RECLAMATION

Managing Water in the West

Interim Report: Zebra Mussel Eradication, Potash Study San Justo Reservoir

Research and Development Office
Science and Technology Program
Final Report ST-1610-01

Mission Statements

The U.S. Department of the Interior protects America’s natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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The invasive exotic zebra mussel (*Dreissena polymorpha*) has colonized San Justo Reservoir. A group of personnel from Reclamation Mid Pacific Region, California Department of Fish and Wildlife, San Benito County, and the San Benito County Water District, is proposing an attempt to eradicate the mussels by treating the reservoir with potassium provided in the form of muriate of potash (MOP). The successful mussel eradication at Millbrook Quarry (Virginia) established that water treated with MOP at 100 ppm potassium can be lethal to mussels. A suitable treatment for achieving 100% kill at San Justo reservoir may be constrained by time available for treating the reservoir (water storage and delivery obligations) and the seasonal changes in water quality parameters, therefore an evaluation of the site-specific dose and temperature effects on mussel mortality over time was necessary. This study was conducted as a proof-of-concept for a MOP treatment to kill zebra mussels at San Justo reservoir, and to provide data to help refine the final eradication plan. The results of this study were successful and a future peer reviewed publication of the data results is anticipated.

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Acronyms and Abbreviations

°C – temperature in degrees Celsius

K - Potassium

MOP- muriate of potash

PPM – parts per million

pH – measure of acidity on a scale of 1-14, neutral being 7

ZM- zebra mussel

Executive Summary

The invasive exotic zebra mussel (*Dreissena polymorpha*) has colonized San Justo Reservoir. A group of personnel from Reclamation Mid-Pacific Region, California Department of Fish and Game, San Benito County, and the San Benito County Water District, is proposing an attempt to eradicate the mussels by treating the reservoir with potassium provided in the form of muriate of potash (MOP). The successful mussel eradication at Millbrook Quarry (Virginia) established that water treated with MOP at 100 ppm potassium can be lethal to mussels. A suitable treatment for achieving 100% kill at San Justo reservoir may be constrained by time available for treating the reservoir (water storage and delivery obligations) and the seasonal changes in water quality parameters, therefore an evaluation of the site-specific dose and temperature effects on mussel mortality over time was necessary. This study was conducted as a proof-of-concept for a MOP treatment to kill zebra mussels at San Justo reservoir, and to provide data to help refine the final eradication plan. The results of this study were successful and peer reviewed publication outlining the efficacy data is anticipated to be released in the near future.

Contents

Page

Tables

Figures

Background

The invasive exotic zebra mussel (*Dreissena polymorpha*) has colonized San Justo Reservoir. A group of personnel from Reclamation Mid-Pacific Region, California Department of Fish and Wildlife, San Benito County, and the San Benito County Water District, is proposing an attempt to eradicate the mussels by treating the reservoir with potassium provided in the form of muriate of potash (MOP).

Previous work by others, such as the successful mussel eradication at Millbrook Quarry (Virginia) established that water treated with MOP at 100 ppm potassium can be lethal to mussels. A suitable treatment for achieving 100% kill at San Justo reservoir may be constrained by time available for treating the reservoir (water storage and delivery obligations) and the seasonal changes in water quality parameters. Because of the scale, cost, and risks involved in an effort to eradicate mussels in San Justo reservoir, as well as the logistical timing with ongoing reservoir operations, an evaluation of the site-specific dose and temperature effects on mussel mortality over time was necessary.

This study was conducted as a proof-of-concept for a MOP treatment to kill zebra mussels at San Justo reservoir, and to provide data to help refine the final eradication plan.

Methods

Our study design was a 2 factor experiment, with water temperature and potassium dose as main factors. There were two levels for water temperature (12 °C and 22 °C) and five levels for potassium dose (0, 25, 50, 100, and 200 ppm). The 12 °C and 22 °C temperature treatments were created via a water bath using flow-through chillers, aquarium heaters, and plastic wading pools. We used 0 ppm potassium as a negative control and 200 ppm potassium as a positive control, expecting little to no mortality over the experiment at the 0 ppm dose and relatively fast and 100% mortality at the 200 ppm dose. There were five replicates for each treatment combination (total of 50 experimental units).

Each replicate was a mason jar containing ten zebra mussels and aerated with aquarium bubblers. Mussels were collected from the infested reservoir, examined and confirmed live, then sorted into one of 3 size classes. Mussels were assigned at random to each replicate at the ratio of 7 large: 2 medium: to 1 small mussel, and each replicate was in turn assigned at random to a treatment combination.

For the first 3 weeks of the experiment, the number of mussels in each replicate that were dead and the number that were alive was recorded. The water in each replicate was replaced daily with fresh reservoir stock solutions of water dosed with the appropriate amount of MOP. Each mussel in each replicate was observed to determine whether they were dead or alive. If a mussel exhibited symptoms characteristic of a dead mussel (e.g., gaping and unresponsive), it was removed from the treatment jar and placed into a separate jar supplied with untreated reservoir water (i.e., no MOP, 0 ppm potassium), allowing it to recover. A recovery jar was created for each experimental unit that yielded mussels that appeared dead on a given day. Mussel(s) that appeared dead were allowed to recover for 3 days and then were then observed again to verify their status (dead or alive). Any mussel(s) that had failed to recover (i.e., exhibit symptoms of a living mussel) after 3 days in the recovery conditions were recorded as dead (on the date it was removed from the treatment jar and placed in the recovery jar) and they were removed from the experiment. If a mussel recovered, it was deemed an inaccurate mortality assessment and removed from the experiment. Mussels exhibit levels of “intoxication” when exposed to potassium, where their shells gape and are unresponsive, but will return to normal after being placed in untreated water. Two of the experimental treatments were initially suspected to be dead but recovered after 24 hours. These treatments were re-created with new mussels from the reservoir, and the protocol modified for determination of live vs. dead mussels. None of the mussels recovered after being assessed as dead following the initial misclassification.

In addition to the number of dead and live mussels in each jar, water temperature, dissolved oxygen content, and the pH at the time of the observation were recorded. Also, the length of the shell for mussels that were confirmed to be dead was either measured directly, or the shell was photographed for later size measurement.

After three weeks of daily observations, the time between observations of the remaining live mussels was increased from 1 to 4 days through the duration of the study (total of 45 days). Observations were continued in order to gather information on mortality of mussels subjected to treatments with live mussels remaining (lower temperatures and lower doses), where effects were expected to be delayed.

Summary

Both concentration of potassium and water temperature had considerable effects on mussel mortality. Dose-exposure curves for MOP treatments are presented in Figure 1, and days required to reach complete mortality by treatment are presented in Table 1. Control treatments (0 ppm) at both temperatures did not exhibit any mussel deaths, confirming mortality in treatment jars was caused by the MOP treatment and not an artifact of jar confinement, low oxygen/nutrient levels, etc. The 25 ppm treatments at both temperatures reached nominal mortality (2%) by the end of the 45 day trial.

At concentrations at and above 50 ppm the effects of water temperature were more apparent, with lower temperatures exhibiting slower mortality, likely the result of a slower metabolic rate and less-frequent feeding by the mussels, as they were observed to be generally more tightly shut in their shells at 12 °C vs. 22 °C. The 50 ppm treatment reached 100% mortality in 36 days at 22 °C, whereas the 12 °C/50 ppm treatments topped out at 42% mortality at the end of the 45 day trial. All mussels treated with 100 or 200 ppm potassium attained 100% mortality within the study period. Both concentrations in the warmer water treatments died off more quickly than the cooler water treatments.

These results suggest that eradication of zebra mussels at San Justo reservoir is feasible at 100 ppm potassium concentrations, and should be able to eradicate mussels within the reservoir in just under 30 days, even in the later part of the season when temperatures are low. However, these tests were conducted in artificial environment and may not translate directly to reservoir-scale treatments. Water currents, thermal stratifications, and varying depths may prevent complete mixing of the applied MOP and cause a much longer holding period necessary to achieve the desired concentration throughout the reservoir and result in mussel eradication. Treatment with MOP when water temperatures are higher (late summer-early fall) will likely distribute throughout the reservoir more quickly and hit the mussels while they are more active metabolically, resulting in quicker eradication and potentially less risk of escapes (eradication failure).

A statistical analysis has been performed on the mortality data, and will be discussed in the final report.

Table 1. Days to achieve 100% mussel mortality by potassium concentration and water temperature. Treatments with missing values did not reach 100% within the study period.

Treatment Concentration (ppm K)	Treatment Temperature (°C)	Days to 100% Mortality
0	12	-
25	12	-
50	12	-
100	12	25
200	12	17
0	22	-
25	22	-
50	22	36
100	22	8
200	22	6

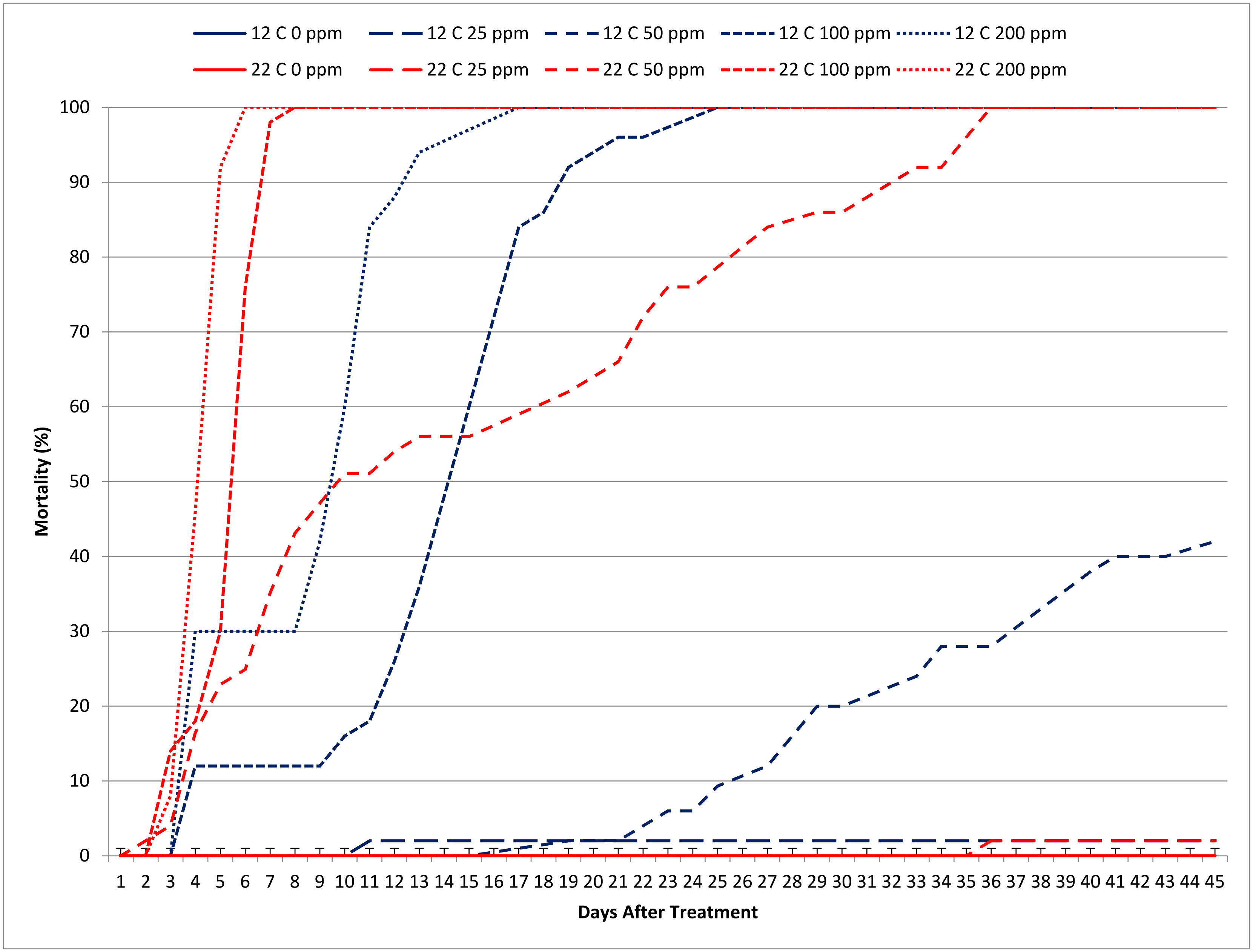

Figure 1: Mean dose-exposure curves for mussels treated with potassium at 12° C and 22°C.