Conductivity Limits Survival and Growth of the New Zealand Mud Snail from the Upper Owens River

David Herbst
Michael Bogan
Rob Lusardi

Sierra Nevada Aquatic Research Laboratory
University of California

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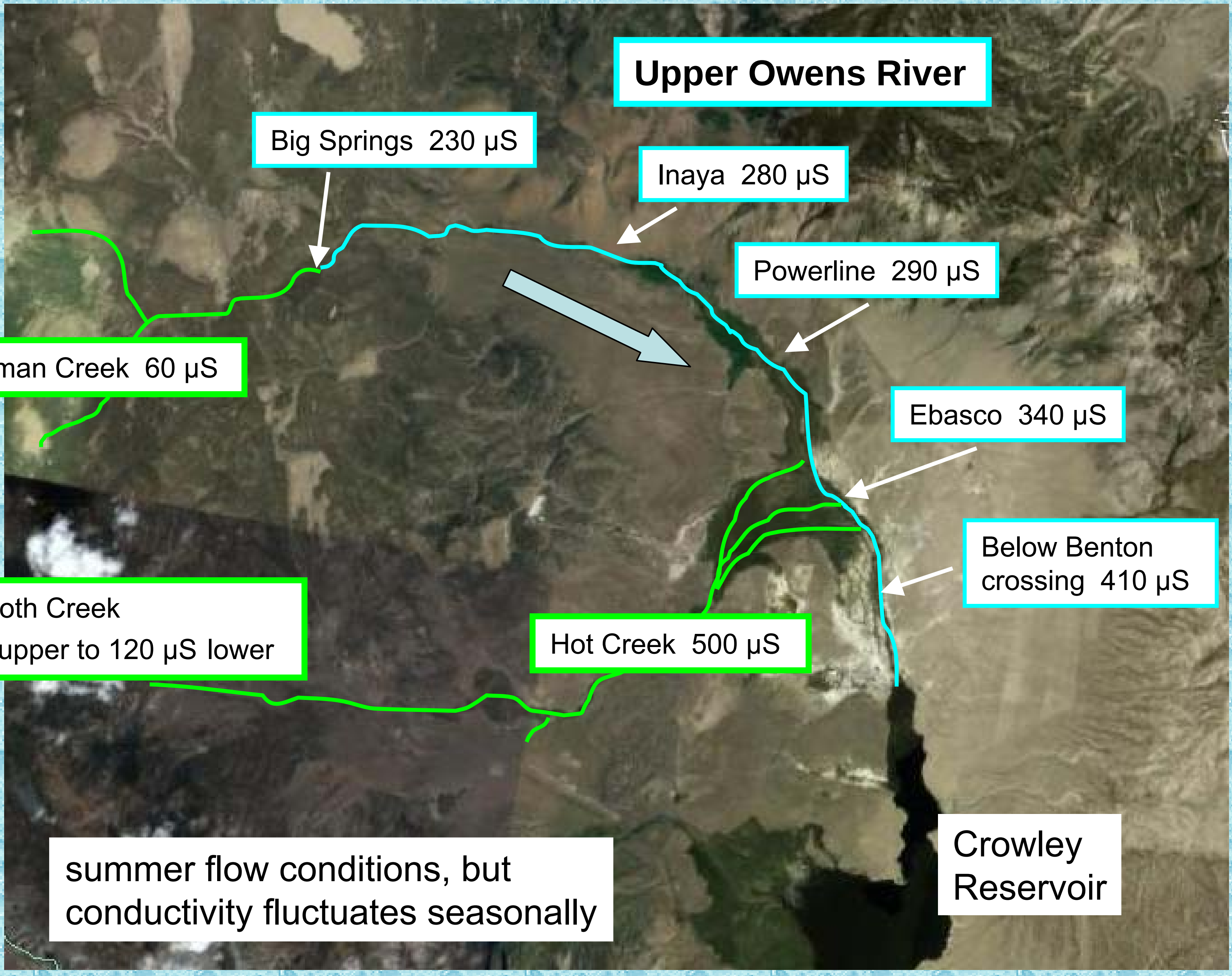
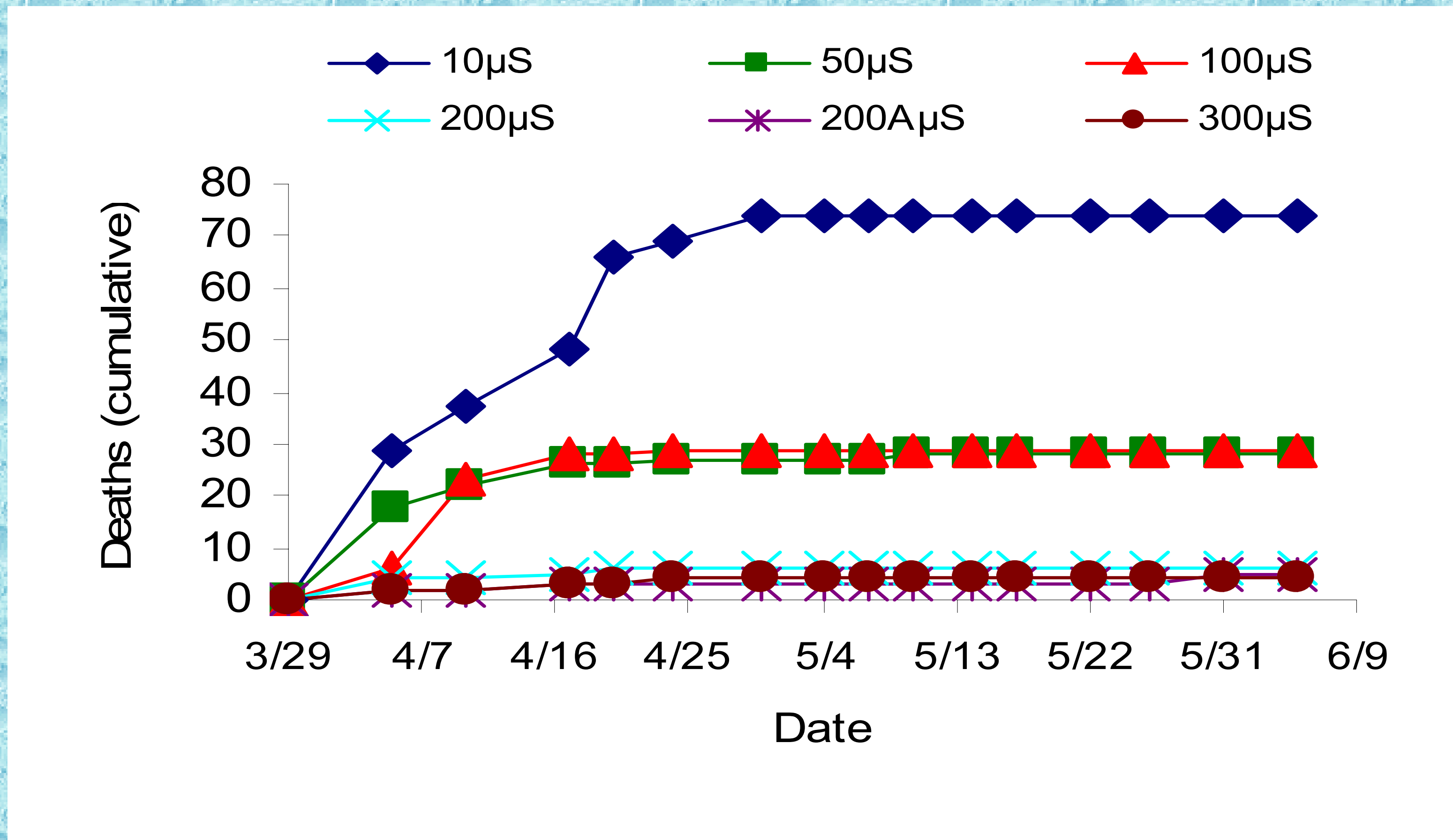

Upper Owens River
Big Springs 230 µS
Inaya 280 µS
Powerline 290 µS
Ebasco 340 µS
Below Benton crossing 410 µS
Hot Creek 500 µS
Deadman Creek 60 µS
Mammoth Creek
50 µS upper to 120 µS lower
Crowley Reservoir
summer flow conditions, but conductivity fluctuates seasonally

Experimental Methods

- Uniform size class of snails (~1 mm) selected from field collections to begin experimental cohorts (from Upper Owens at Benton Xing)
- Dilutions of Upper Owens river water to final conductivities of 10, 50, 100, 200, 300 µS (plus 200 µS artificial Ca-free river water to test for mineral limitation independent of osmotic effect)
- 200 snails / treatment, used for survival and growth experiments over >2 month time period (set up in Petri dishes)
- Periphyton collected and placed into culture for weeks ahead of experiment, removing any remnant snails, with equal amounts used to start each treatment replicate
- Treatment water replaced frequently (every 3-4 days) and algal food never depleted, mortalities removed
- Temperature 15-20 °C over course of experiment
- Shell length from growth harvests made using ocular micrometer, and individual dry mass weighed using Cahn electrobalance (0.1 µg)
- Growth regressions compared with ANCOVA & Tukey HSD tests

NZMS Mortality over 2+ months



No survival at 10
Some mortality at 50 & 100

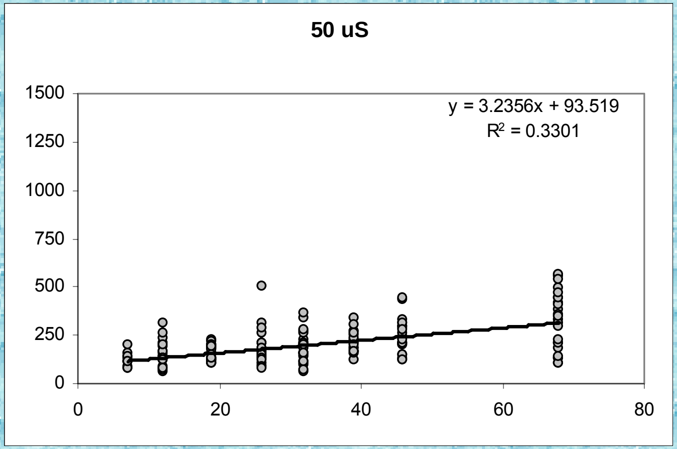
<u>Apparent causes of mortality</u>:

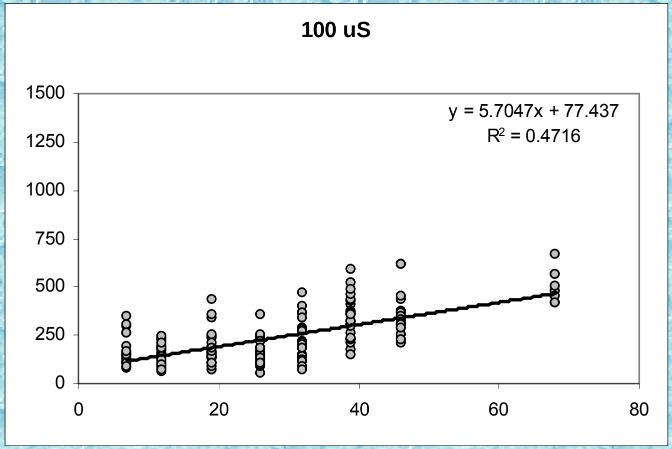
1. **Shell thinning, weakening**
2. **Invasive fungus growth**
3. **Inactivity, no feeding**

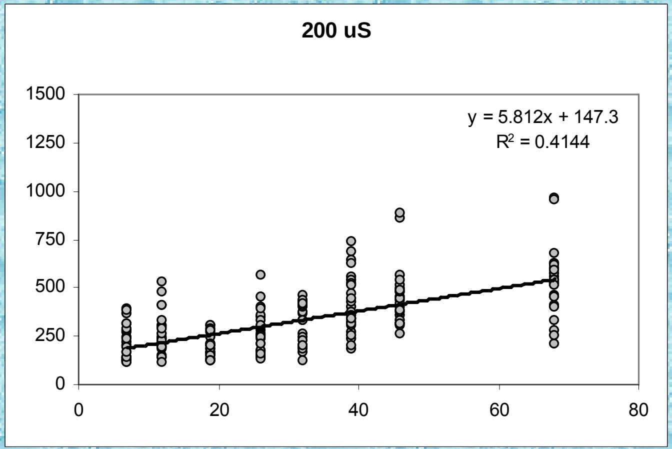
Growth rates of NZMS at varied conductivity

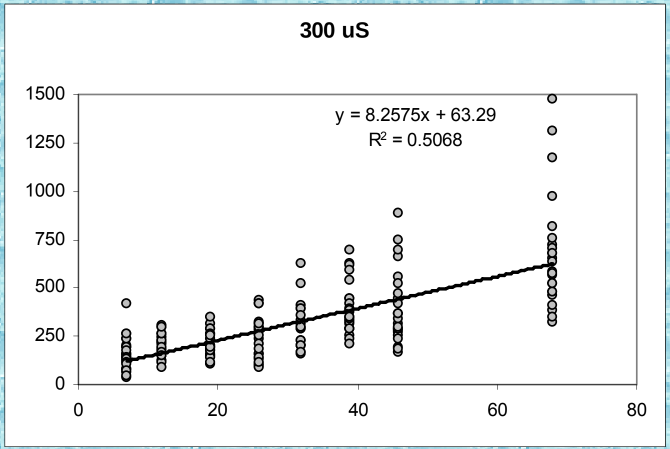
10 µS = no growth   50 < 100 < 200 = 300

ANCOVA, Tukey HSD multiple comparisons $p<0.0001$



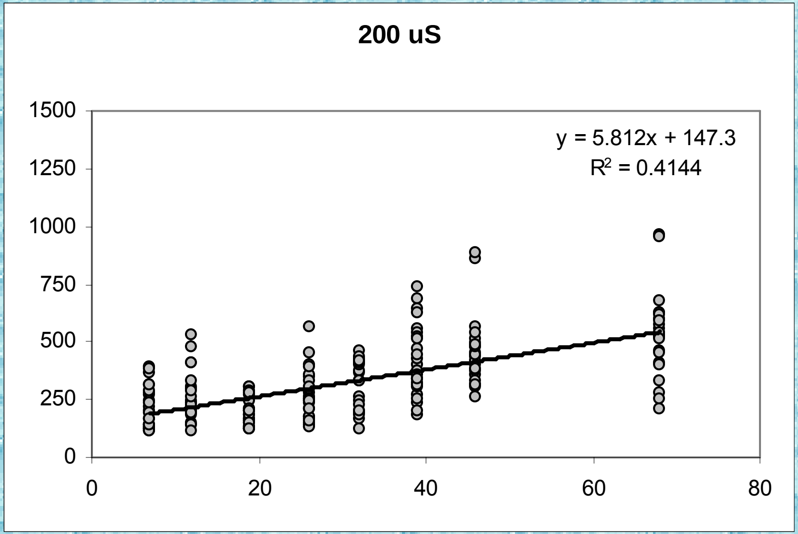


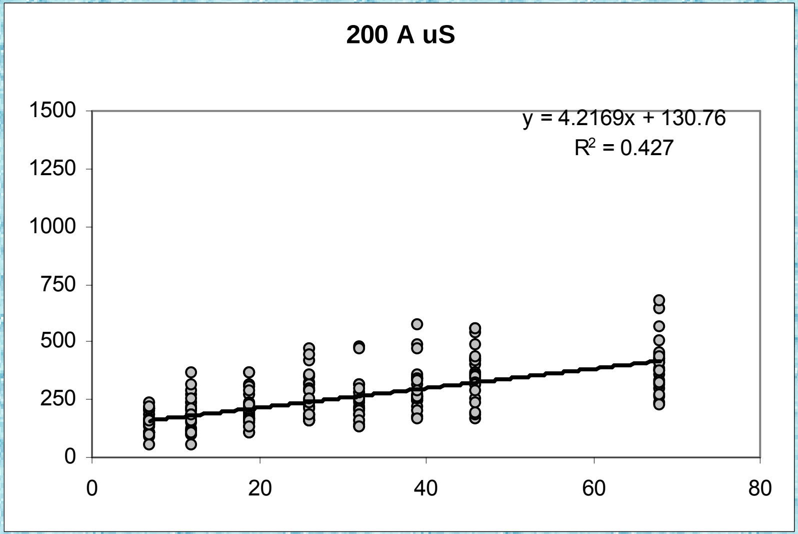




Ca-limitation?
Tested by comparing 200 µS Owens River water to artificial Ca-free river water at 200 µS

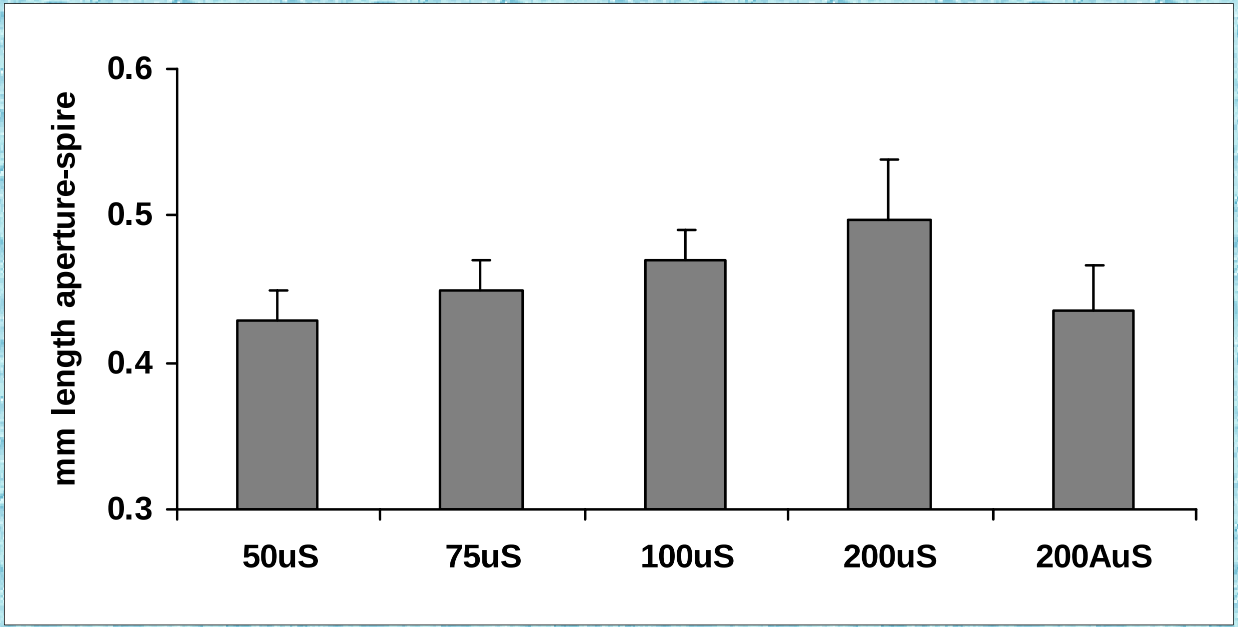
200 A (=100) < 200 natural, p<0.0001





Both Ca-limitation <u>and</u> osmotic stress at lower conductivity indicated (since growth in natural 50 water still slower than 200A)

- Additional experiments conducted with newborn clonal snails, uniform cohorts assigned to 25, 50, 75, 100, 200, 200A μS treatments, for one month
- These expected to be more sensitive, and should be indicative of limits on field populations
- No survival at 25, and growth at 50=75 < 100=200, and 200A equivalent to growth at 50 and 75 (but graded series suggests that long-term growth differences would probably develop over this conductivity range - as indicated in first experiment)



Some examples of dense NZMS populations and associated conductivity

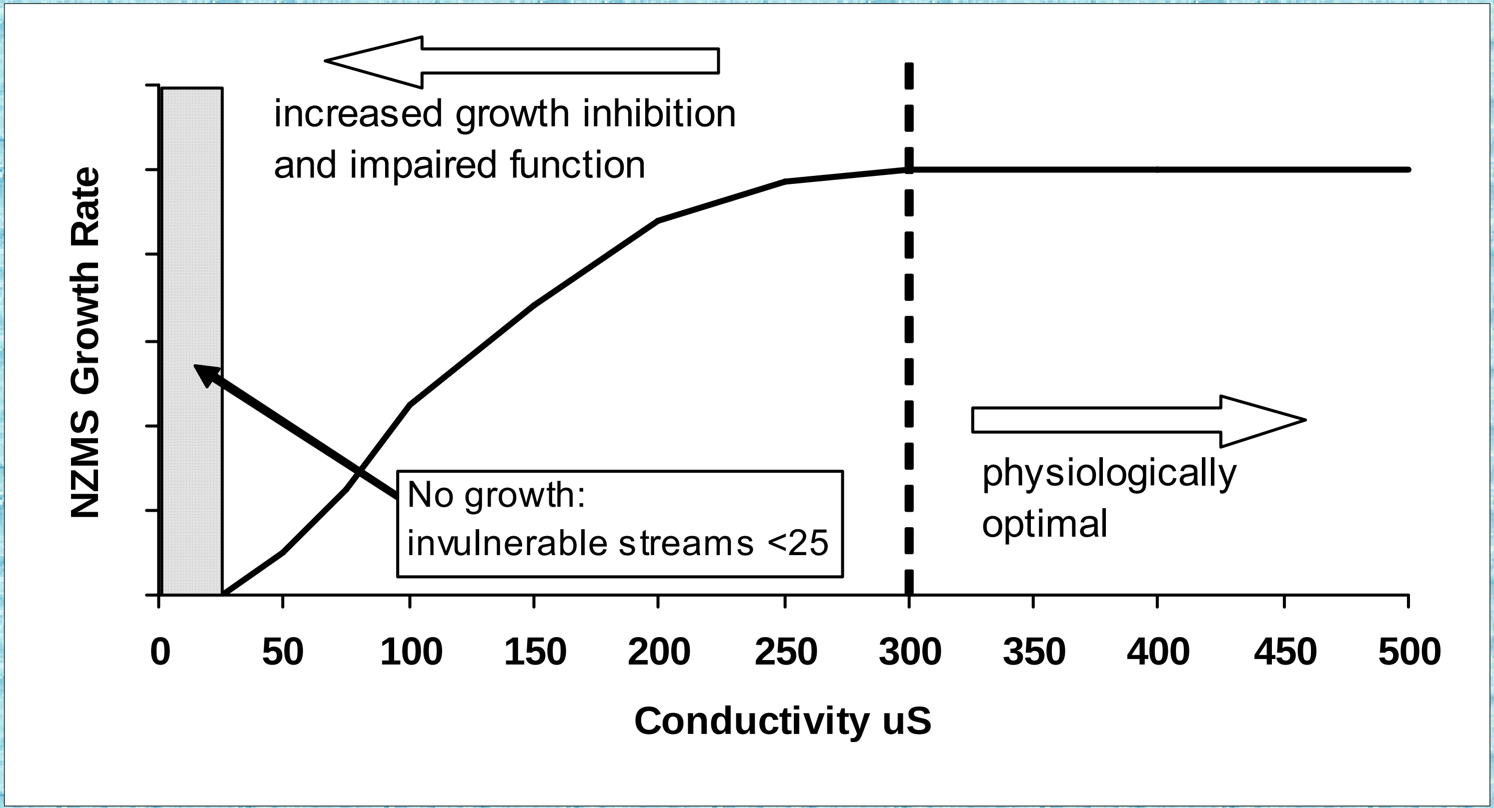
Greater Yellowstone Area: mainly from studies of Hall et al.

- Polecat Creek - 155 >80% PPR consumed by NZMS
- Firehole River - 300-600 seasonal
- Gibbon River - 150-550 seasonal
- Madison River - 200-550 seasonal

Kerans et al. 2005, JNABS 24:123-138

Found NZMS in high densities only below thermal inflows in Firehole, Gibbon, but above inflows were <u>absent</u>. No explanation given, but conductivities above were only 20-30% of those below (approx. 60-120 and 50-200 μS range, respectively) – indicating growth-limited conditions

model for NZMS ecophysiological constraints on distribution, abundance & productivity



Ionic and osmotic limits on metabolism and costs to function & viability

Conclusions

- No survival < 25 µS
- Growth limitations 25 to 200 µS (graded effect)
- Best conditions for growth at and above 200 µS
- Ca & osmotic-limits on growth and shell-building

<u>ECOLOGICAL SIGNIFICANCE:</u>

- Mechanism for decreased competitive impact of NZMS on native invertebrate communities
- Interpretation of known distribution, absences
- Useful for predictive geographic modeling of the relative susceptibility of streams to new invasion and priorities for protection
- Potential control through minimizing effluent discharge and agricultural return flows?