

# Adult quagga survival & potential reproduction in Lake Tahoe: low risk or reality?

Dr. Sudeep Chandra & Dr. Marion Wittmann



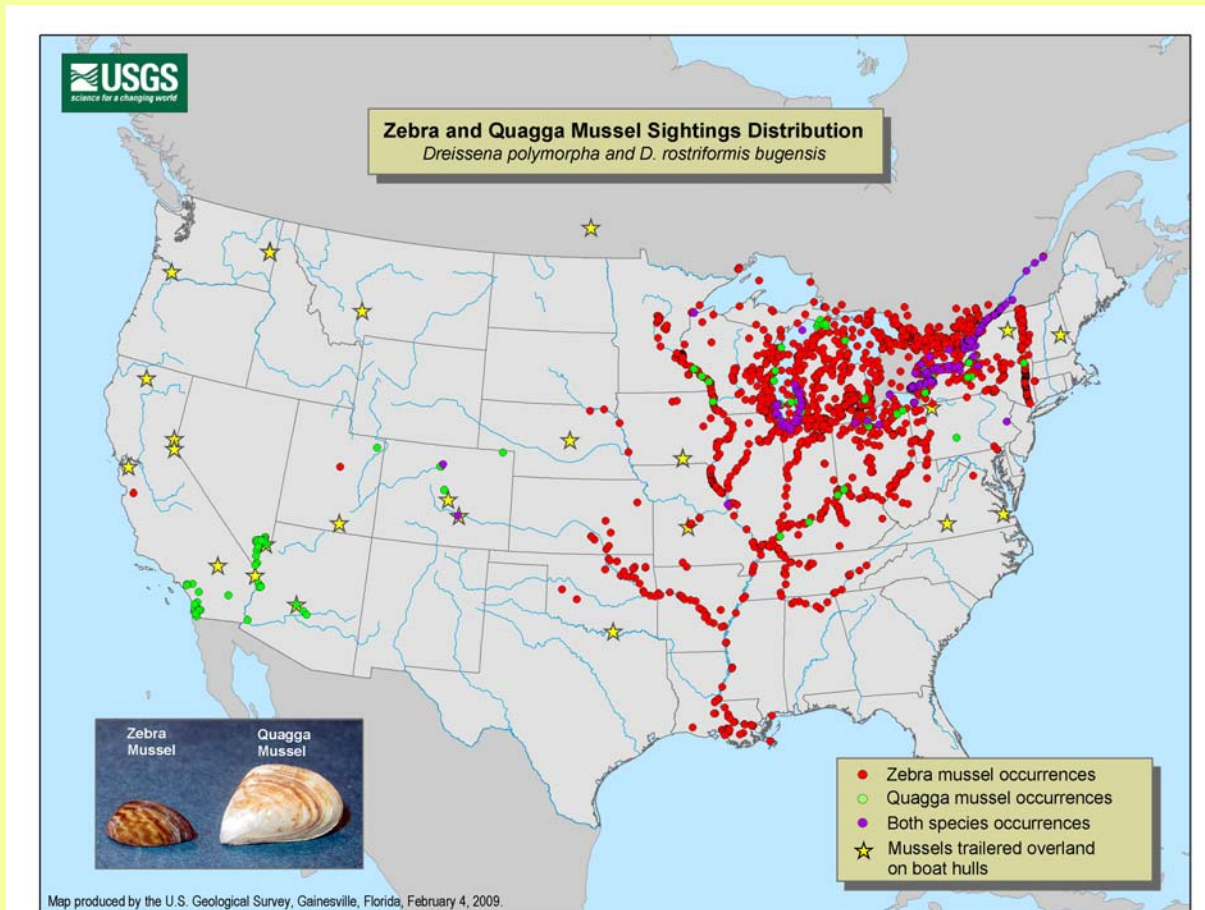
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# Special thank you

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  - Geoff Schladow, UC Davis Tahoe Environmental Research Center
  - John Reuter, UC Davis Tahoe Environmental Research Center
- **Field assistance and access**
  - Rita Whitney, Tahoe Regional Planning Agency
  - Tahoe Keys Marina

# How did we get here?

- Quagga rapidly spreading throughout the western US
- No confirmed locations in Northern CA/NV lakes; there have been attachments on boats in the area

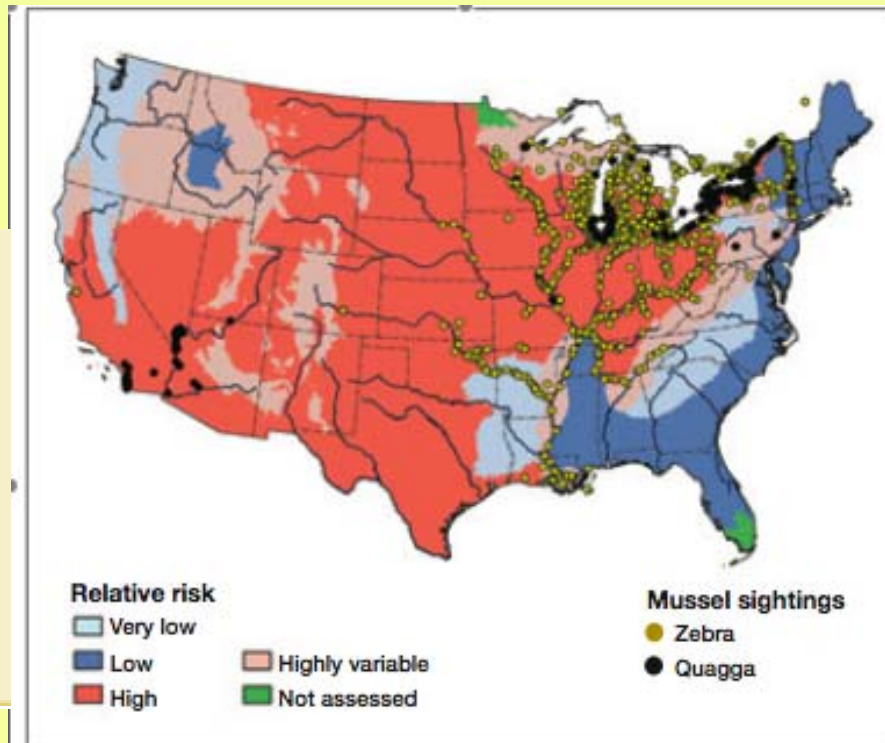


# How did we get here?

- May 2007- Lake Tahoe's 1st Aquatic Invasion Workshop
- 2007 Formalized the Lake Tahoe's Aquatic Invasive Species Working Group
- March/ April 2008- Discussion whether or not quagga could establish in Lake Tahoe's low calcium waters
- Whittier et al. 2008 suggests low risk based on calcium levels

**Table 1. Ecoregional risk classifications based on calcium concentration sample statistics in US streams and rivers (USEPA EMAP unpublished; USEPA WSA 2006)**

Risk class	Distribution of calcium concentrations at sites
Very low	75th percentile $< 12 \text{ mg L}^{-1}$
Low	$12 \text{ mg L}^{-1} \leq 75\text{th percentile} < 20 \text{ mg L}^{-1}$ or 75th percentile $< 21 \text{ mg L}^{-1}$ and maximum $< 28 \text{ mg L}^{-1}$
High	mean $\geq 28 \text{ mg L}^{-1}$ and 25th percentile $> 12 \text{ mg L}^{-1}$
Highly variable	$\geq 15\%$ of sites with Ca $< 12 \text{ mg L}^{-1}$ AND $\geq 15\%$ of sites with Ca $\geq 28 \text{ mg L}^{-1}$



**Figure 2.** Dreissena invasion risk classes for ecoregions of the contiguous US based on calcium concentrations in streams and rivers. Depending on watershed characteristics, some portions of the highly variable ecoregions will be at high risk, while others will be at very low risk. Dots indicate zebra mussel and quagga mussel observations through March 2008. (Note in press: this figure has been updated from the version available on Frontiers' e-View; mussel sightings have been added to the map.)

- Research of another invader (NZ mudsnail) suggested 5-40% short term survival in Lake Tahoe

# How did we get here?

- Adopted a “need to know” approach since once established quagga can not be controlled
- Data gaps included calcium information gaps along the nearshore where introductions are likely to occur
- October 08- Quagga potential establishment at Lake Granby (calcium levels similar to Lake Tahoe)

# Project questions?

Quagga potential survival, growth, and establishment questions:

- Based on previous calcium based, risk models what areas of Lake Tahoe may exhibit survival?
- Bonus question: based on previous calcium based, risk models what areas in the local region may exhibit survival?
- What is the survival and growth of adult quagga in Lake Tahoe water?
- What is the reproductive potential after living in lower calcium waters?
- What potential water quality impacts may occur due to quagga establishment?

Asian clam and quagga interactions

- Bonus question: Will Asian clam beds infesting Lake Tahoe facilitate the establishment of quagga?

# Approaches

To determine survival, growth, and water quality

- Semi natural laboratory experiment using Lake Tahoe water (52 days)
- Adult quagga obtained from Lake Mead and fed daily rations of Tahoe Keys water (1 mussel/ 5 gallon bucket)
- Experiment maintained at a constant temperature & monitored twice per day for temperature, dissolved oxygen, specific conductivity; once per day for calcium, chlorophyll *a*, nutrients- (nitrogen and phosphorus)
- Survival- daily measurement
- Growth- 2 time periods (days 0-36, 36-52, and overall growth period 0-52)
- Water quality impacts (chlorophyll *a* and nutrient recycling) at end of experiment (48 hour depletion experiment)

# Approaches

To determine areas of potential risk based on calcium levels

- Nearshore sampling at 1 mile increments from Lake Tahoe
- Boat ramps and fishing access points from other regional water bodies
- Run off (May) & non runoff periods (October)

To determine if Asian clams can facilitate quagga establishment

- 1 adult quagga added to Marla Bay sediments containing Asian clams



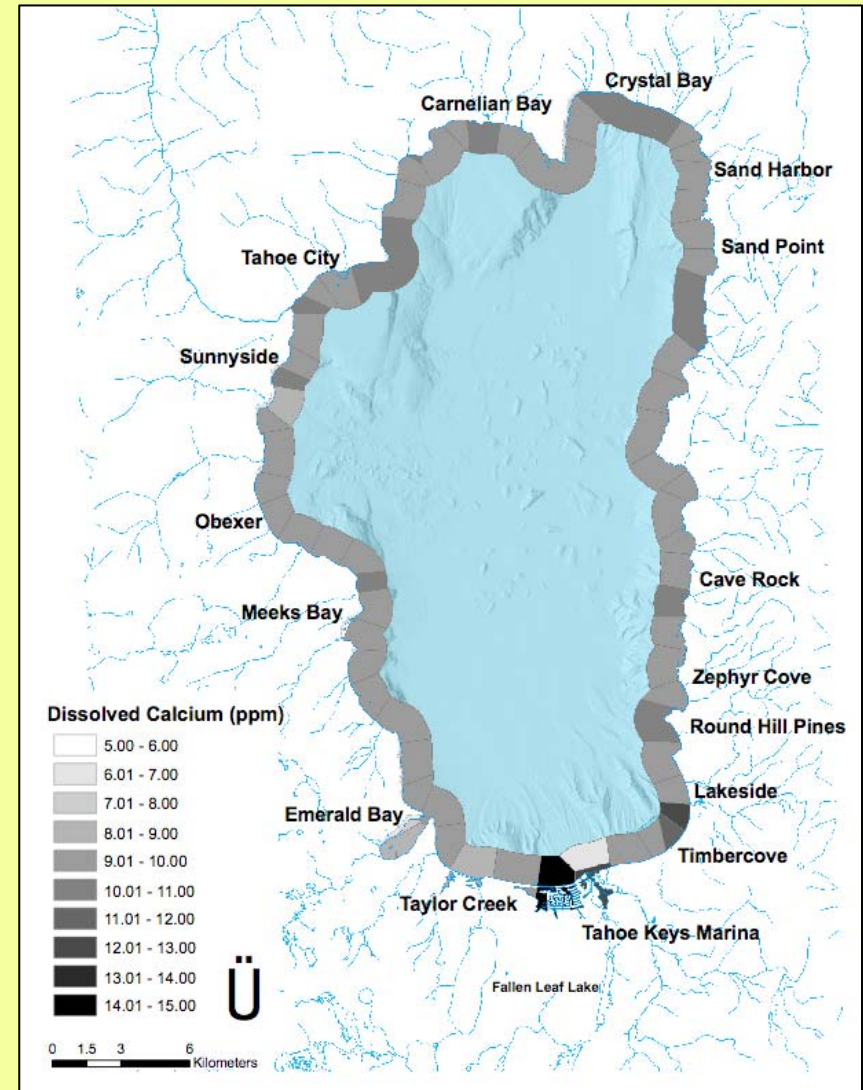
Based on previous calcium based, risk models  
what areas of Lake Tahoe may exhibit  
survival?

# Lake Tahoe calcium levels are variable but low with the greatest levels in the Keys

- Previous calcium based models suggest low to low risk for Lake Tahoe

**Table 1. Ecoregional risk classifications based on calcium concentration sample statistics in US streams and rivers (USEPA EMAP unpublished; USEPA WSA 2006)**

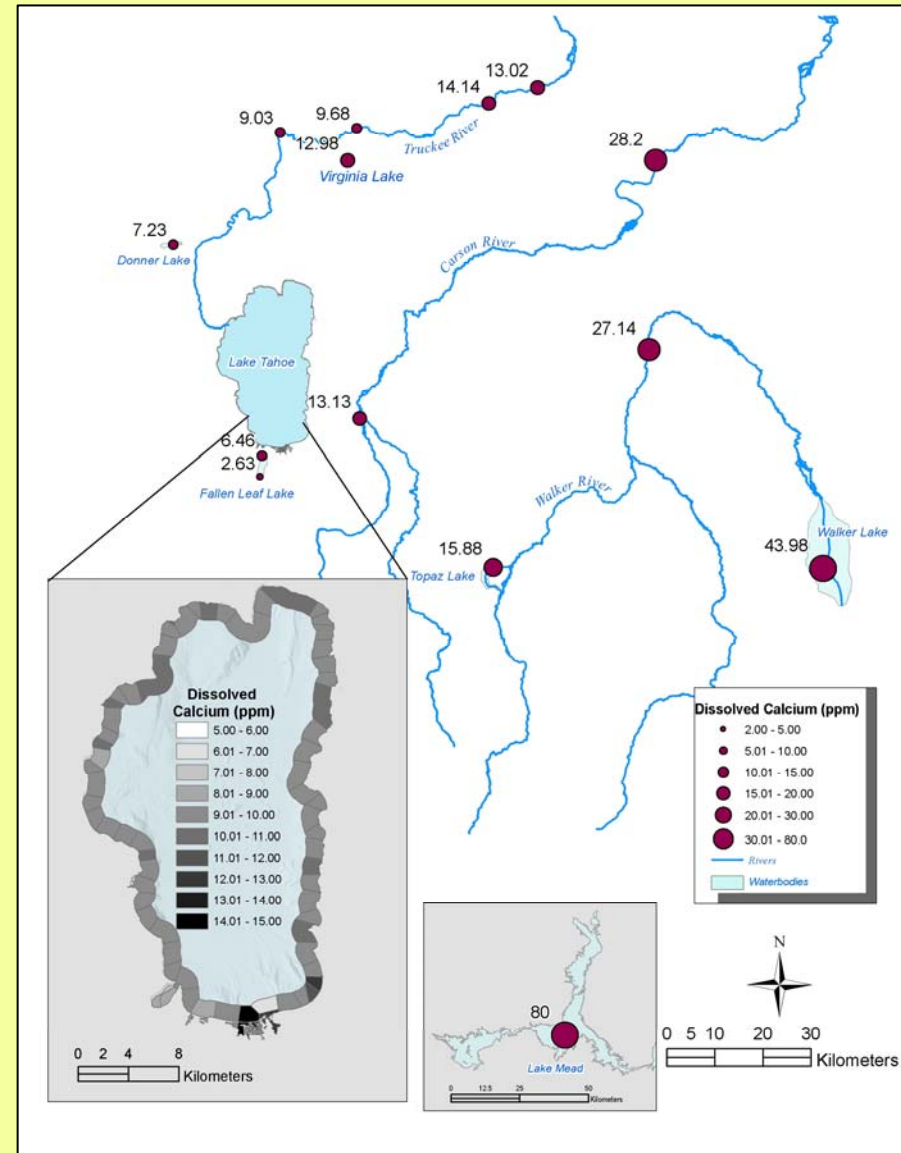
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Bonus question: Based on previous calcium based, risk models what areas in the local region may exhibit survival?

# Eastern slope ecosystems from which boats visit Lake Tahoe exhibit the highest calcium levels

- Previous calcium based models suggest moderate to high risk for Lahontan Reservoir, Walker River, & Walker Lake
- While these lakes do not have quagga, boats arrive to Lake Tahoe from these lakes

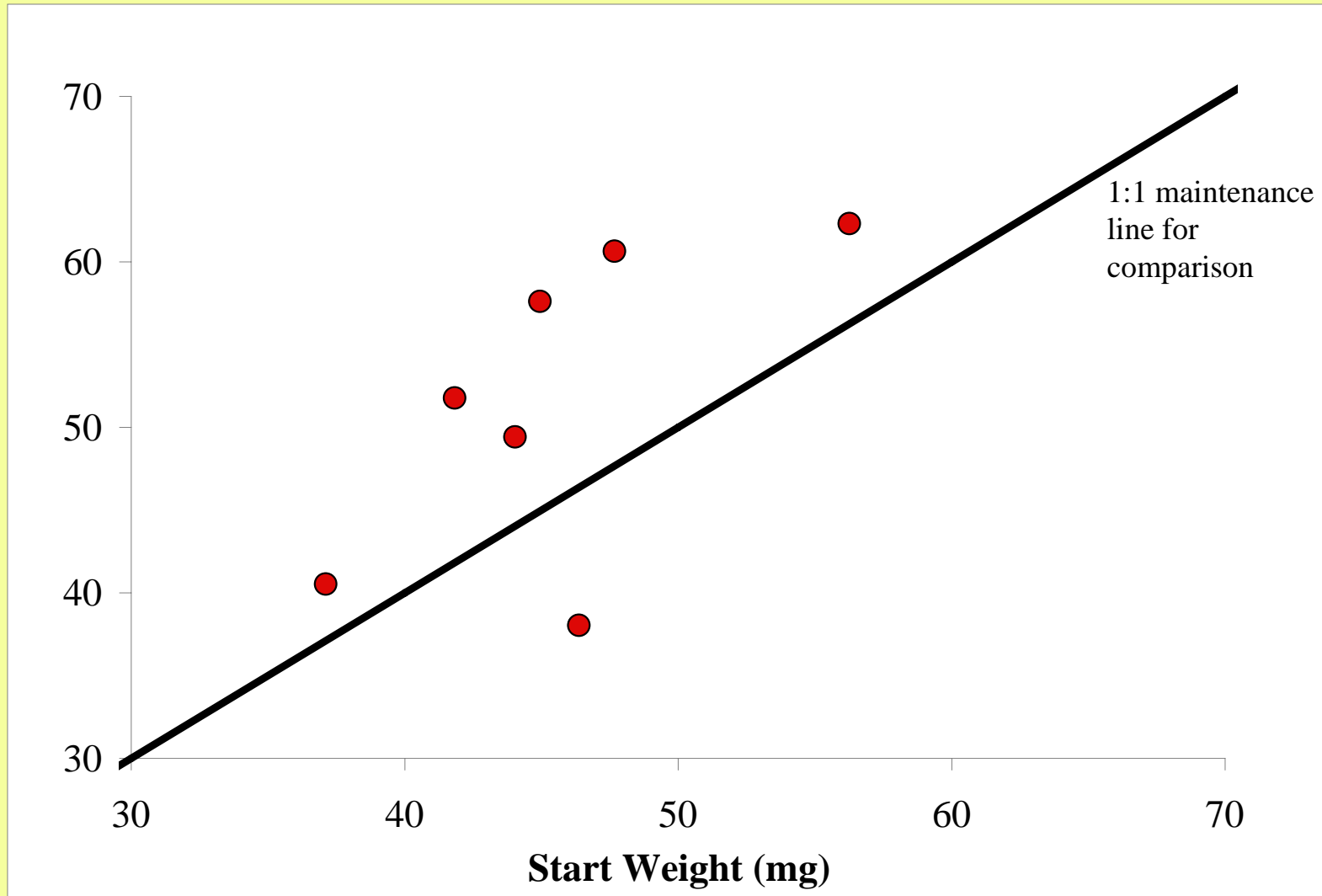


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High	mean ≥ 28 mg L <sup>-1</sup> and 25th percentile > 12 mg L <sup>-1</sup>
Highly variable	≥ 15% of sites with Ca < 12 mg L <sup>-1</sup> AND ≥ 15% of sites with Ca ≥ 28 mg L <sup>-1</sup>

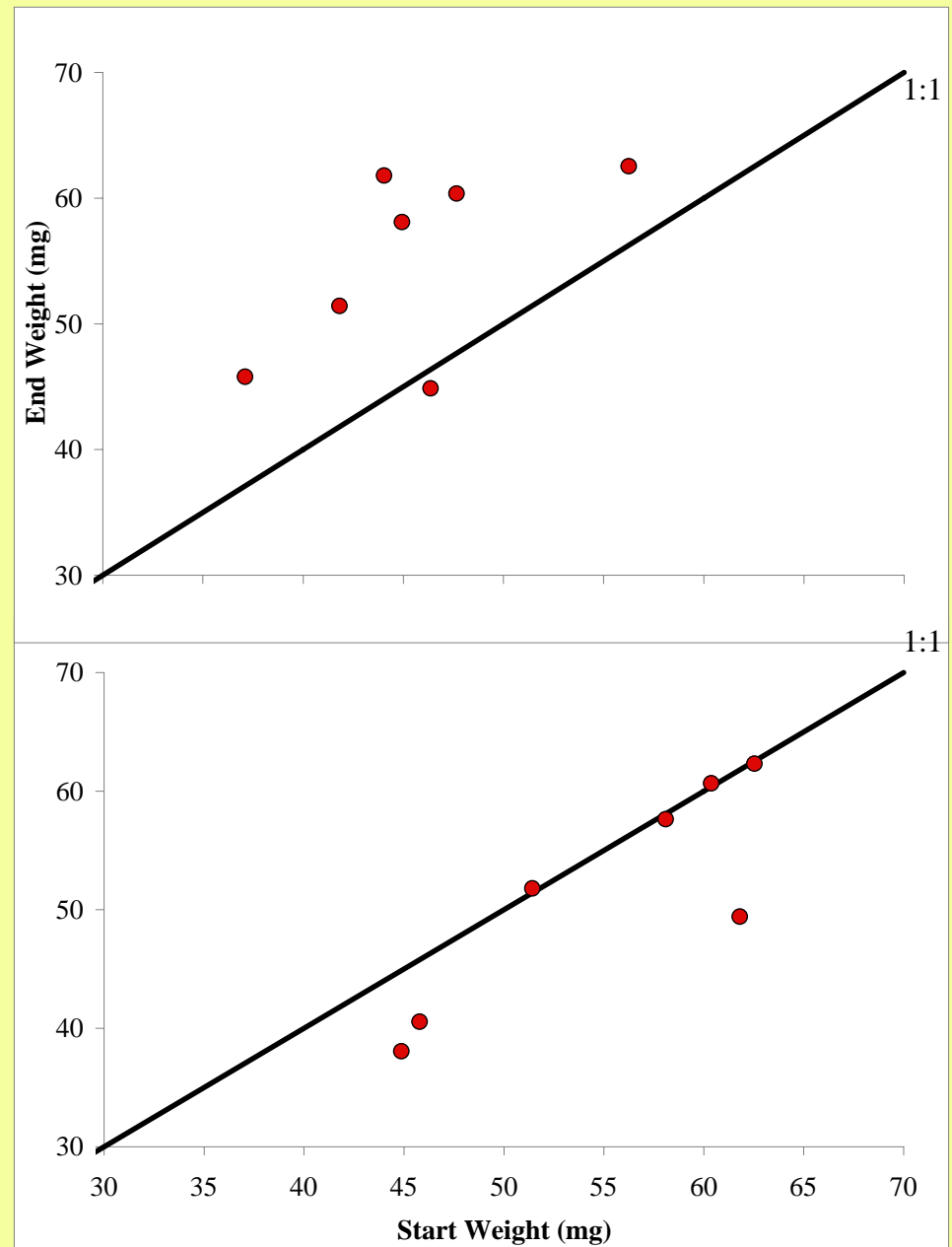
What is the survival and growth of adult quagga in Lake Tahoe water?

86% survival over 52 days with positive growth over the project period



# Growth is positive but slowing over time

- Days 0-36 exhibit strong positive growth
- Days 36-52 are slowing in their growth but still positive
- Long run survival in question?  
No. pattern found with other invertebrates and quagga growth rates can change over time



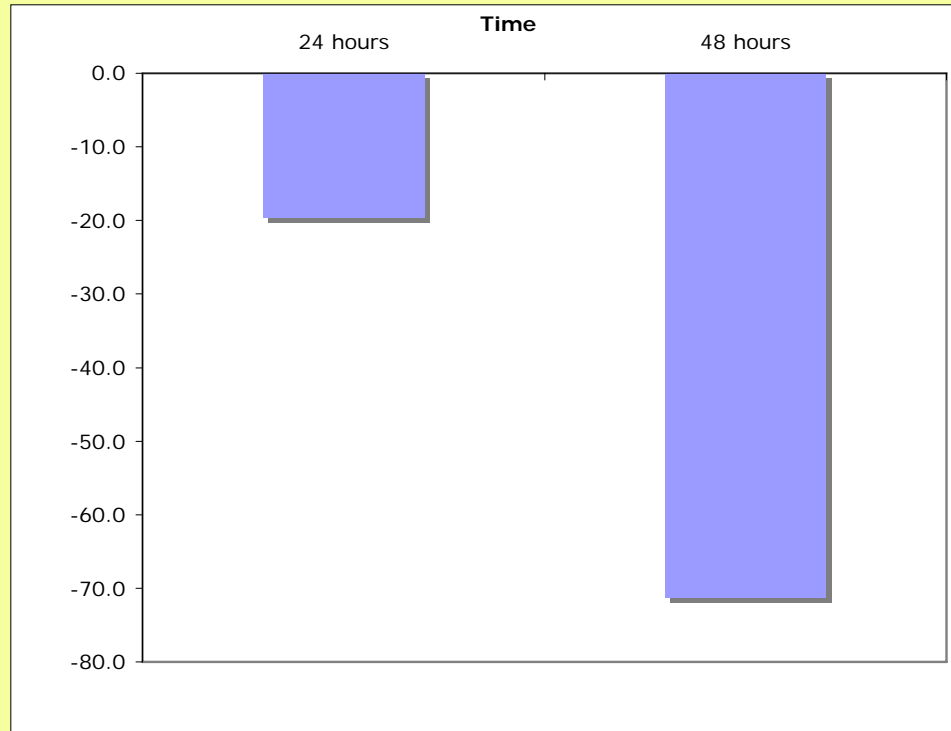
What is the reproductive potential after living  
in lower calcium waters?

# 58% of the quagga are mature or have spawned

<b>Gonad stage</b>	<b>No. of Quagga after 52 days</b>
Early development/ very immature	2
Intermediate	1
Mature sperm or oocytes	3
Post-spawn	1

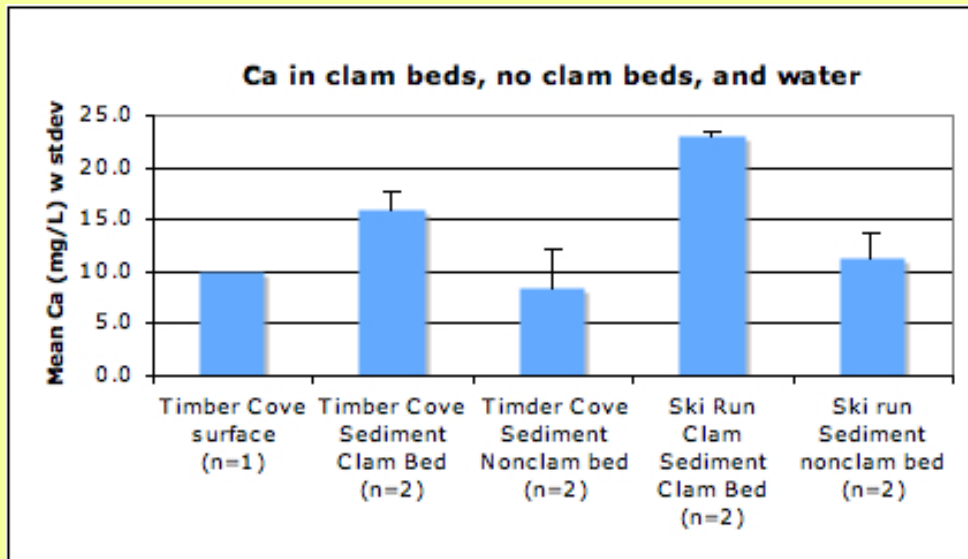
What potential water quality impacts may occur due to quagga establishment?

# Quagga substantially decrease algal biomass in a short period of time

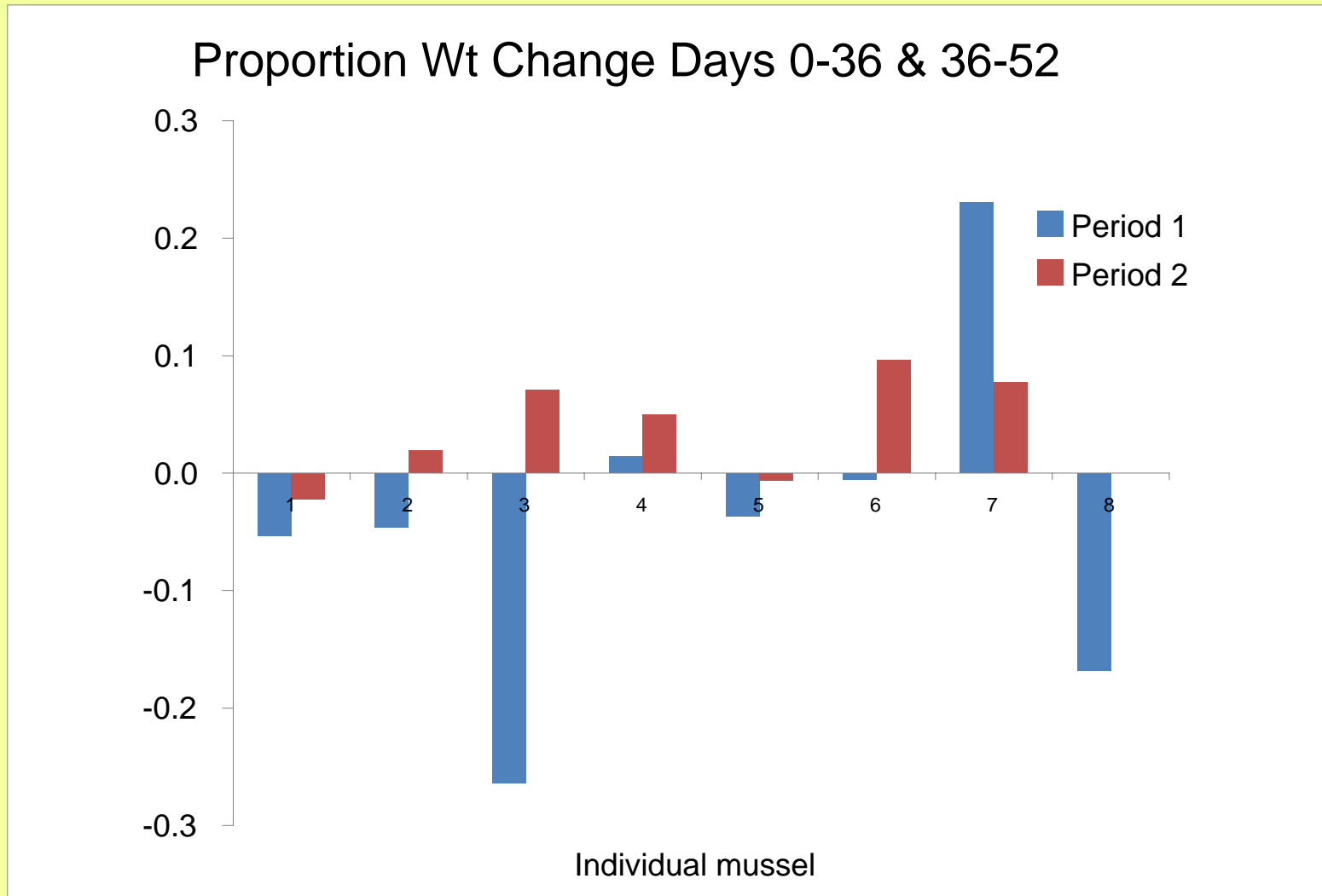


Bonus question: Will Asian clam beds infesting Lake Tahoe facilitate the establishment of Quagga?

Some clam beds are elevated in calcium and provide hard substrate habitat for growth



# Quagga mixed with clams appear not to be doing well... Experimental issue of not enough food



# Conflicting information or cautionary management practices?

- Previous calcium based models suggest low to low risk survival in Lake Tahoe water
- Our results suggest
  - 86% survival over 52 days
  - Positive but changing growth
  - Potential for reproduction or at least holding onto developed gametes in low calcium waters
- Previous models are incorrect or at the least need to be developed further for conservation purposes
- Risk of adult survival is likely in waters of Lake Tahoe (5-15 ppm calcium with sediment beds of Asian clams at 20+ ppm)
- Argument for cautionary management practices and the urgent need to prevent infected boats from arriving at Lake Tahoe

# So are you depressed?

- You should not be!
- No invasions yet!
- Boat washing programs are being implemented
- Information needs are still urgent
  - Adults may survive but will veligers under low calcium?
  - Conduct a veliger growth assay with Tahoe water
- Regional approach to invasions
  - Need to make sure state officials are working towards a regional solution
  - Tahoe is clearly a lead example in the west of how science is shaping invasion policy
  - Spread the word