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Managing Water in the West

Factors Affecting the Spread of Dreissenid Mussels in Western Reservoirs

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Background

- Reclamation had been using substrate sampling to look for mussels since the 1990s
- Adult quagga mussels were discovered in Boulder Basin, Lake Mead, in January 2007
- Reclamation's Technical Service Center (TSC) started early detection monitoring in Lake Mead in March 2007, and at other locations, primarily along the Colorado River, in May 2007
- Reclamation found veligers along the entire length of the Colorado River by May 2008, with positive detections at most sites on the initial sampling dates



Initial Reclamation findings in the Colorado River

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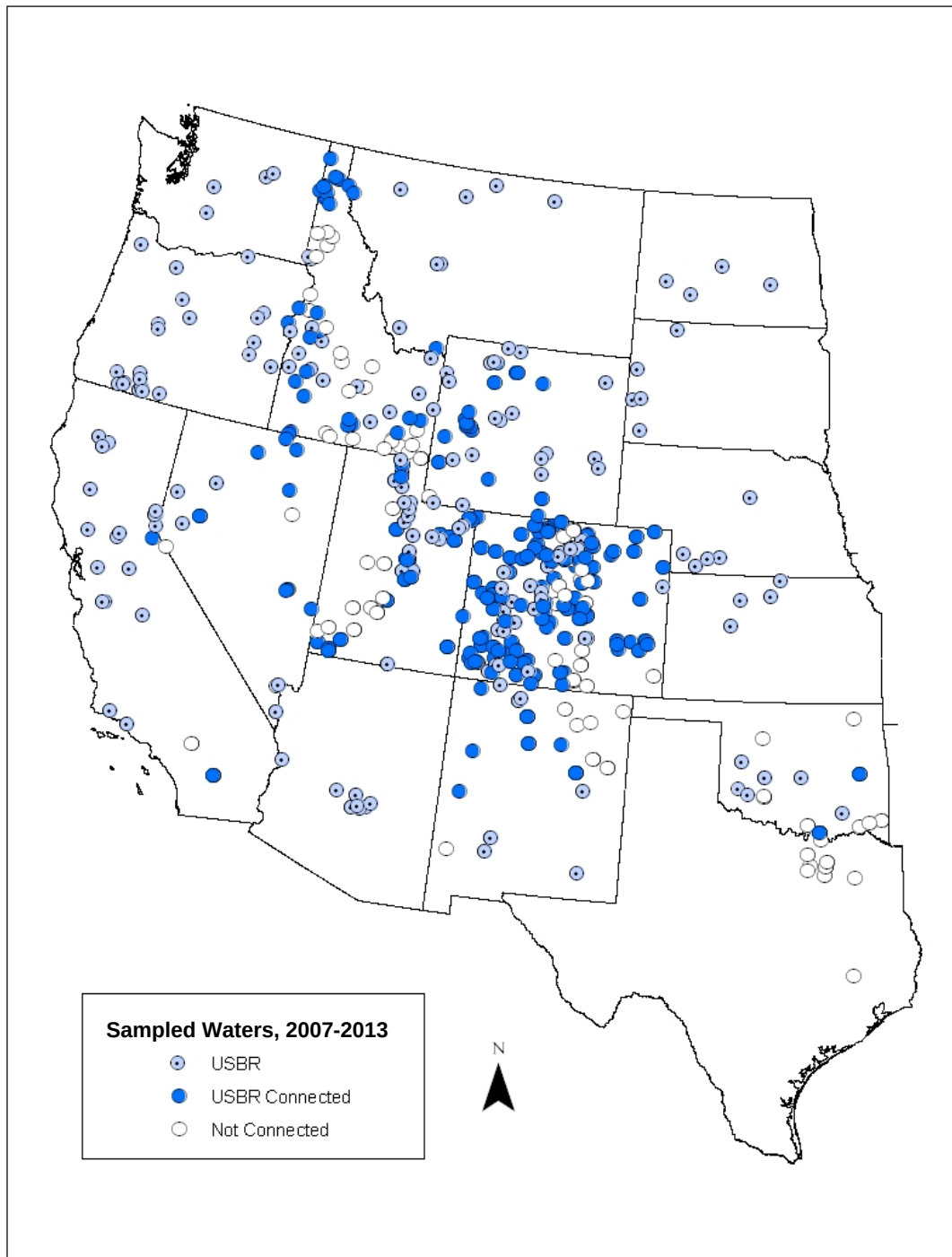
ARRA Monitoring Program

- Reclamation received funding from the ARRA program in 2009 for early detection monitoring for dreissenid mussels
- Originally intended for 60 priority reservoirs in the western states
- 60 priority reservoirs, 48 additional Reclamation water bodies, and 44 additional waters were sampled in 2009
- 1592 total samples analyzed in 2009 by microscopy, including 1266 ARRA samples, with positive samples further analyzed by PCR

Sampling Locations 2007-2013

**15 States have
collaborated in this
program**

**To date, 12,652 samples
have been analyzed at
over 1,900 separate
locations in 425 water
bodies in cooperation with
state and local partners**



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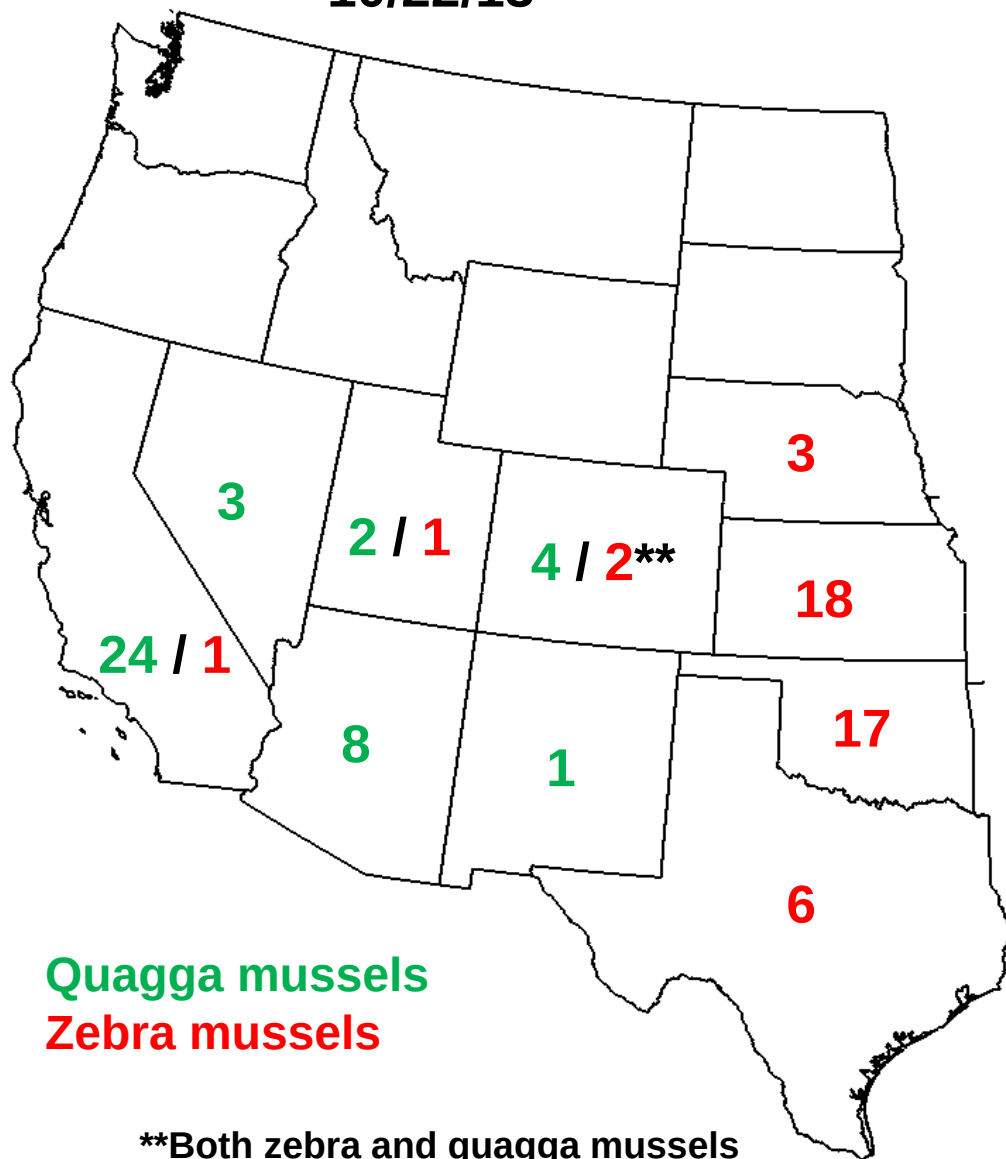
Reclamation's Approach

- **Cross-polarized light microscopy (CPLM) is the primary detection method – it has been the most sensitive and reliable detection method for over 25 years**
- **Scanning Electron Microscopy (SEM) is used for positive CPLM samples to reduce questions about identification**
- **Polymerase chain reaction (PCR) sensitivity has been improved and is also used as further confirmation**
- **Gene sequencing is used to confirm PCR results and to identify the species present**

Issues with Early Detection

- Differences in both sampling and analytical methodology can result in different results from different labs
- Some differences should be expected
 - Veligers are not always present
 - Most introductions do not result in permanent populations
 - The number of organisms present is very low
- False negatives are common, especially with q-PCR (E-DNA) methods

Locations from USGS, 10/22/13



Quagga mussels
Zebra mussels

**Both zebra and quagga mussels
detected in Lakes Granby and
Pueblo

Additional Reclamation Locations (1st Detection)

AZ – 4 (Aug 2008)
CA – 4 (Mar 2008)*
CO – 9 (May 2008)
ID – 2 (Aug 2011)
KS – 2 (Jul 2003)
MT – 2 (Aug 2009)
NE – 1 (May 2009)
NM – 4 (Jul 2010)
NV – 5 (Mar 2007)
OK – 2 (Jul 2008)
OR – 2 (Aug 2011)
UT – 9 (Jul 2007)
TX – 0 (Apr 2009)

*First detected by state
or other agency

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How Many Samples are Positive?

- **11,683 samples analyzed from 2009-2012**
- **419 samples (4%) were positive**
- **These numbers do not include known positive locations (i.e., Lake Mead)**
- **In Lakes Mead and Mohave, nearly all veliger samples were positive within a year after the discovery of adult mussels.**

Where Were 1st Time Positive Samples Found?

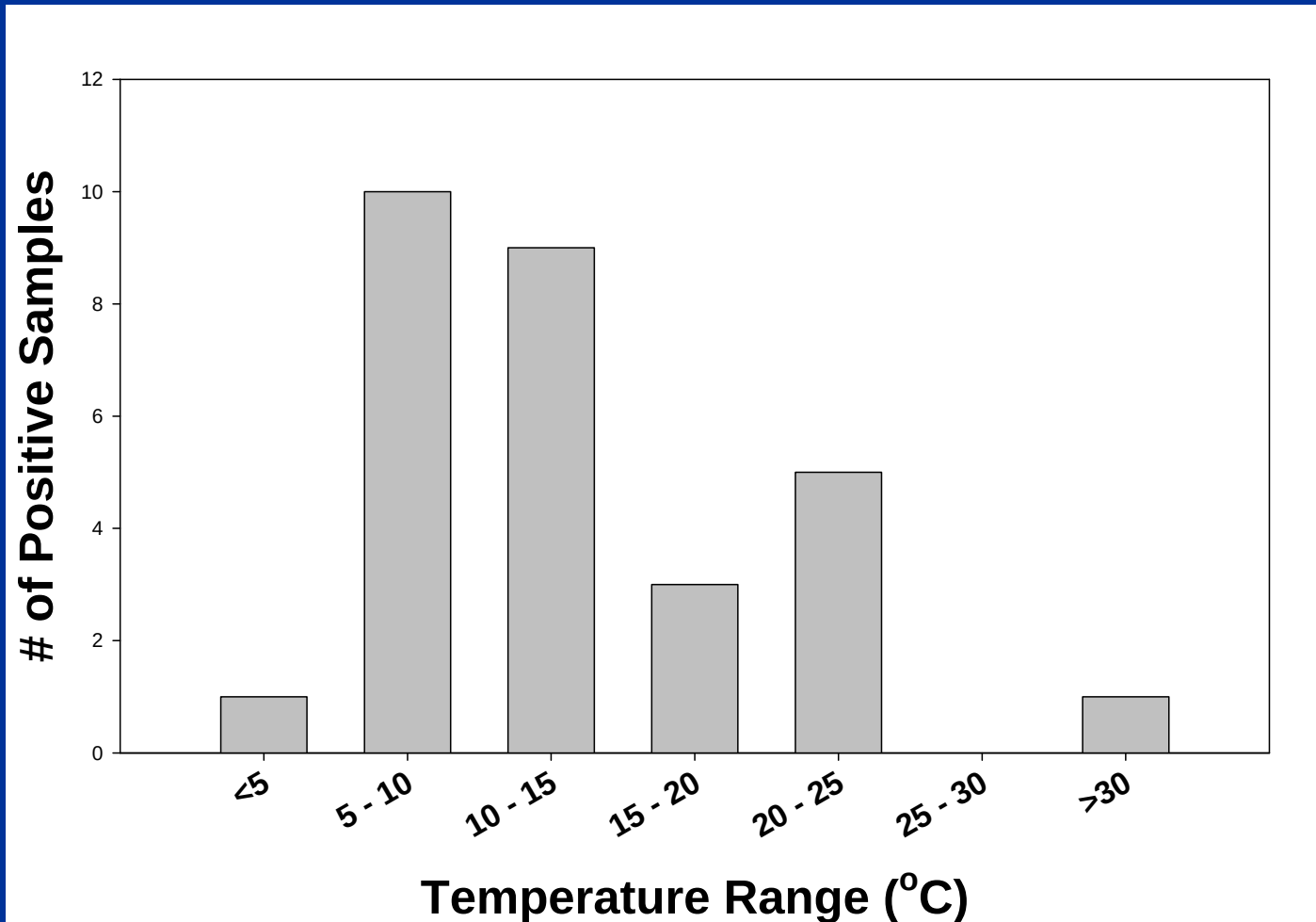
- Near dams - 15 %
- At a marina or boat launch - 60 %
- Midlake - 23 %
- Other locations - 2 %

(Based on all samples through spring 2013)

Environmental Conditions Where Veligers Were Found

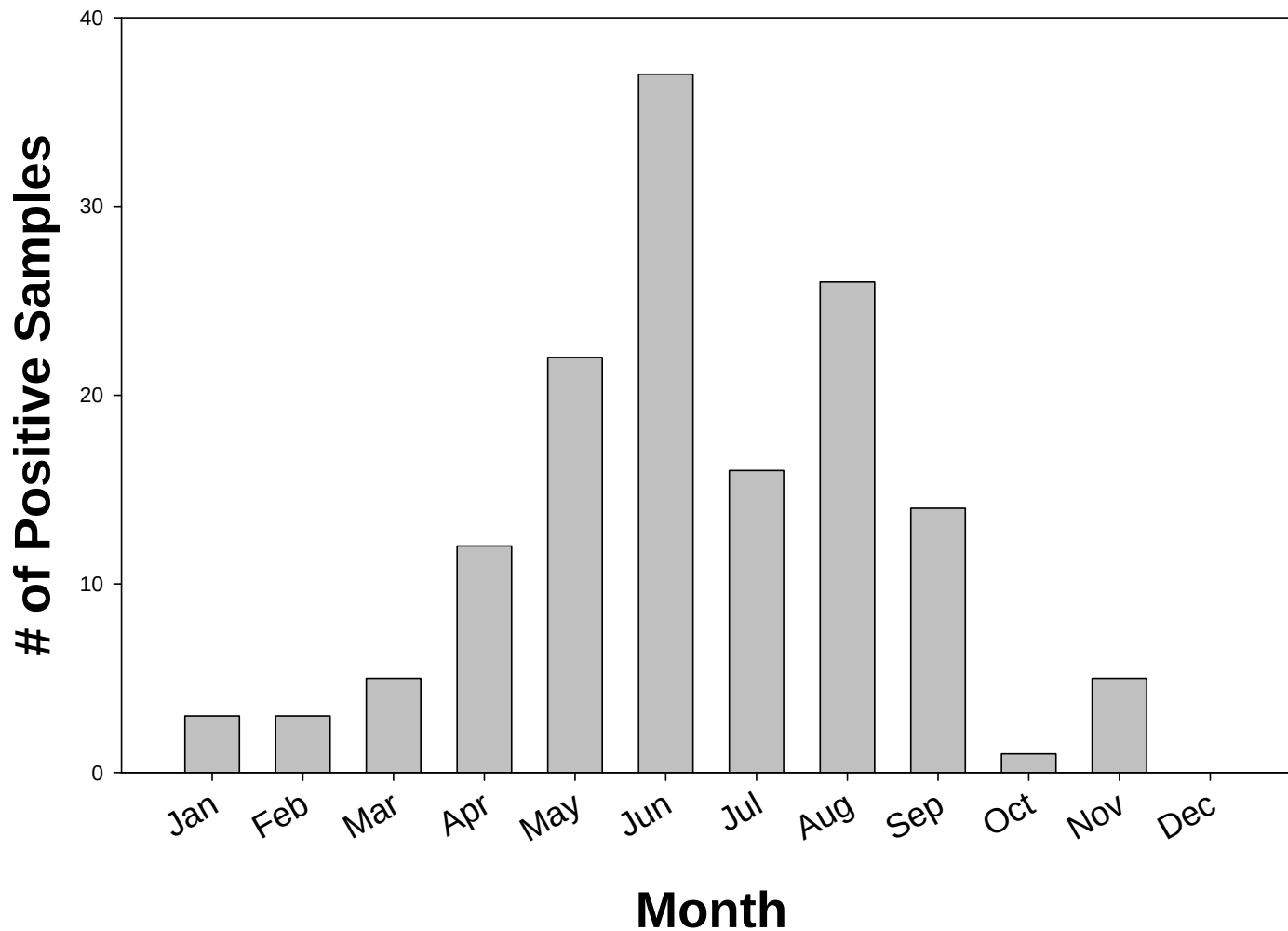
- **Temperature: 4.45 – 31.08 °C**
- **Dissolved oxygen: 74.1 – 164% sat.**
- **pH: 7.67 – 9.00**
- **Conductivity: 35 – 4191**

Temperatures for Positive Detections



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Positives by Month



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Case Study: Lake Mead

- Analysis of the size and distribution of adult mussels indicated that the initial introduction probably occurred 3-5 years before adults were first noticed in 2007
- Veligers were detected by microscopy in 58 % of all Lake Mead samples in 2007, 88 % in 2008, 90 % in 2009, 94 % in 2010, and 93 % in 2011
- Western lake managers incorrectly extrapolated these results to other systems

Case Study: Lake Powell

- Reclamation found veligers in 3 samples (with 1 additional suspect) collected at 8 locations on 5 separate dates in 2007, with 3 samples confirmed positive by PCR
- These results were later deemed false positives by the state of Utah
- Veliger sampling results were negative for 3/3 samples in 2008, 13/14 samples in 2009, 10/10 samples in 2010, and 13/13 samples in 2011

Case Study: Lake Powell

- 19/39 samples in 2012 were positive by CPLM (6), or PCR (12), or both (1), with positives found by both Reclamation and the NPS lab in Utah
- Veligers were found from April through November at locations throughout the lake
- Utah's PCR contractor got negative results for ALL samples in 2012
- Hundreds of adults were found throughout the lake in 2013 although 22/24 veliger samples were negative

Conclusions

- Early detection monitoring may be able to provide at least a 3-5 year advance warning period before infestations become severe
- Conventional wisdom has NOT been a good guide for veliger monitoring
- Most lakes do not behave like Lake Mead – negative results do not mean mussels are not present



Photograph by Bryan Moore, NPS

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