable	F	Significance
Agent Concentration	4394.8	.000
Temperature (°F)	6.1	.003

Conclusions

- 1% Quat 128 is the most effective when killing **adult** quagga and zebra mussels within 48 hours
- 0.25% Quat 256 is the most effective when killing quagga and zebra mussel **veligers** within 5 min at all temperature ranges (35, 60, and 85°F)

Implications

- Quats 128 and 256 are effective in killing dreissenid mussels in low doses, safe to use on fire suppression equipment, and there are little to no adverse human health effects
- Could be used in the development of a standard decontamination protocol on firefighting equipment exposed to quagga or zebra mussels

Future Work

- Determine the effectiveness of Quats 128 and 256 at different water temperatures as well as the strength of the solution exposed to different ambient temperatures
- Important to find out what specific AIS are threats in the Southwest region
  - Is the dose adequate for not only dreissenids, but other AIS?

QUESTIONS
Thank you!