FUTURE SUPPLY ACTIONS PROGRAM
WEBINAR SERIES

One Water
THE METROPOLITAN WATER DISTRICT of SOUTHERN CALIFORNIA

Restoration of Local Recharge Sources from Invasive Dreissenid Mussels

October 15, 2021

SINCE 1933

KASF Consulting

Trussell TECHNOLOGIES INC

WRD

Central Basin Municipal Water District

Agenda

Speaker Spotlight

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The Metropolitan Water District of Southern California

- Nation's largest wholesale water provider
- Service area: 19 million people/5,200 square miles/parts of six counties
- 26 member agencies
- Supports $1 trillion regional economy
- Imports water from Northern Sierra and the Colorado River, invests in local projects

Metropolitan's Role for Southern CA

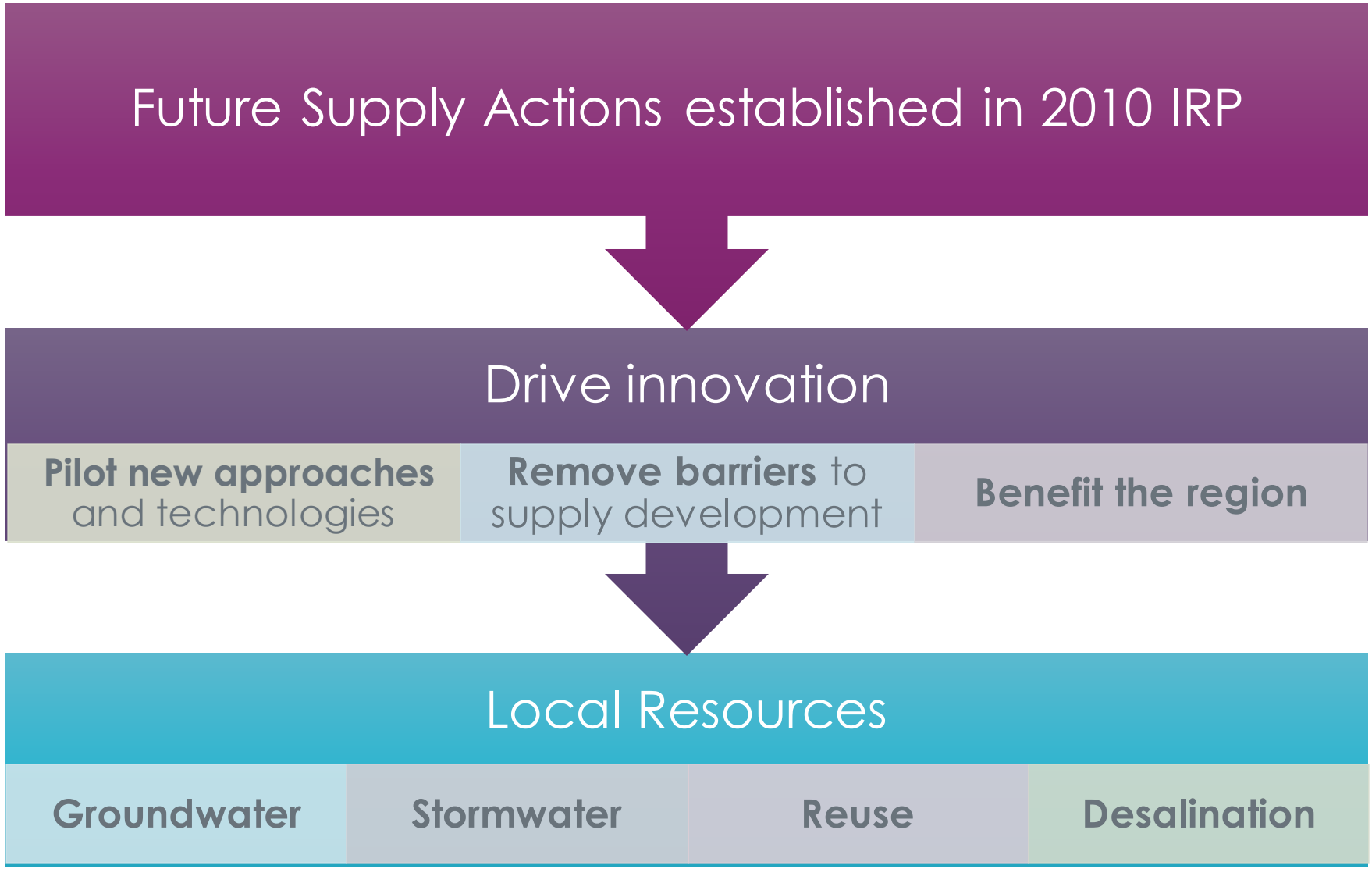
REGIONAL PROVIDER

VISION

INNOVATION

SAFE & RELIABLE

Future Supply Actions Funding Program



Current Program

Member Agency

- 14 studies
- $3.1 million

Water Research Foundation

- 6 potable reuse studies
- 1 agricultural reuse study
- $975k

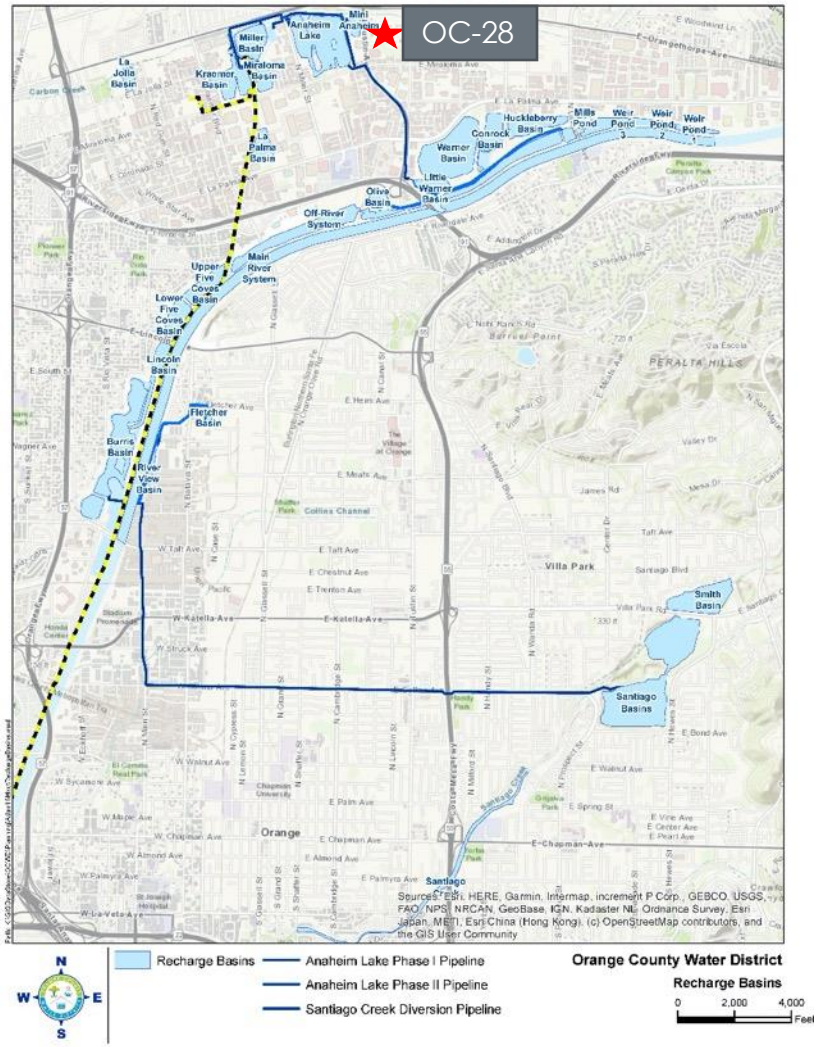
Introduction

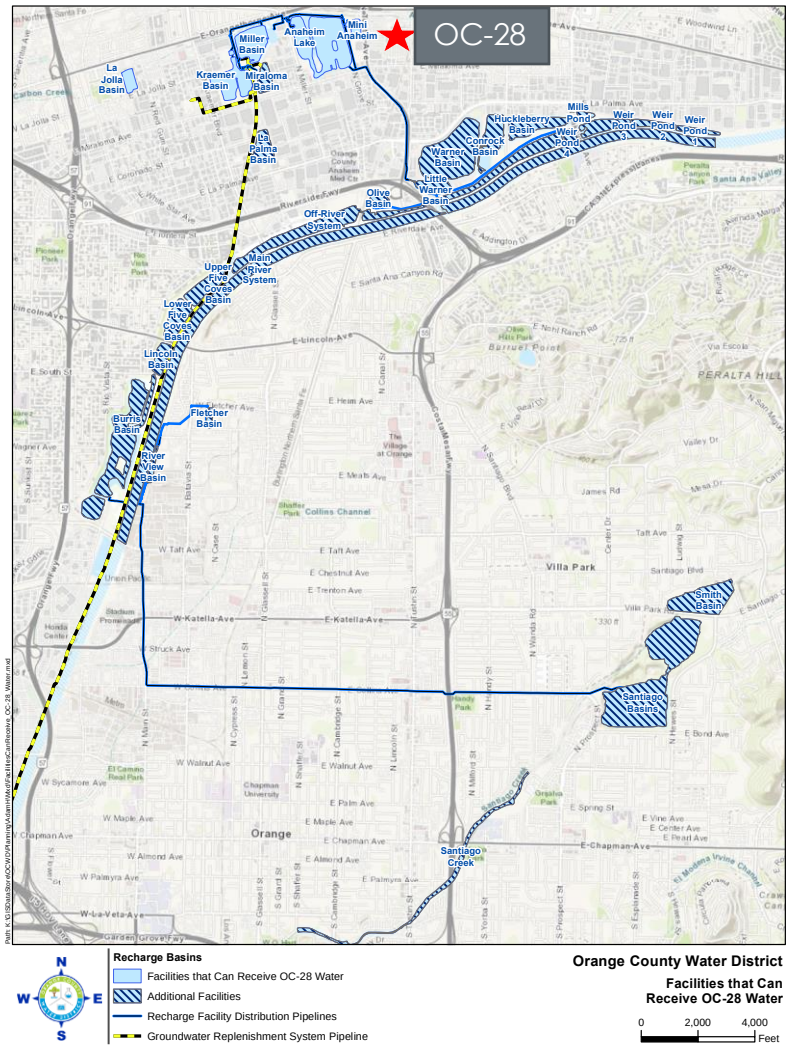
Question for MWD: Could you provide a map highlighting the MWD service area along with imported water systems (SWP & CRA)?

- With limited water resources, Southern California relies on imported water, groundwater, and stormwater
- Groundwater recharge facilities can use both imported water and stormwater
- Imported waters include Colorado River Aqueduct (CRA) and State Water Project (SWP)
- Invasive quagga mussel infestations
  - Throughout CRA system
  - In SWP at Pyramid Lake, Castaic Lake, Lake Piru
- Infested water restricted for groundwater recharge by California Department of Fish and Wildlife (CDFW) regulations

OCWD Recharge Challenges

OCWD Recharge Basins before (left) and after (right) quagga restrictions. Shaded areas are now restricted.





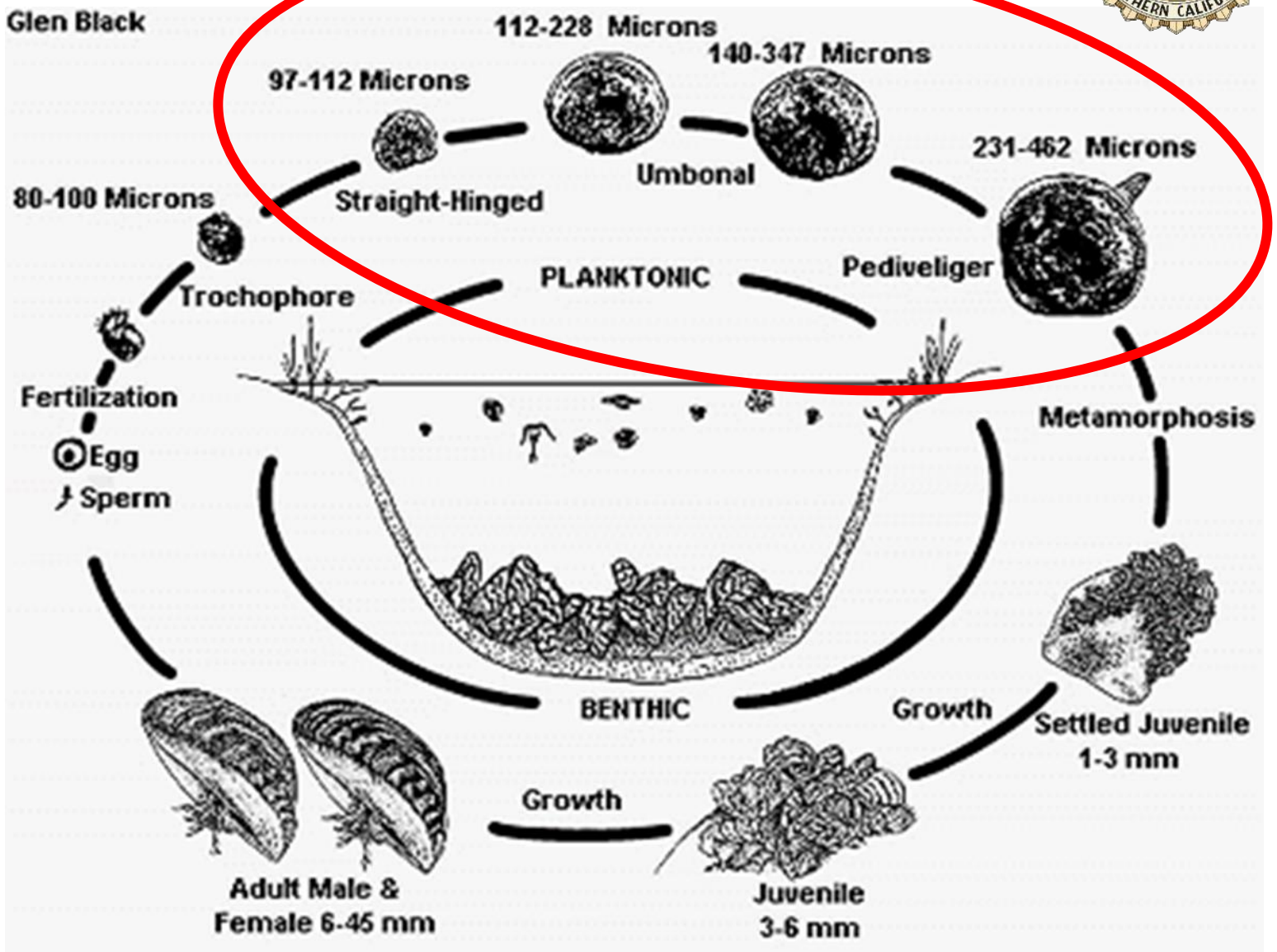
- 87% of OCWD's recharge system cannot accept CRA water due to quagga mussel

Project Objectives

- Evaluate EarthTec QZ for controlling invasive quagga mussels (*Dreissena bugensis*) and toxicity to non-targets
- Test in different water qualities from impacted Southern California waterbodies
  - Lake Piru – SWP and local runoff
  - Lake Mathews – CRA reservoir
  - Weymouth WTP influent – Lake Mathews (CRA) water exposed to chlorine in pipeline for approx. 8 hours

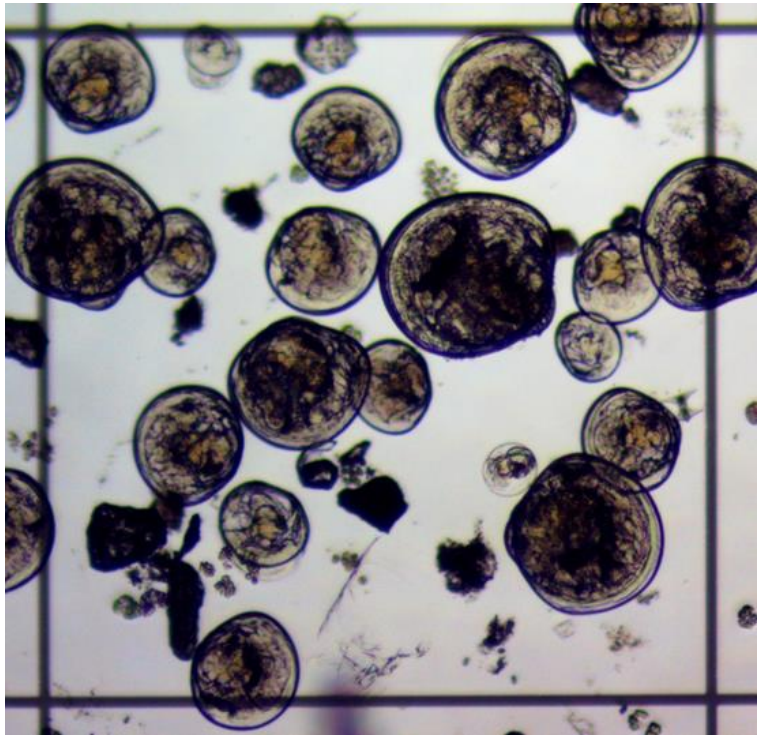
Invasive Quagga Mussels

- Quagga reproduce rapidly
  - Females release >1,000,000 eggs per spawning
  - Multiple spawning events per year
- Highly efficient filter feeders, impacting food web
- Quagga life cycle
- Veligers delivered in CRA



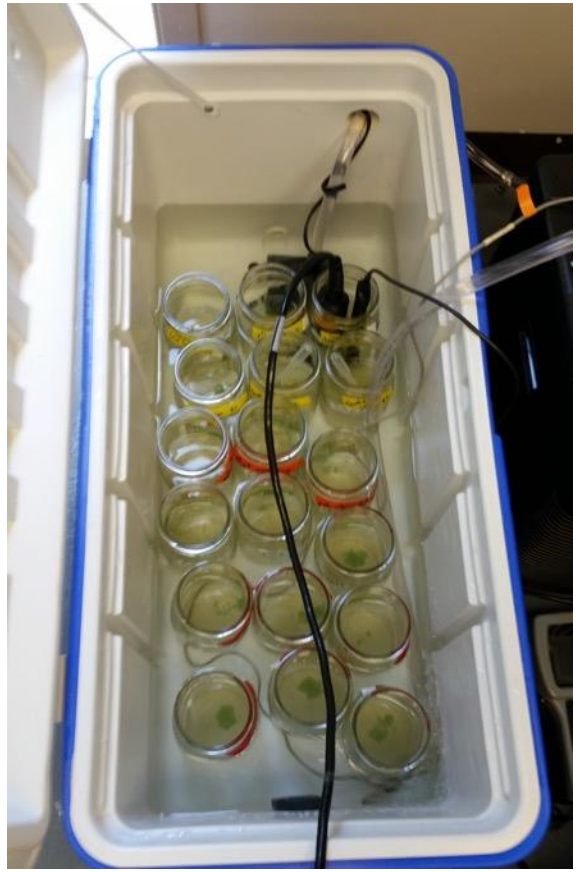
Approach

- Evaluate efficacy of EarthTec QZ™ molluscicide
  - NSF/ANSI 60 certified
  - Main component: Copper sulfate pentahydrate
- Target quagga veligers
- Other considerations
  - Toxicity to non-target aquatic organisms
  - Copper limits in drinking water
    - Lead and Copper Rule action level at 1.3 mg/L (90th percentile distribution system value)
    - Secondary Maximum Contaminant Level (sMCL) at 1.0 mg/L

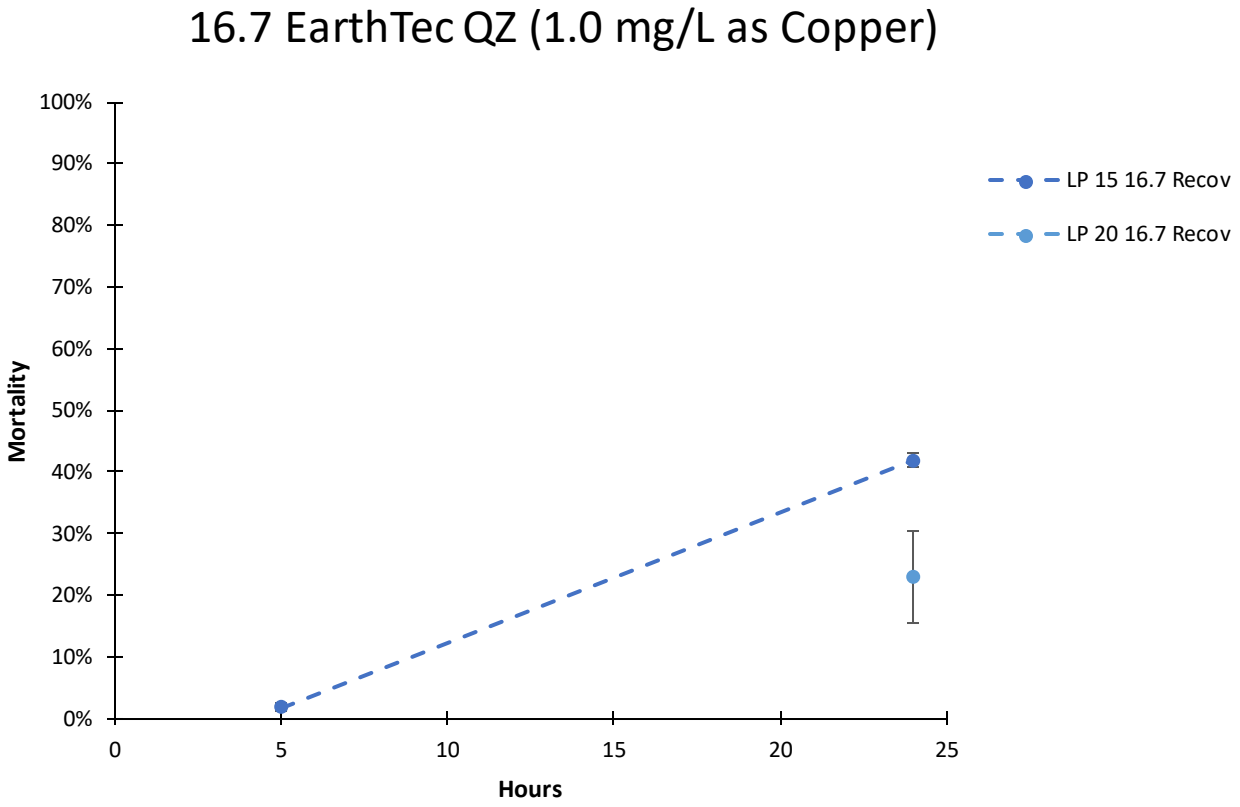


Dose-Response Testing

- Quagga veliger testing
  - Two temperatures (15 and 20°C)
  - Five doses of EarthTec QZ per temperature
    (0, 3, 16.7, 33.4, 50.1 µL/L)
    (0, 0.18, 1.0, 2.0, 3.0 mg/L as Copper)
  - 4 exposure times per dose (0.5, 2, 5, 24 h)
  - 24-hour recovery measurements
- Water quality monitoring
  - Treated water: total and free copper, pH, dissolved oxygen, conductivity, temperature
  - Raw water: dissolved organic carbon (DOC), alkalinity, hardness, chemical oxygen demand (COD)
- Acute toxicity testing for 3 non-targets

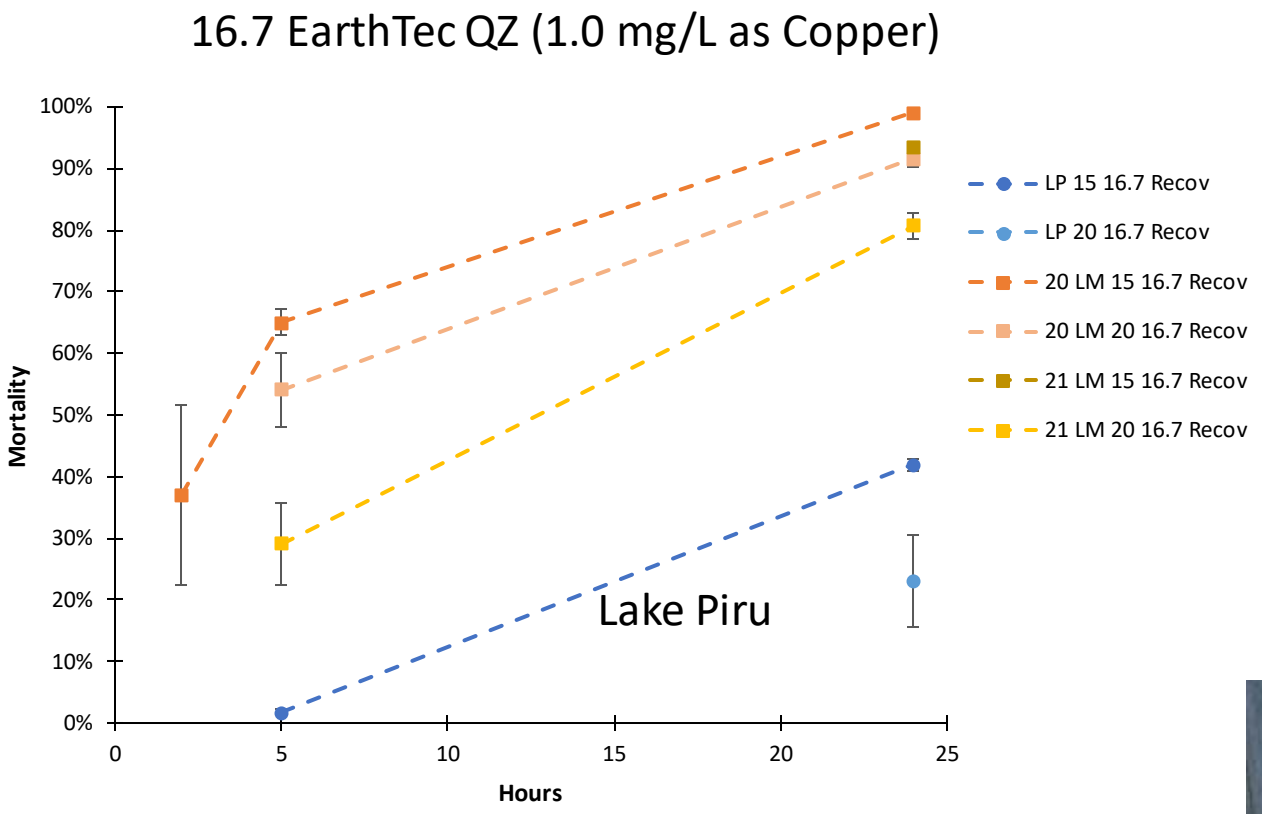


Lake Piru Test Results



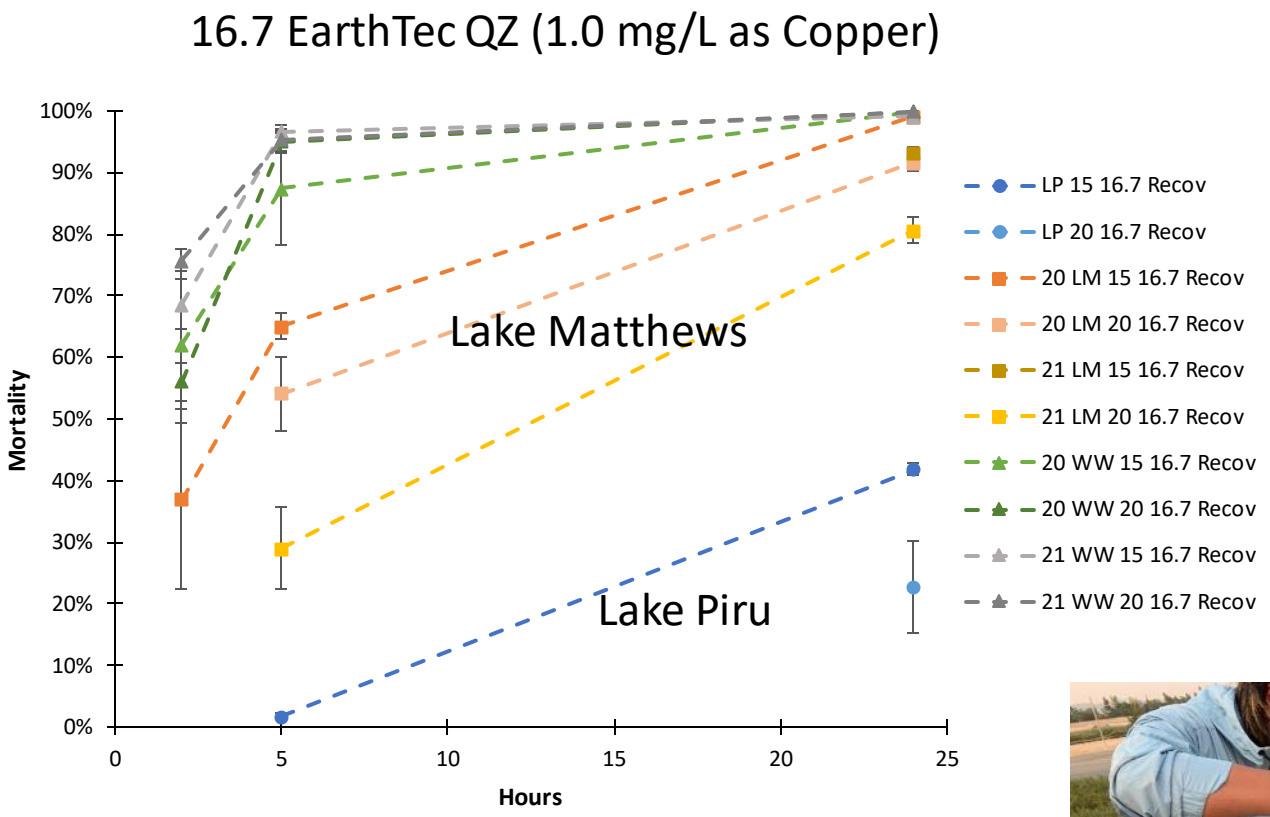
- Conducted December 2019
- 23% and 42% mortality after 24h for 20°C and 15°C, respectively
- Mortality increased with higher concentrations
  - 66.4% at 33.4 EarthTec QZ (2.0 mg/L Cu)
  - 92.5% at 50.1 EarthTec QZ (3.0 mg/L Cu)

Lake Mathews Test Results



- Conducted September 2020 and July 2021
- 2020: 99 and 92% mortality after 24h
- 2021: 93 and 81% mortality
- Mortality increased with higher concentrations
  - 97.3% at 33.4 EarthTec QZ (2.0 mg/L Cu)
  - 98.9% at 50.1 EarthTec QZ (3.0 mg/L Cu)

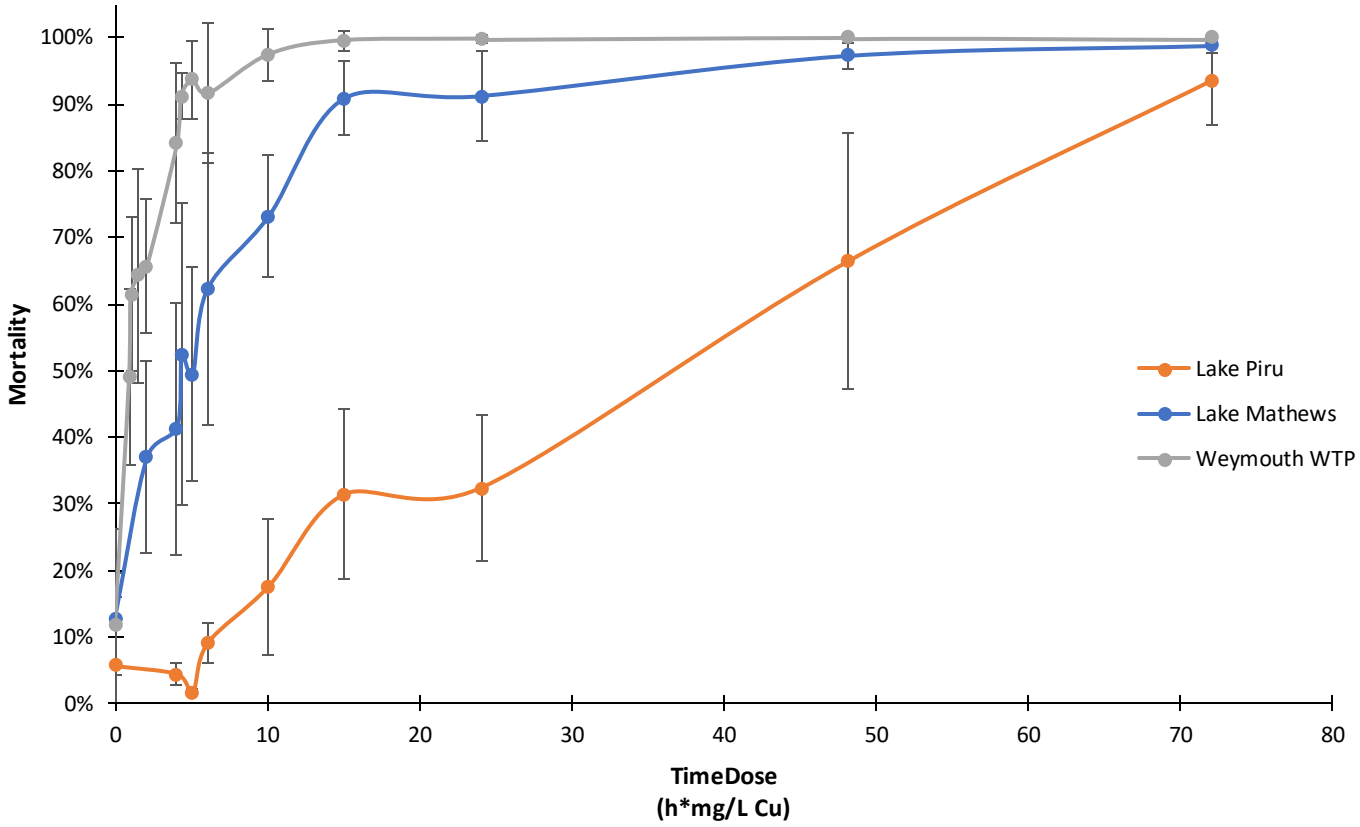
Weymouth WTP Test Results



- Conducted September 2020 and July 2021
- 2020: 100% mortality after 24h (all)
- 2021: 99 and 100% mortality
- Mortality increased with higher concentrations
  - 100% at 33.4 EarthTec QZ (2.0 mg/L Cu)
  - 100% at 50.1 EarthTec QZ (3.0 mg/L Cu)

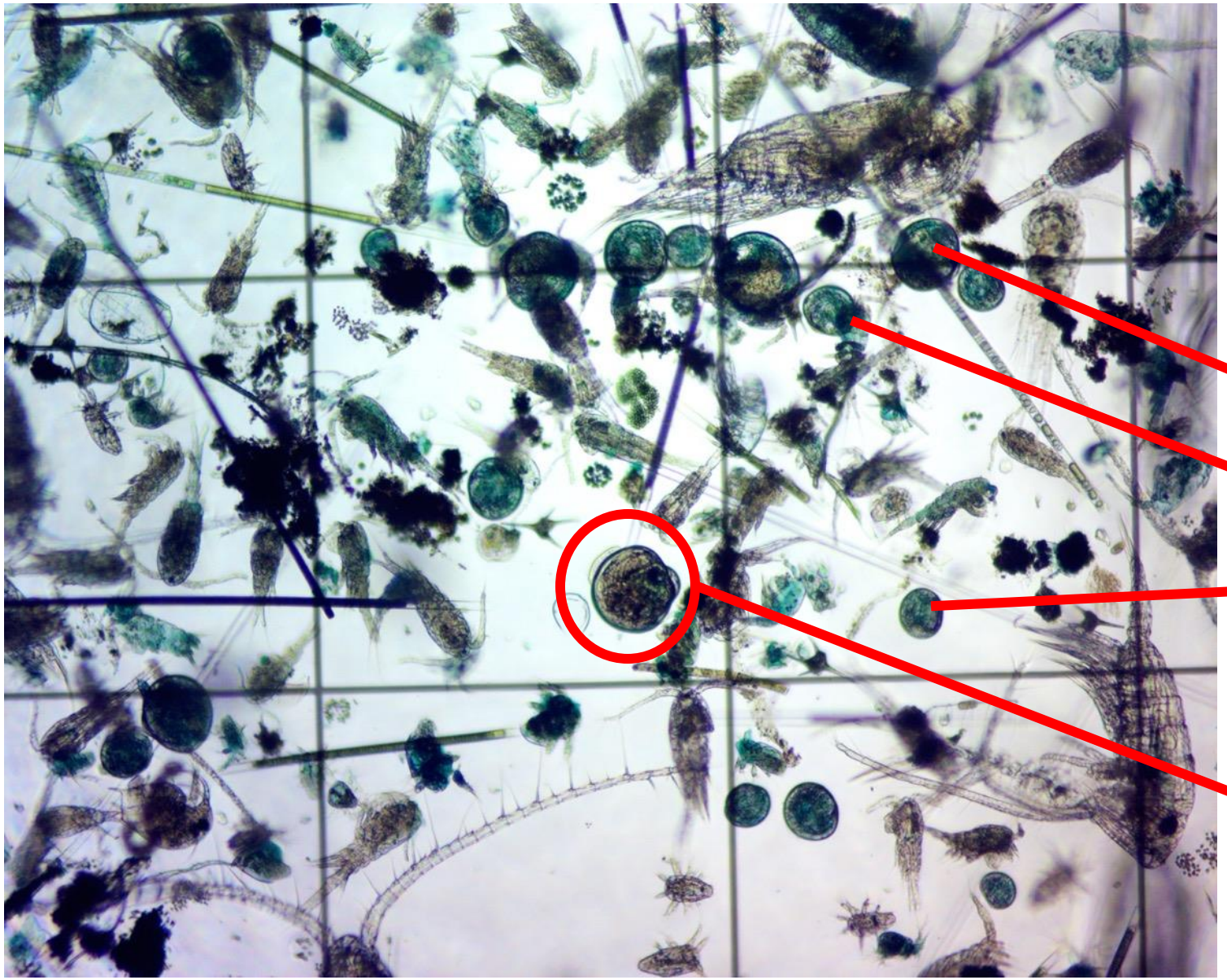
! Lake Mathews water chlorinated in pipeline to Weymouth WTP

Veliger Mortality with Time-Dose Variable



- Time-Dose calculation is the exposure time (hours) x copper concentration
- Weymouth WTP had highest mortality at all concentrations over time (chlorinated)
- Lake Piru veligers were less susceptible to EarthTec QZ (SWP water & runoff)
- Linear regression modeled data
  - Temperature & year not a factor
  - Location was a significant factor

Veliger Size Class Examples



Field observation:
Larger veligers had higher survival rates

Dead large umbonal

Dead small umbonal

Dead D-shaped

Live large umbonal

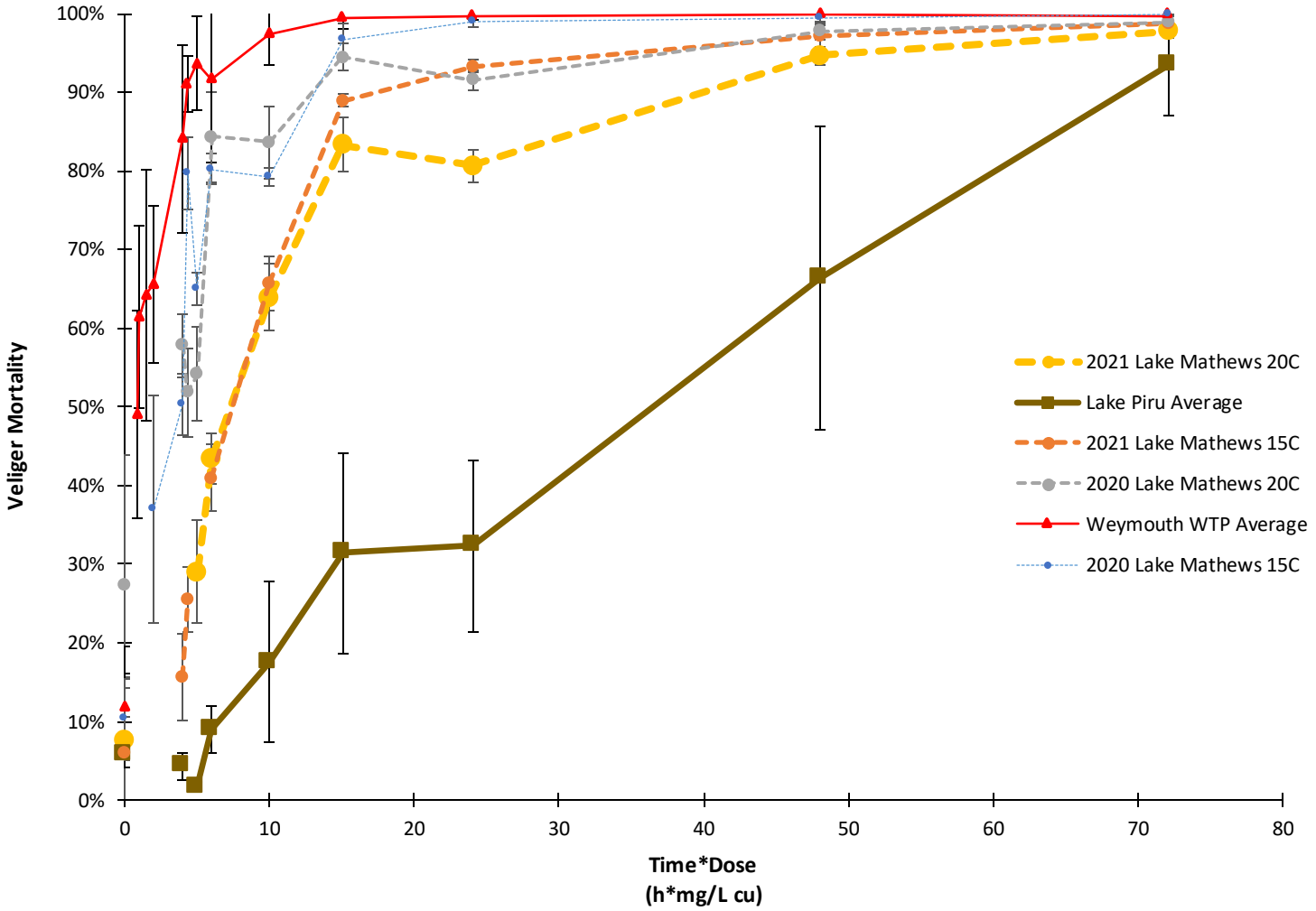
Veliger Size Class Distribution

Size class distribution of quagga mussel veligers used in testing

Sample Site	Size Class				Rank (score wt)
	D-shaped (50-150 µm)	Small umbonal (150-250 µm)	Large umbonal (200-350 µm)	Pediveliger (350-500 µm)	
2021 Lake Mathews (20°C)	32%	18%	38%	11%	A (8)
Lake Piru (15 & 20°C)	45%	15%	20%	20%	B (9)
2021 Lake Mathews (15°C)	52%	22%	23%	3%	C (16)
2021 Weymouth WTP (15°C)	74%	8%	17%	2%	D (17)
2020 Lake Mathews (20°C)	50%	30%	15%	5%	E (20)
2021 Weymouth WTP (20ºC)	53%	25%	22%	1%	F (22)
2020 Weymouth WTP (15 & 20°C)	80%	15%	3%	2%	G (23)
2020 Lake Mathews (15°C)	75%	20%	4%	1%	H (26)

- Each site was ranked by density of large to small veligers
- Locations sampled during the same week were combined
- Lake Mathews had highest variability

Influence of Veliger Size Class



Largest

Size Class

Smallest

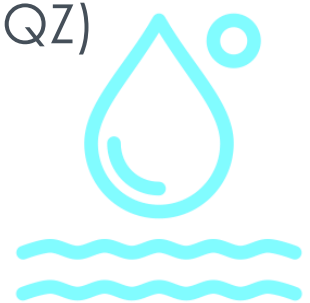
- Lake Mathews (LM) had largest variation in veliger mortality for each sampling event
  - The largest size class from LM had the lowest mortality
  - The smallest size class had the highest mortality
- Size class explained variation in mortality by locations

Water Quality Parameters

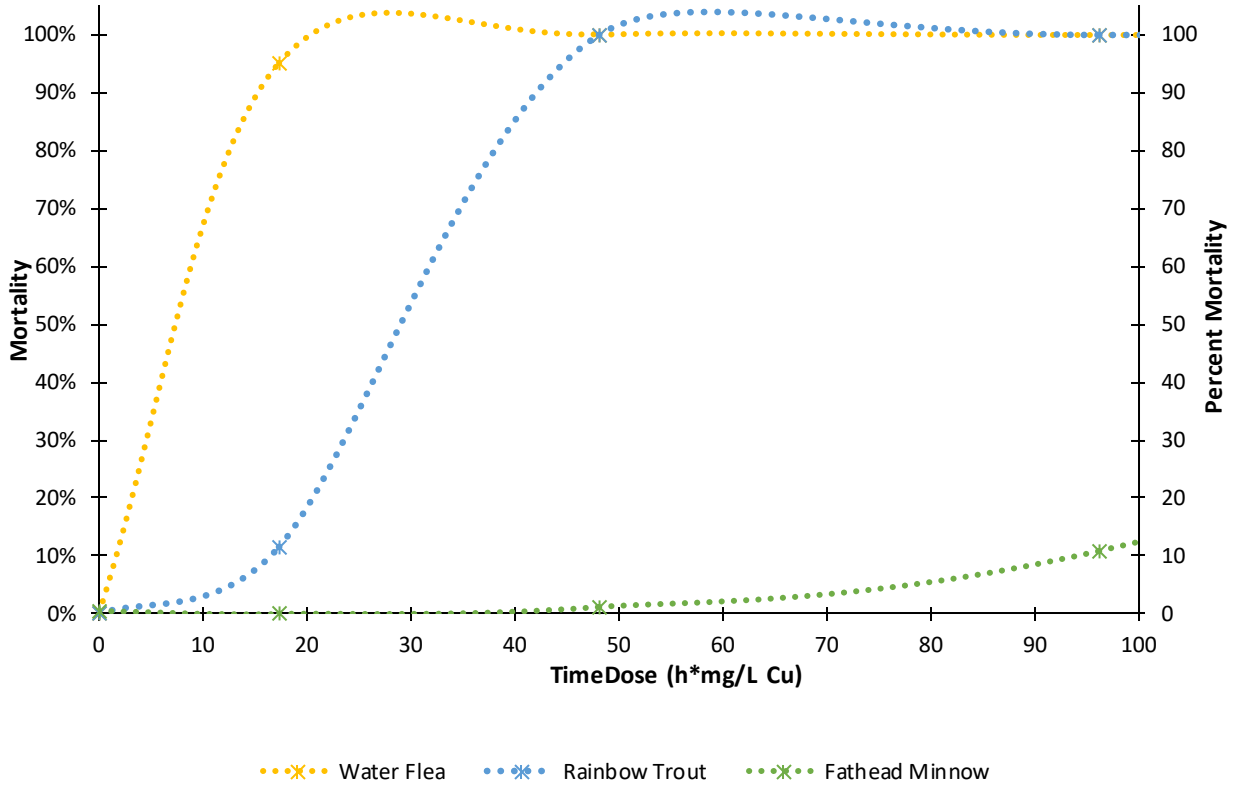
Average Water Quality Readings for Each Site

	Hardness (mg/L as CaCO3)	Alkalinity (mg/L as CaCO3)	Dissolved Organic Carbon (mg/L)	Chemical Oxygen Demand (mg/L)
Lake Piru	315	171	5.19	7.83
Lake Mathews	185	126	2.96	4.58
Weymouth WTP	179	126	3.69	6.79

- Liner regression modeling used to predict veliger mortality
  - All locations have hard water (>100 mg/L), thus not a significant variable
  - Alkalinity (buffering capacity) was a significant variable
  - Dissolved organic carbon (material available to react with EarthTec QZ) also significant variable
- Water quality explains differences in mortality results

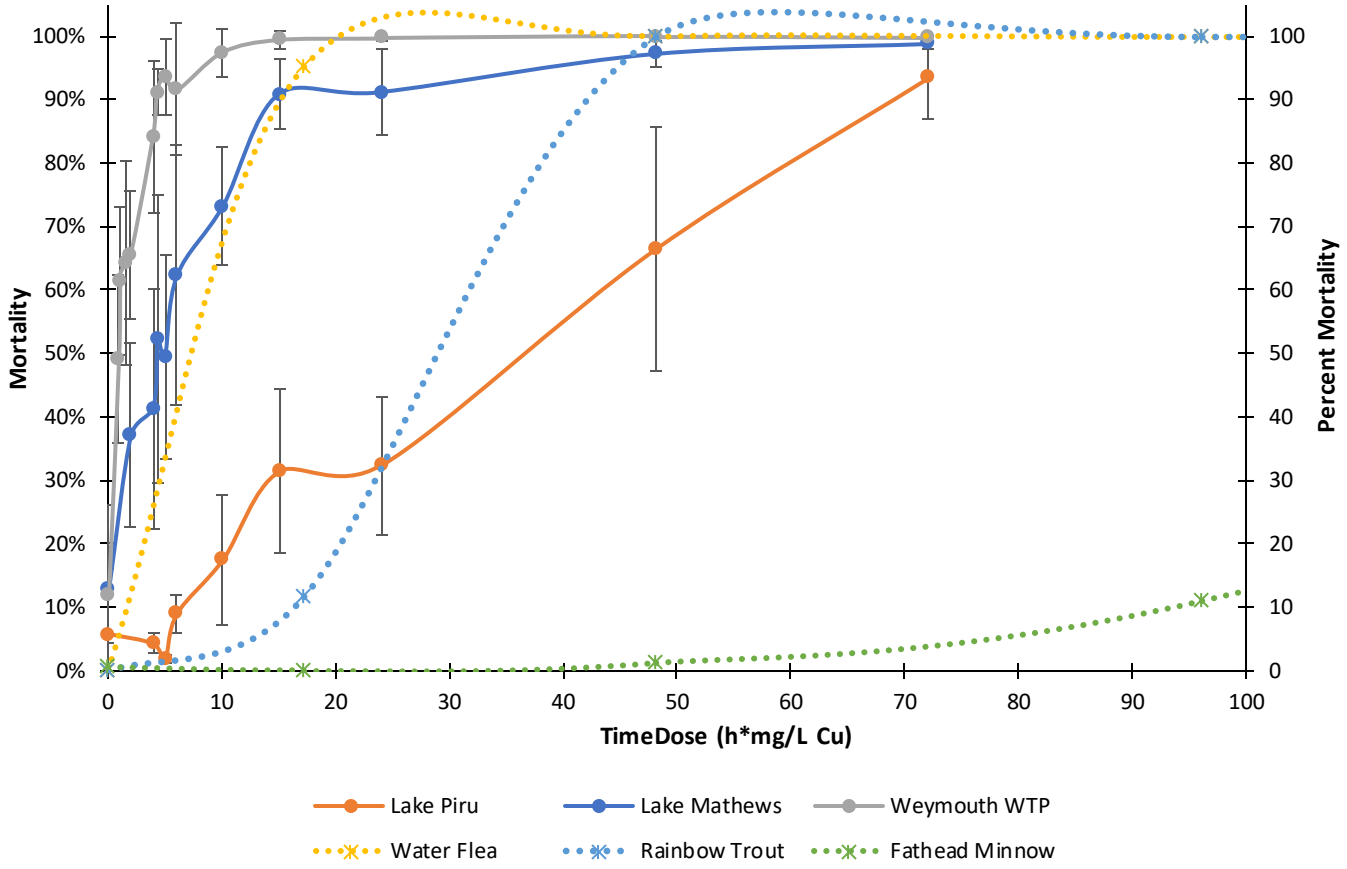


Acute Toxicity of Non-Targets



- Three non-target organisms
  - Water flea (*Ceriodaphnia dubia*)
  - Rainbow trout (*Oncorhynchus mykiss*)
  - Fathead minnow (*Pimephales promelas)*
- Aquatic Bioassay and Consulting Labs analyzed acute toxicity per standard EPA test methods (96-hr exposures)
- Water flea most sensitive
- Fathead minnow least sensitive
- Much higher time-dose exposures compared to quagga tests due to test methodology (96-hr exposure)

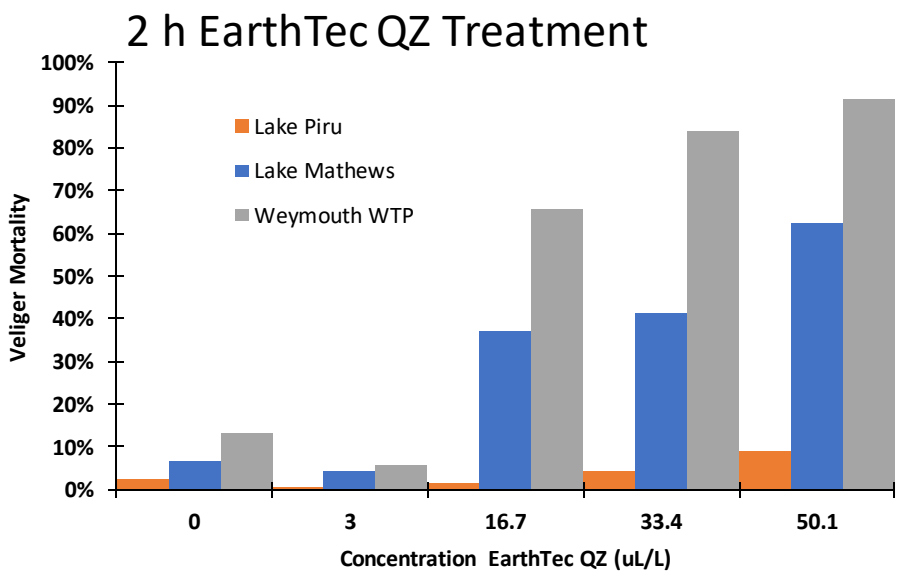
Veliger Mortality Compared to Non-Targets

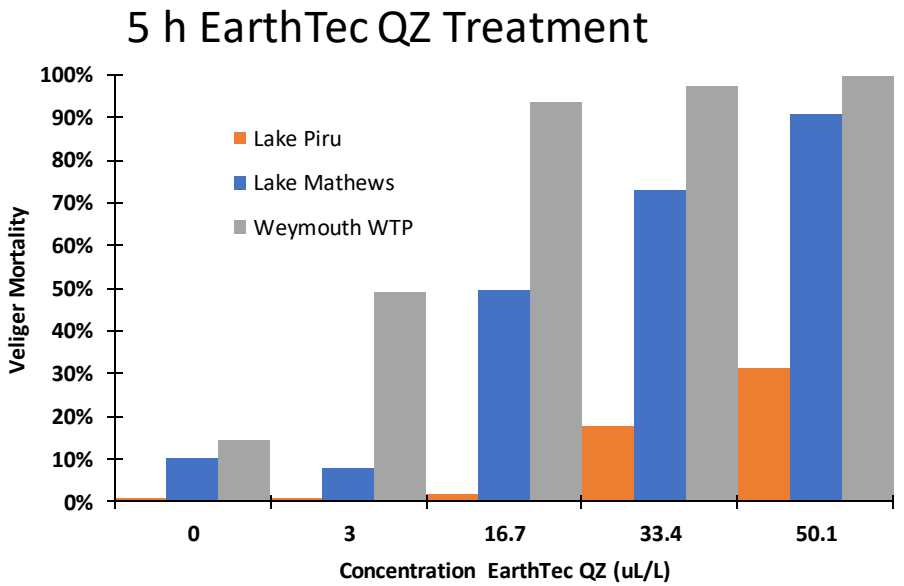


- Quagga mussel veligers were as sensitive to copper as water flea in Lake Mathews and Weymouth WTP water
- In Lake Piru water, the rainbow trout and water flea were impacted by EarthTec QZ before veligers
- Fathead minnows would survive EarthTec QZ doses below 1.0 mg/L copper
- Size of testing organism influences toxicity

Example Applications

- Treatment at OCWD OC-28 (LM water from chlorinated pipeline with similar travel time as Weymouth WTP)
  - Treat for 2 h at 16.7 µL/L to achieve ~70% mortality
  - Treat for 5 h at 16.7 µL/L to achieve >90% mortality
- Site specific testing needed to determine effective dose, copper decay rate, and impacts to species of interest



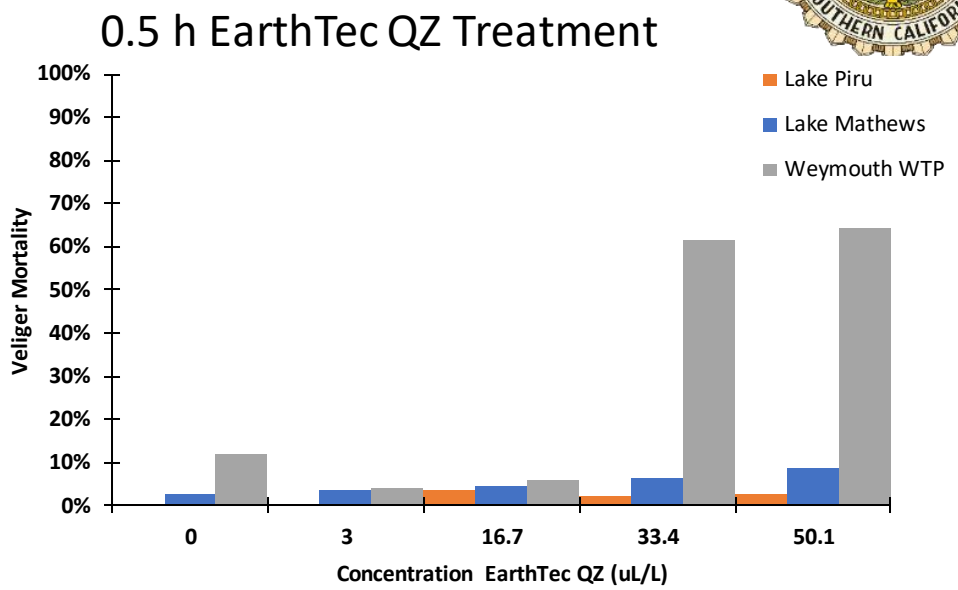


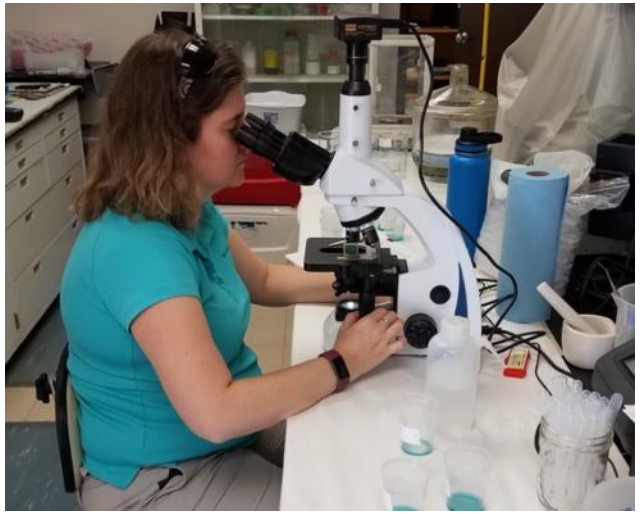
Other Potential Applications

- Treat water from infested location prior to discharge downstream.
  - Other MWD turnouts to groundwater replenishment facilities
    - Water Replenishment District of Southern California
    - Main San Gabriel Watermaster
- Treat water from Irvine Lake
  - Irvine Lake contains local runoff and CRA water
- Recent work in other parts of the country suggest EarthTec QZ can eradicate quagga from water bodies without harm to other aquatic species (Hammond and Ferris, 2019).

Lessons Learned

- Prior study in water from Lake Mead showed (Watters et al. 2013)
  - 100% mortality of veligers at 3 µL/L EarthTec QZ in 30 min
  - In Southern California waters, 30 min at 3 µL/L EarthTec QZ ≠ 100% mortality (this study)
- No concentration tested resulted in 100% mortality within a 30 min exposure time
- Lower dose safer for non-targets, but requires longer contact time to kill veligers





Limitations of this Study

- Bench-testing approach does not provide full assemblage of organisms
  - EarthTec QZ's effectiveness could be decreased
- Exposure time of standard acute toxicity methods (96 hrs) vs. veliger tests (24 hrs) limits correlation of resulting toxicity
  - Need to complete testing on organisms of interest and of ecological value
- Recommend using mesocosms in next studies

Conclusions

- EarthTec QZ is effective
  - Dependent on water quality (hardness, alkalinity, DOC)
  - Chlorine treated veligers were more susceptible to die off and lower doses
  - Large veligers took longer to be impacted
  - Lower doses are safer for non-targets, but requires long contact times to kill quagga mussels

- Site-specific testing recommended prior to application
  - Acceptable veliger mortality
  - Acceptable non-target mortality
  - Full planktonic assemblage present

Acknowledgements

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- Aquatic Bioassay & Consulting Lab

Questions and Discussion

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