Temperature and Dose Response of Invasive Quagga Mussels to Various Molluscicides in High Conductivity Water

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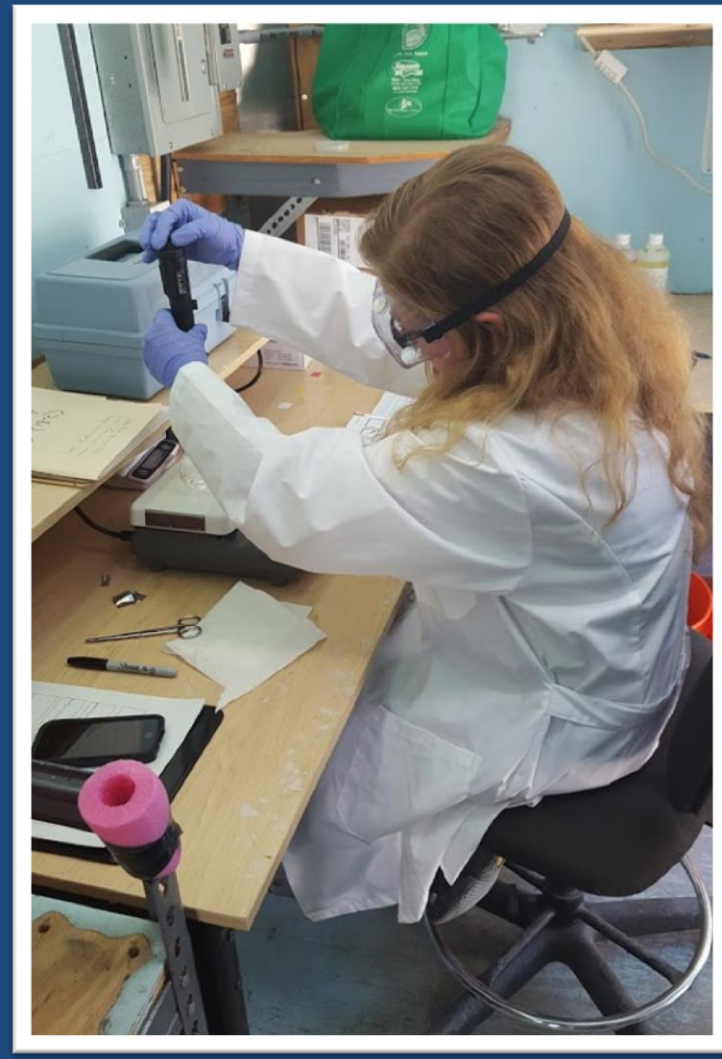
Picton, Ontario

20th International Conference on Aquatic Invasive Species

Ft. Lauderdale, Florida
October 2017



Summary

- What is United Water Conservation District?
- History of Quagga Mussel Infestation
- Goal of Treatment Study
- Methods
- Results
- Discussion
- Future Directions
- Questions

What is United Water Conservation District?

- California special district
- Owner and operator of Santa Felicia Dam and the Freeman Diversion
- Store winter runoff in Lake Piru
- Release water down Piru Creek and the Santa Clara River
- Divert surface water to recharge aquifers in Ventura County

History of Quagga Mussel Infestation

- Detected in Lake Piru in December 2013
- Infestation appeared to have peaked by 2016
- California law requires a plan for control/eradication of quagga mussel adults and veligers
- Critical habitat for federally endangered southern California steelhead makes this challenging, because of required water releases for fish

Infested Lake

Steelhead Critical Habitat with required minimum streamflow requirements

	Millbrook Quarry Virginia	Offut Air Force Base Nebraska
Species	Zebra mussel	Zebra mussel
Treatment Time	January-February 2006	September 2008 Spring (May?) 2009
Size	12 acres	117 acres
Max Depth	93 ft	15 ft
Volume (AF)	551	?
Temp	5.8-13.5℃	Not reported (likely cool)
Conductivity	230µS/cm	409-414µS/cm
Approach	KCl (144 tons)	Copper sulfate (26,000 lbs/treatment)
Dose	104 ppm average (range = 98-115 ppm)	1 ppm elemental copper
Cost	$365,000	$482,000 total
Result	**Successful**	**Not successful/re-infested?**
Nontarget Fish	No dead fish observed	~40,000 lbs of dead fish

	Millbrook Quarry Virginia	Offut Air Force Base Nebraska	Lake Piru California
Species	Zebra mussel	Zebra mussel	Quagga mussel
Treatment Time	January-February 2006	September 2008 Spring (May?) 2009	?
Size	12 acres	117 acres	>200 acres
Max Depth	93 ft	15 ft	>25 ft
Volume (AF)	551	?	>6,000
Temp	5.8-13.5℃	Not reported (likely cool)	Up to ~25℃
Conductivity	230µS/cm	409-414µS/cm	Up to ~1500 µS/cm
Approach	KCl (144 tons)	Copper sulfate (26,000 lbs/treatment)	**Copper sulfate pentahydrate (EarthTecQZ)**
Dose	104 ppm average (range = 98-115 ppm)	1 ppm elemental copper	**200 ppb**
Cost	$365,000	$482,000 total	**$xxx,xxx to $1 million**
Result	**Successful**	**Not successful/re-infested?**	?
Nontarget Fish	No dead fish observed	~40,000 lbs of dead fish	Risk of lethal or sublethal effects?

Goal of Treatment Study

Identify the optimal molluscicide product and concentration to effectively control/eradicate quagga mussels in Lake Piru <u>AND</u> minimize adverse effects to non-target species

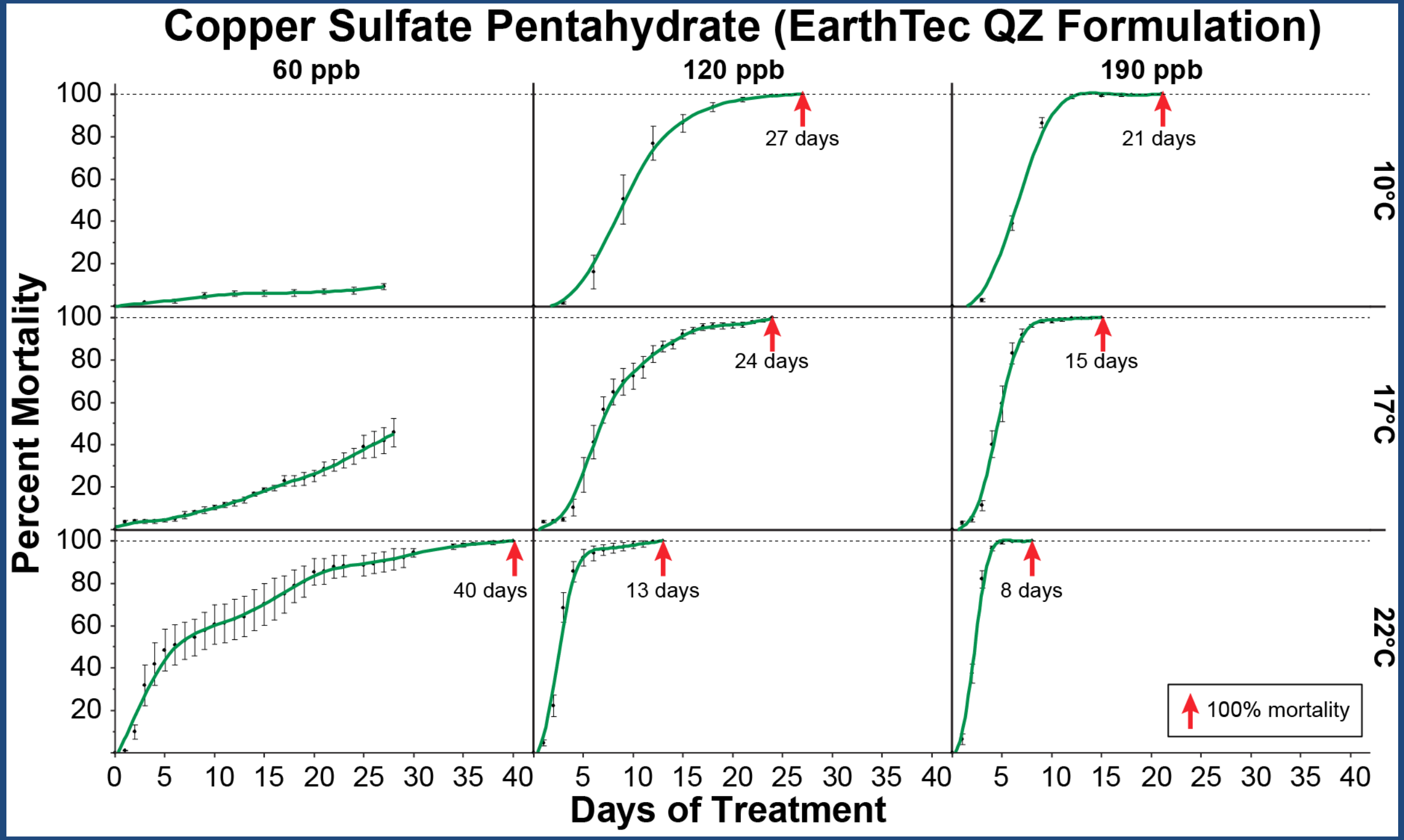
Methods

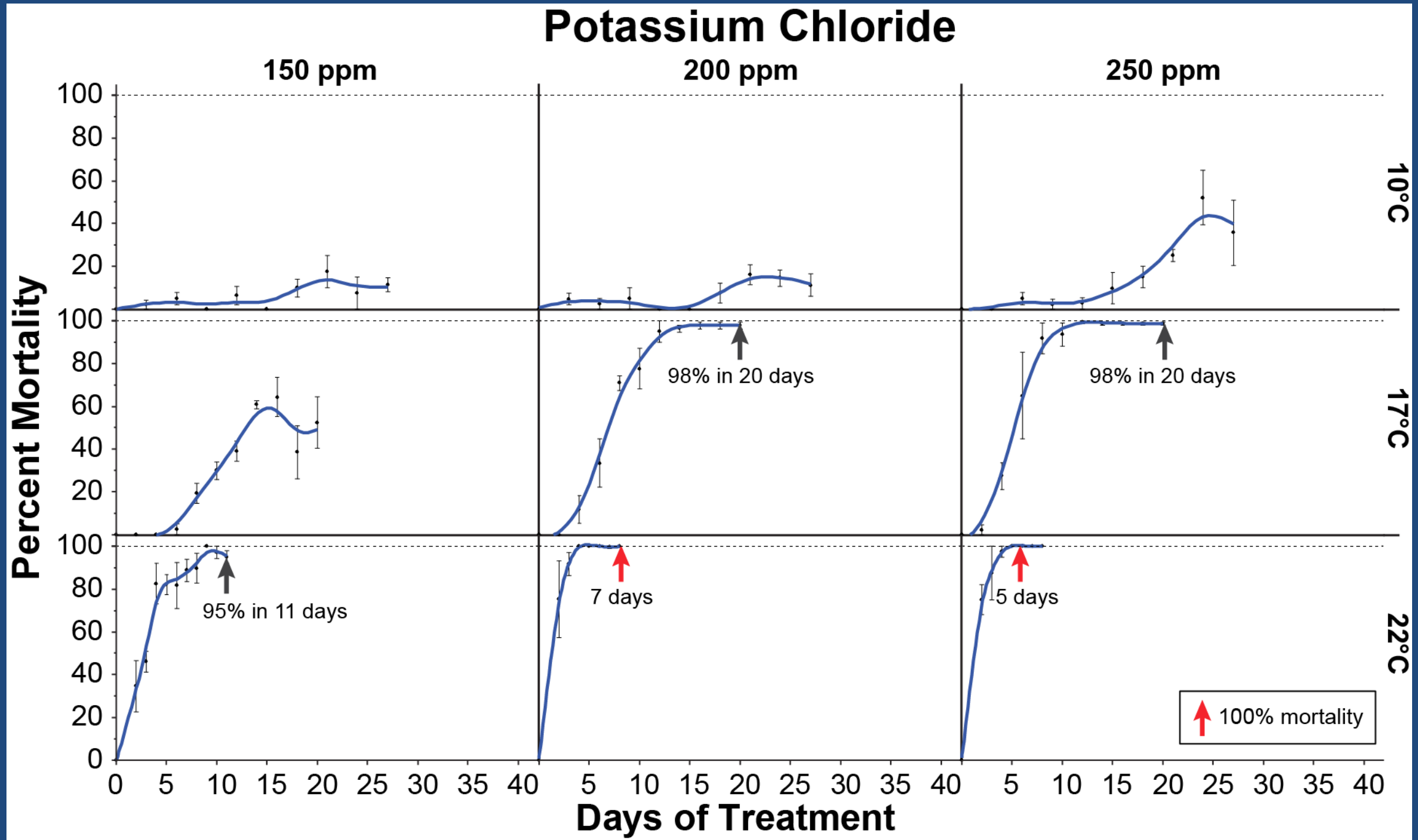
- Potassium chloride (potash)
- Copper sulfate pentahydrate (EarthTecQZ®)
- Citric acid formulation (ZMX)
- Carbon dioxide

3 Treatment Concentrations
(low, medium, high)
X
4 Repetitions of each treatment
X
3 Temperatures
(10°C, 17°C, and 22°C)

Methods

- Experimental temperature maintained by ambient air in the laboratory
- Chemical mixed as a single batch for each of the four repetition
- Copper levels adjusted if levels fell too low by mixing a new batch for all four replicates
- Mortality checked every 3 days for the low temperature experiment, every day for the warmer temperature
- Temperature,pH and DO checked at the same time as mortality in each cooler


Copper Sulfate Pentahydrate (EarthTec QZ Formulation)
60 ppb
120 ppb
190 ppb
10°C
17°C
22°C
Percent Mortality
100
80
60
40
20
27 days
21 days
24 days
15 days
40 days
13 days
8 days
0
5
10
15
20
25
30
35
40
Days of Treatment
100% mortality


Potassium Chloride
150 ppm
200 ppm
250 ppm
10°C
17°C
22°C
Percent Mortality
Days of Treatment
98% in 20 days
98% in 20 days
95% in 11 days
7 days
5 days
100% mortality

Discussion

- Copper sulfate pentahydrate formulation (EarthTecQZ) appears to be most cost-effective option for whole-lake treatment
- We will repeat testing using potassium for a longer period (60+ days) at a lower concentration for more feasible treatment scenario

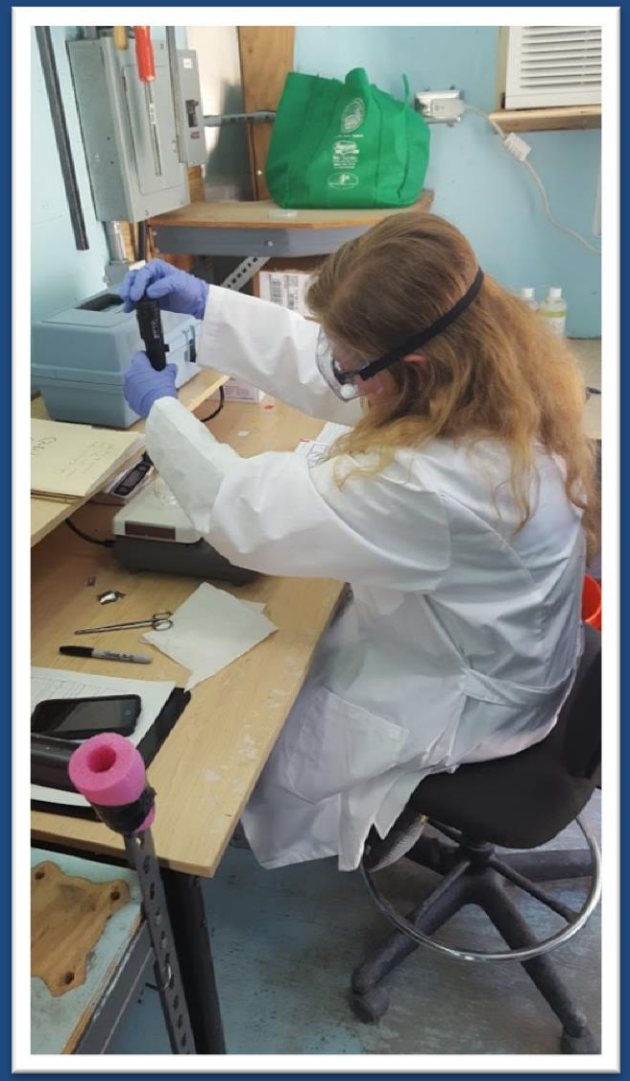
Acknowledgements

United staff:

- Bailey Barkley
- Cherie Benthin
- Evan Lashly
- Griffin Haverland
- Heather D'Anna
- Jayson Garcia
- Rainey Barton

Earth Science Laboratories

- David Hammond



Questions?

Contact

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Cost	$365,000	$482,000 total	?
Result	**Successful**	**Not successful/re-infested?**	?
Nontarget Fish	No dead fish observed	~40,000 lbs of dead fish	Fish toxicity is important