Integrating laboratory data on major ion toxicity for multiple species into a broader assessment approach

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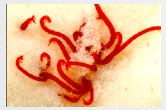
General Approach

- Ions considered: Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^-/CO_3^{2-}
- Toxicity tests (many acute, some chronic) with single salts and binary mixtures

Ceriodaphnia dubia



Chironomus tentans

Lumbriculus variegatus

Lymnaea stagnalis

Pimephales promelas

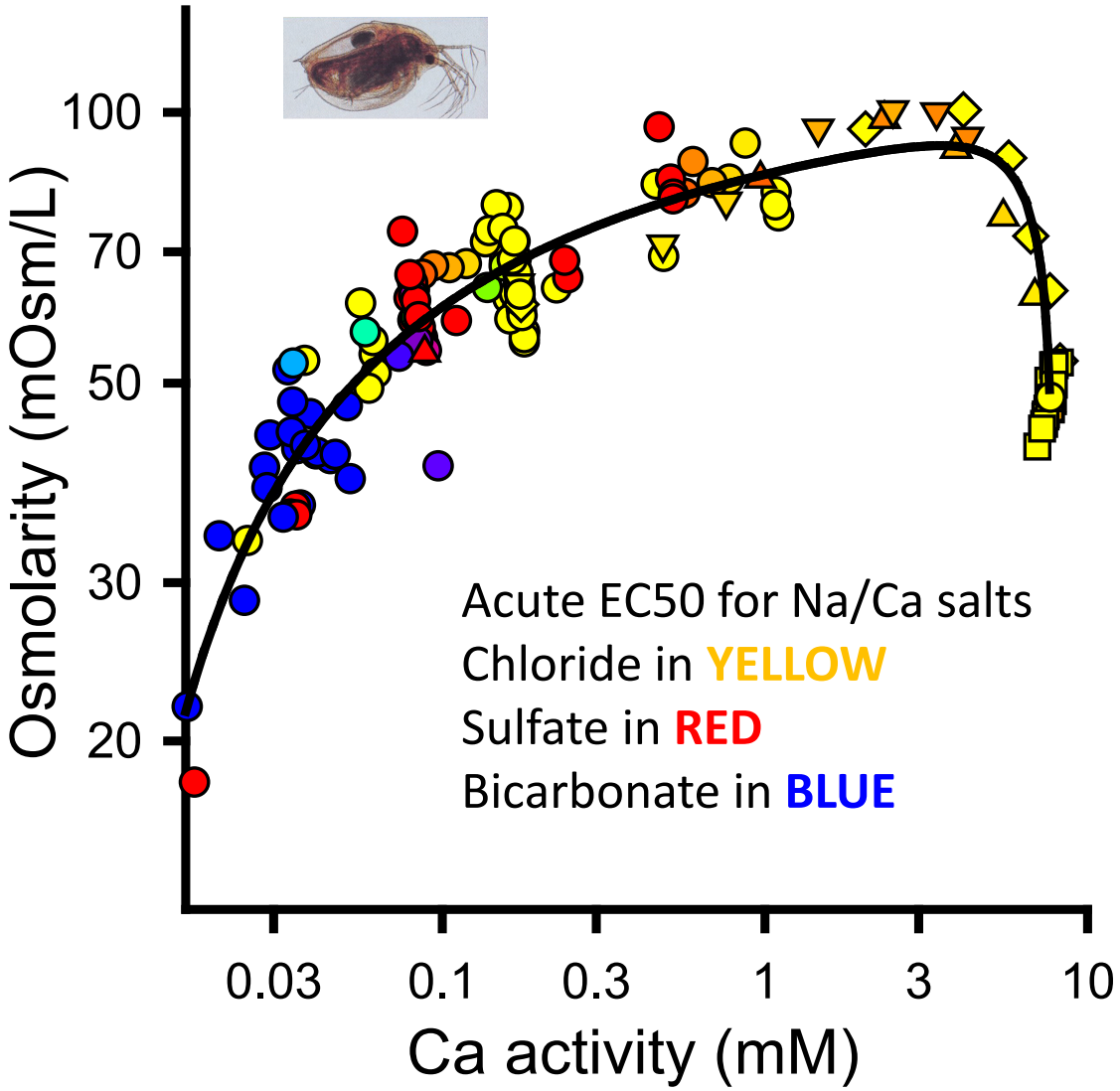
Hyalella azteca

Neocloeon triangulifer

Data collected by Dave Soucek, Illinois Natural History Survey

Initial Findings with *Ceriodaphnia*

- Response to Na salts correlated with osmolarity and Ca dependent



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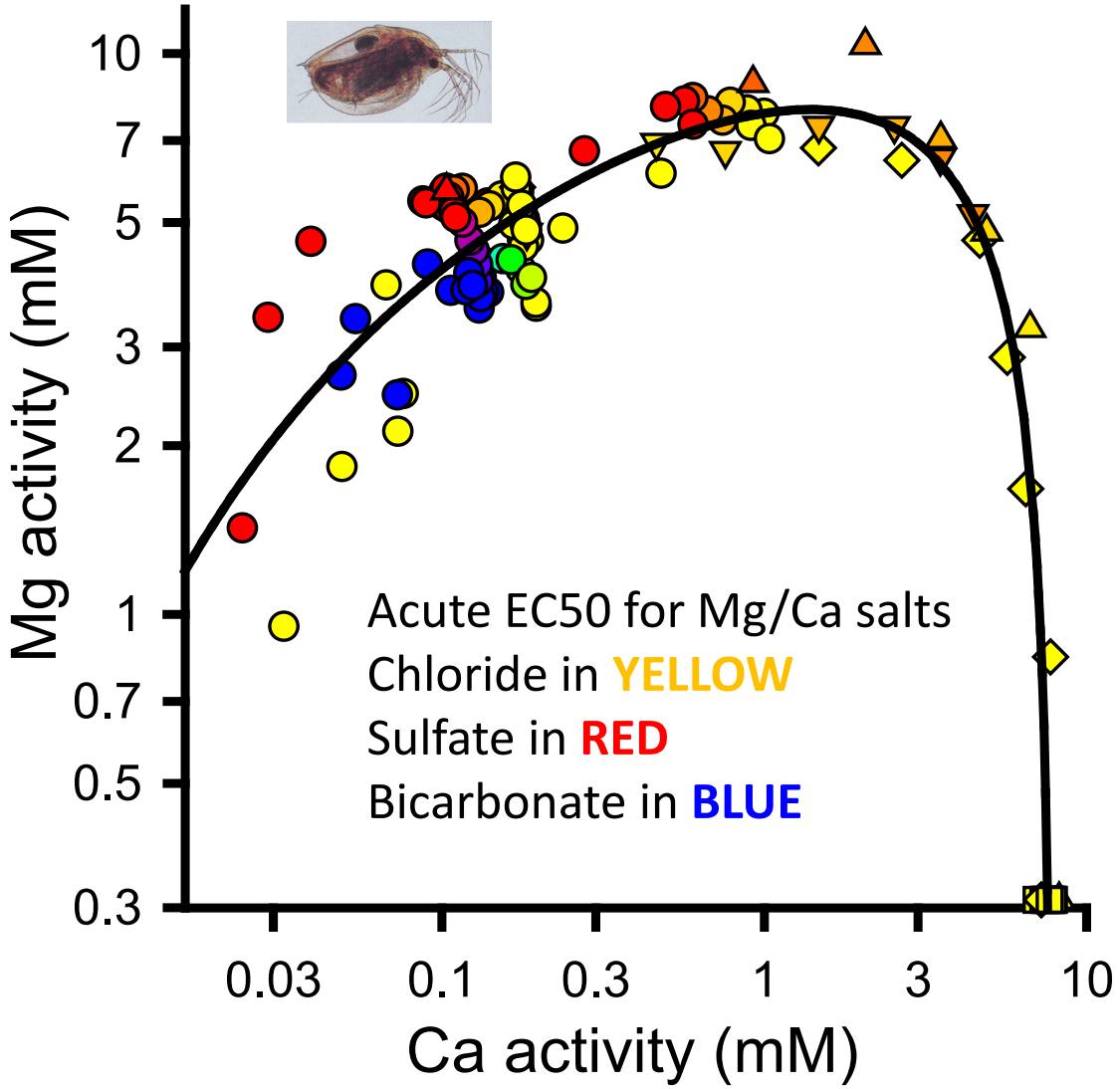
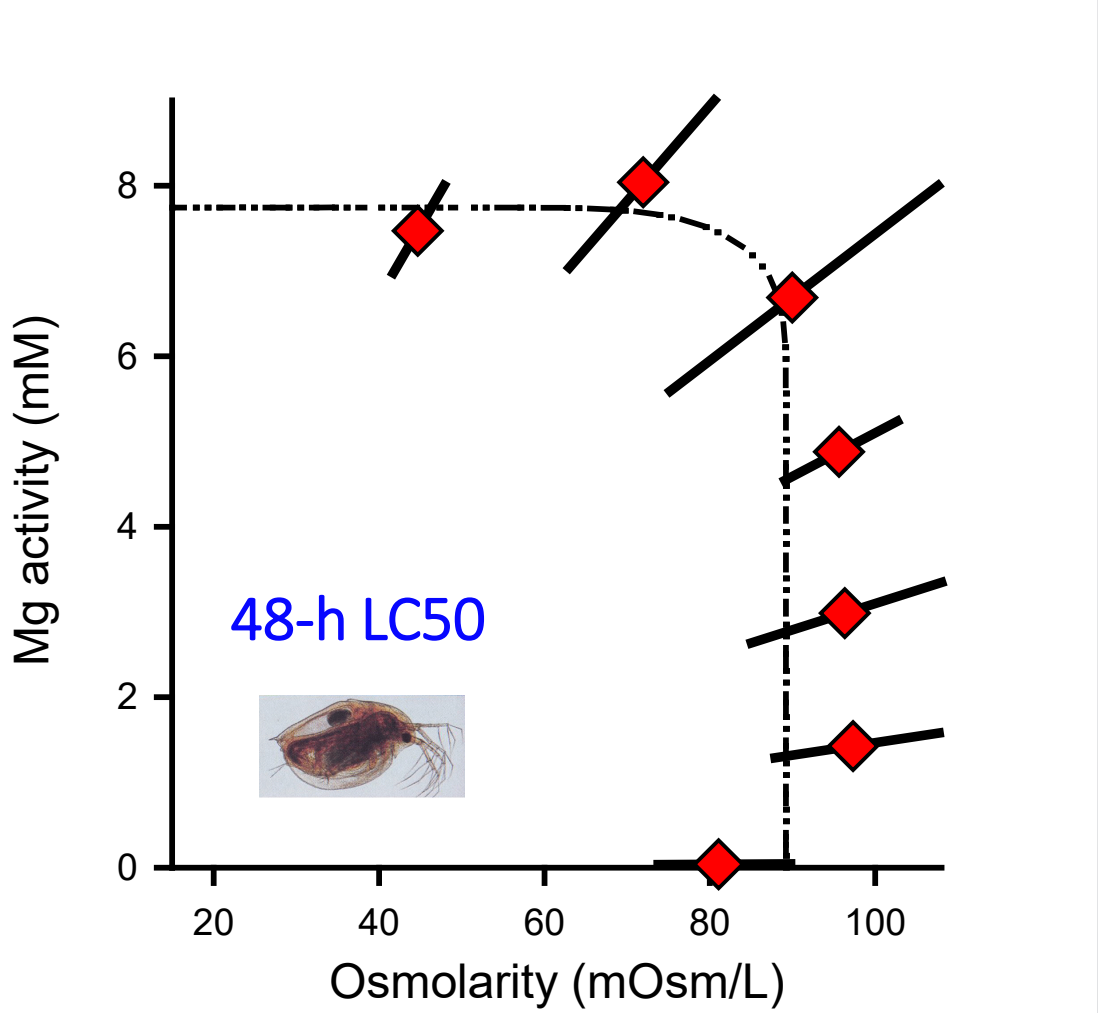


Initial Findings with *Ceriodaphnia*

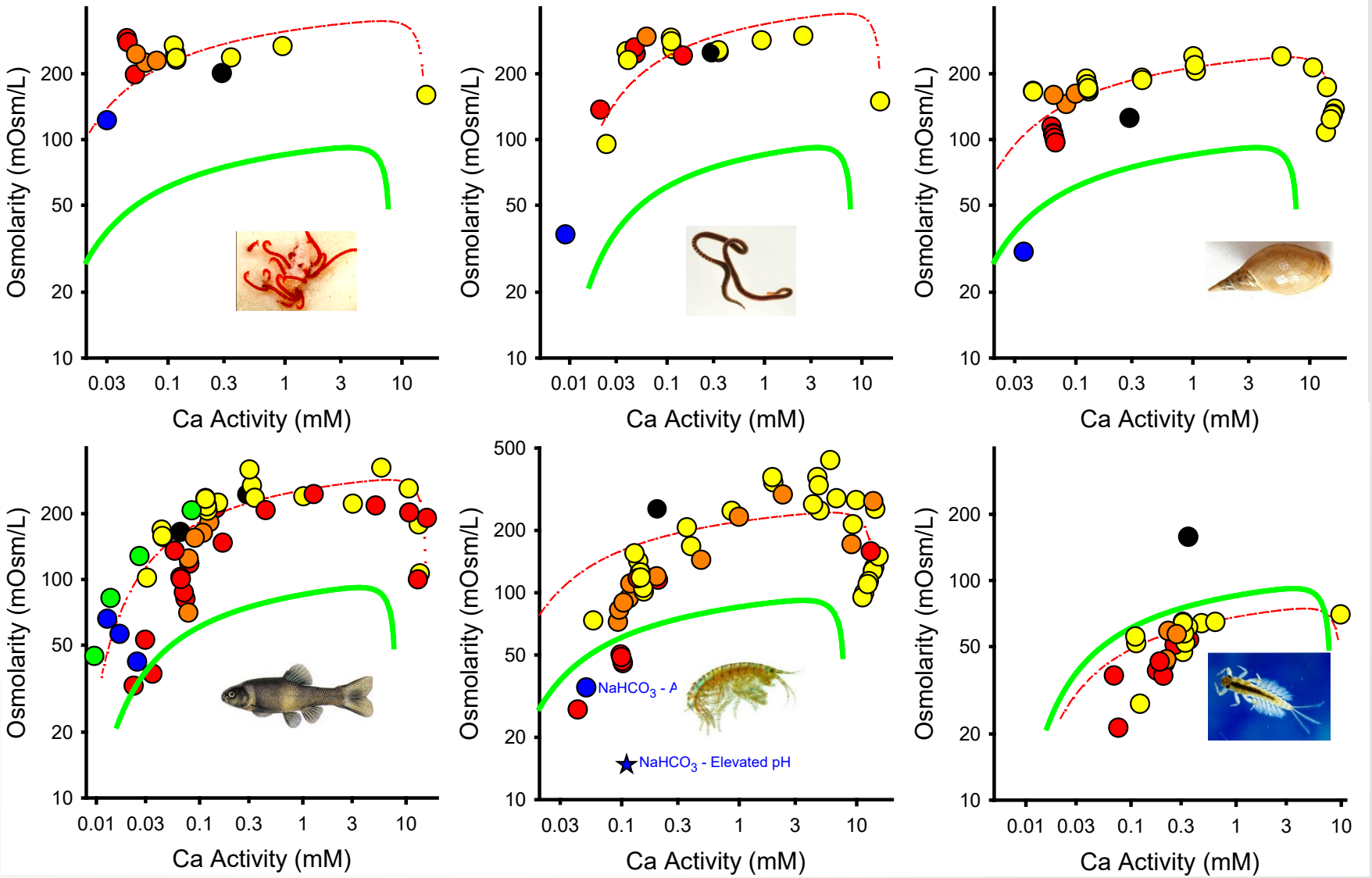
- Response to Na salts correlated with osmolarity and Ca dependent
- Response to Mg salts correlated with Mg activity and Ca dependent
- Responses to mixtures of Na and Mg salts show independent action

Mixtures of $MgSO_4$ and Na_2SO_4



Adjusting the *Cerio* Model to Other Species

- Heavy **green** line is the *Ceriodaphnia* model
- Dashed **red** line is the *Ceriodaphnia* model adjusted to fit the potencies for other species
- Ca slope is <u>not</u> refit for other species



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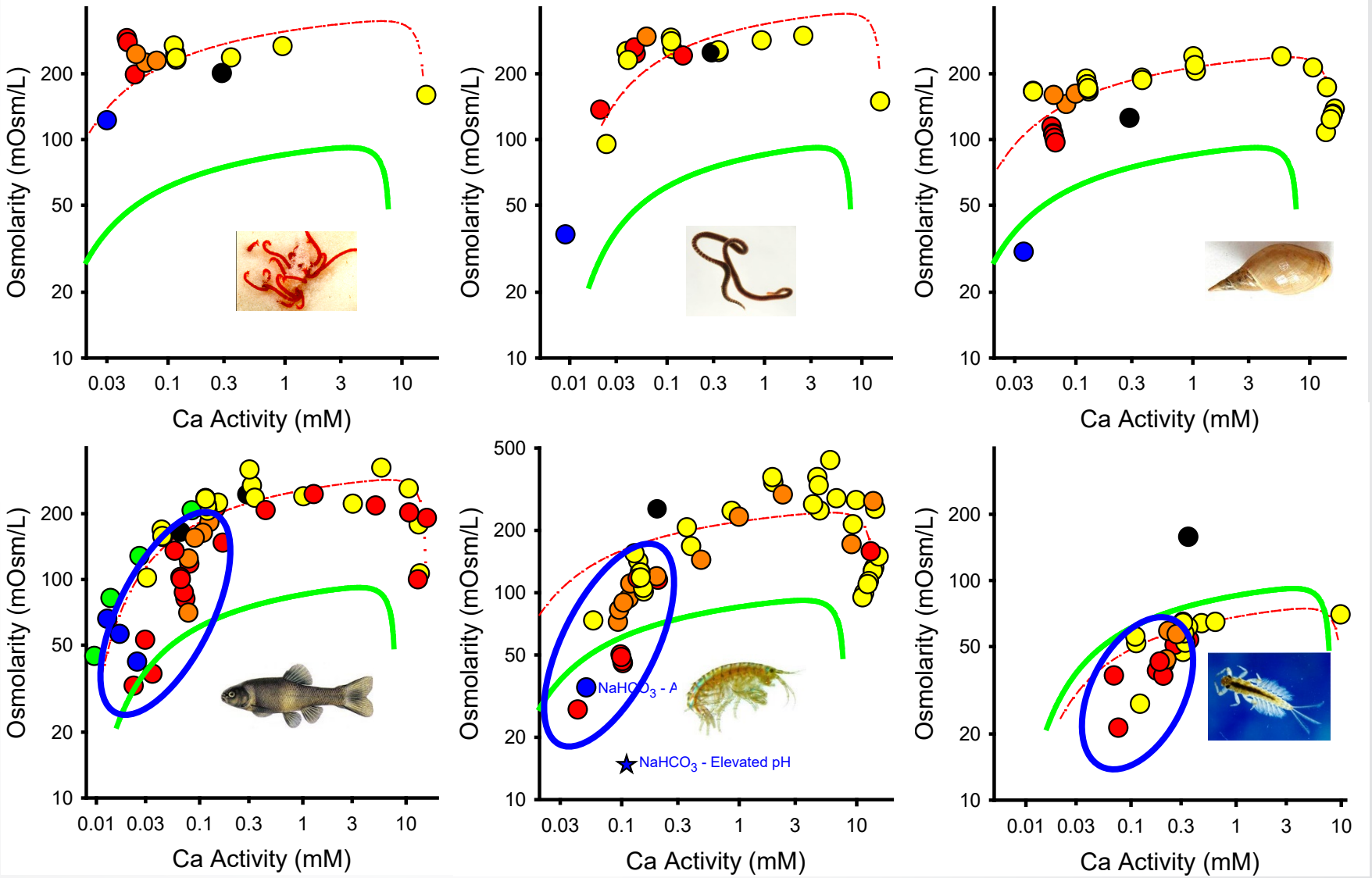
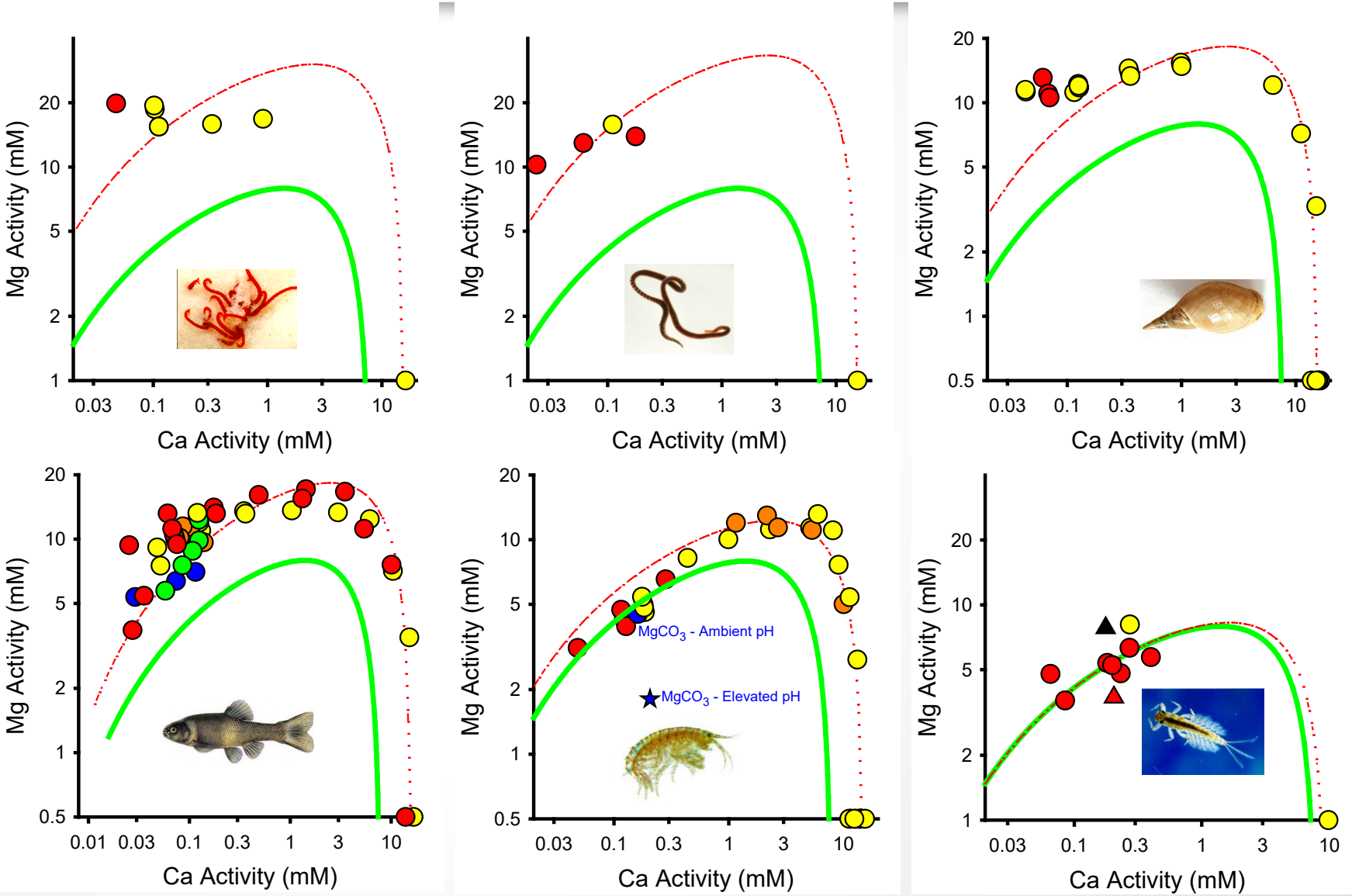
- Ca slope is <u>not</u> refit for other species
- Steeper Ca slope for some species, and/or deviations for SO_4 at low Ca (red/orange symbols)



Cerio Mg-Ca Model Fit to Other Species

- **Green** line is *Ceriodaphnia* model and **red** dashed line is refit to other species
- As before, shape parameters are for *Ceriodaphnia*, only potencies are adjusted
- Fits seem pretty promising overall, although data are sparse in key areas of the curve for some species



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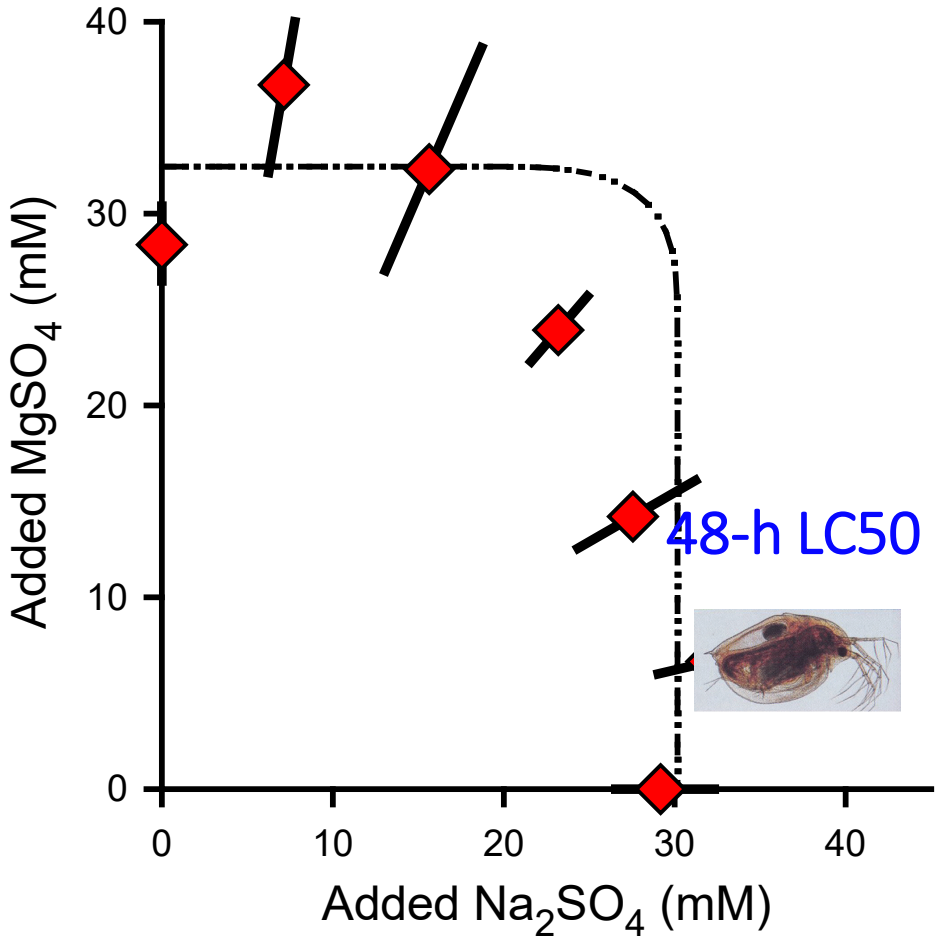
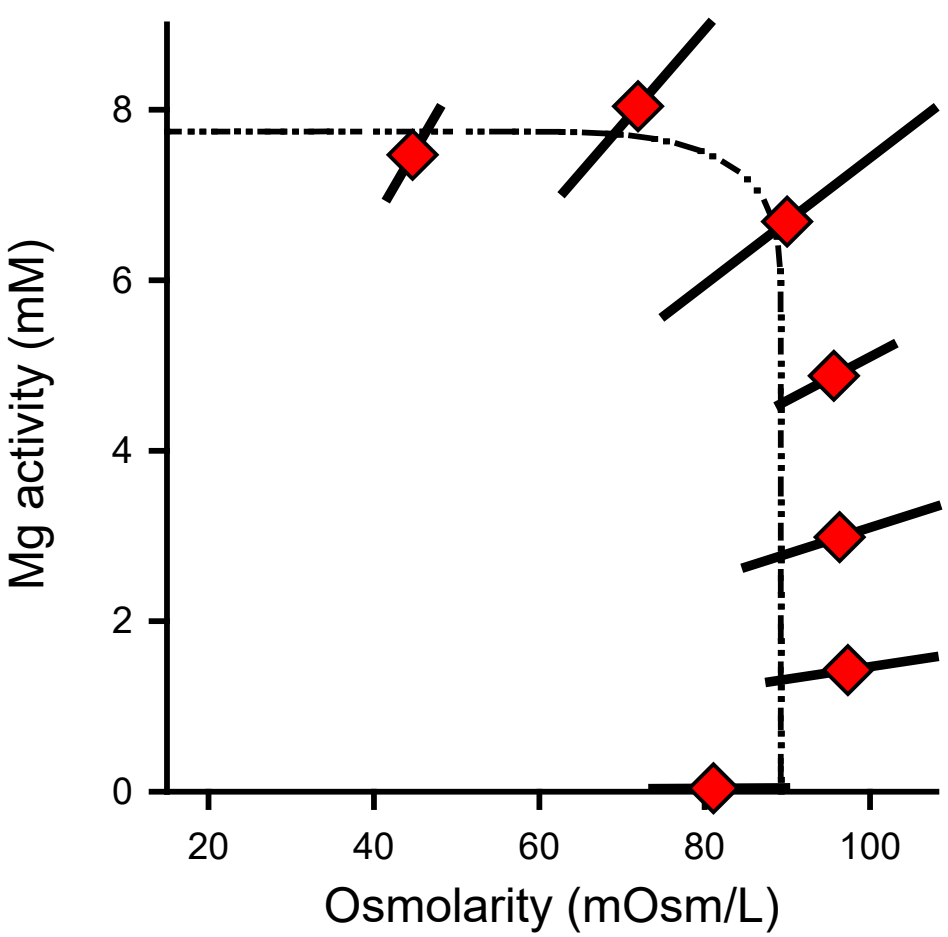
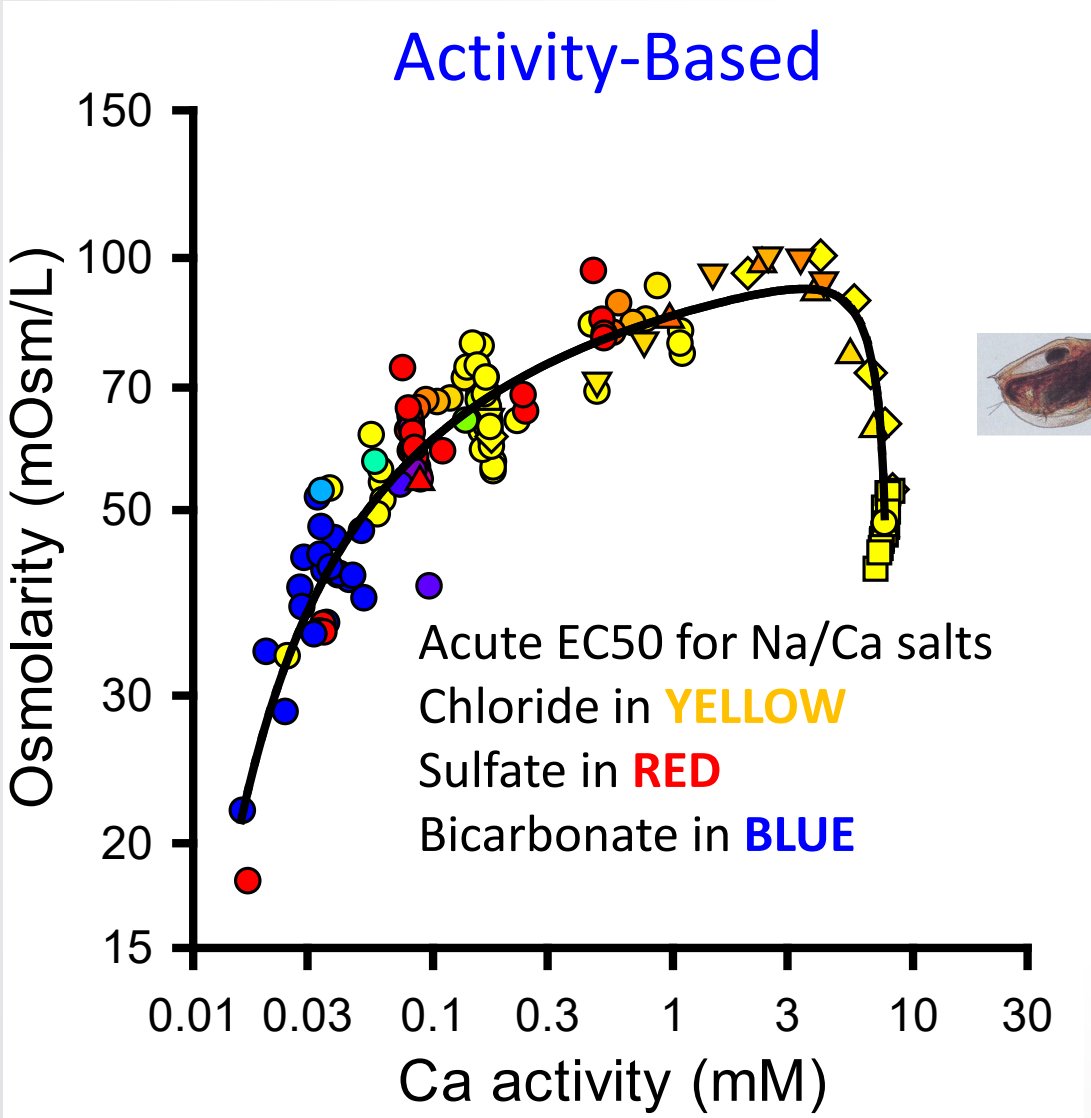
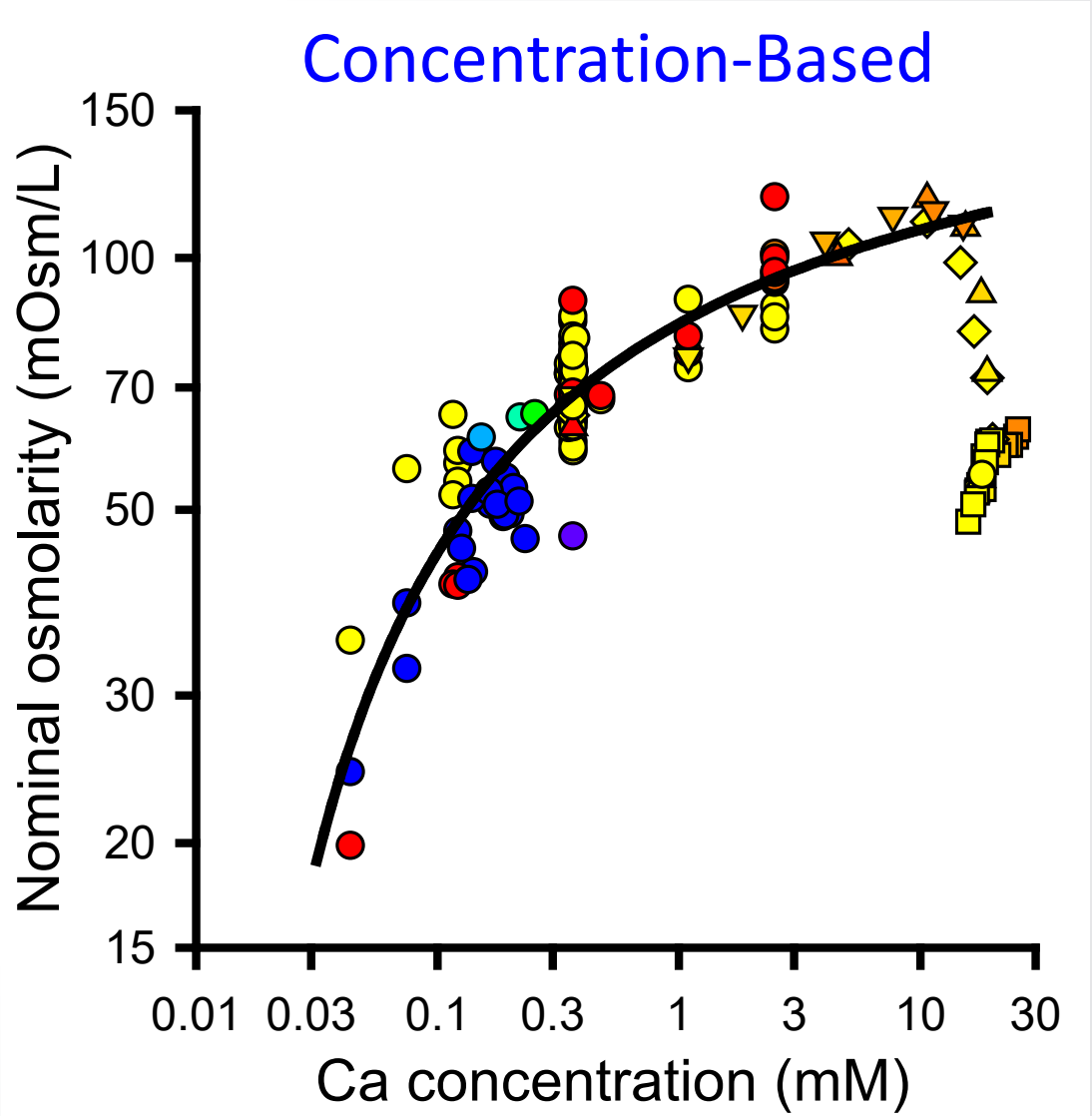




Activity v Concentration Based Models





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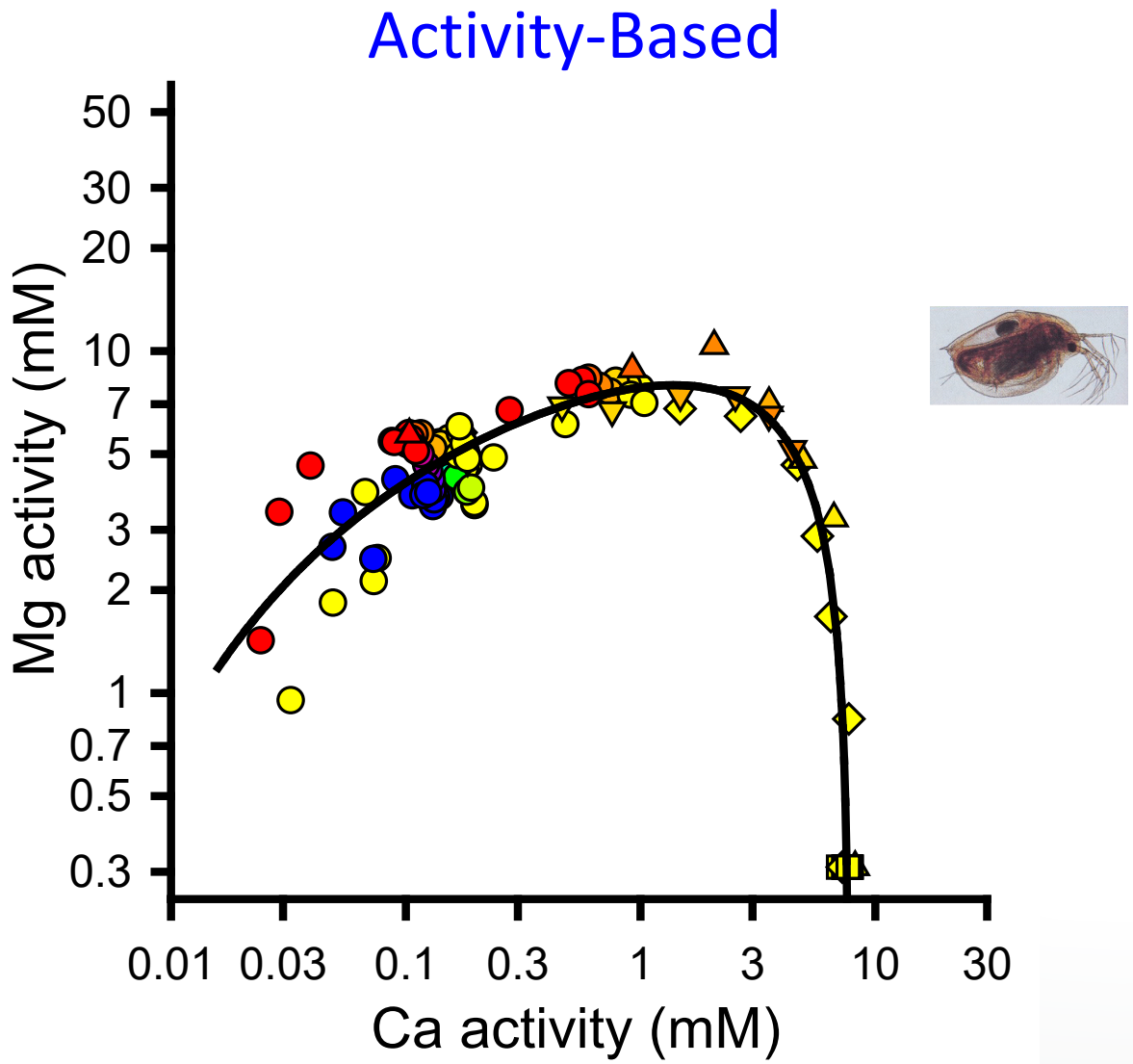
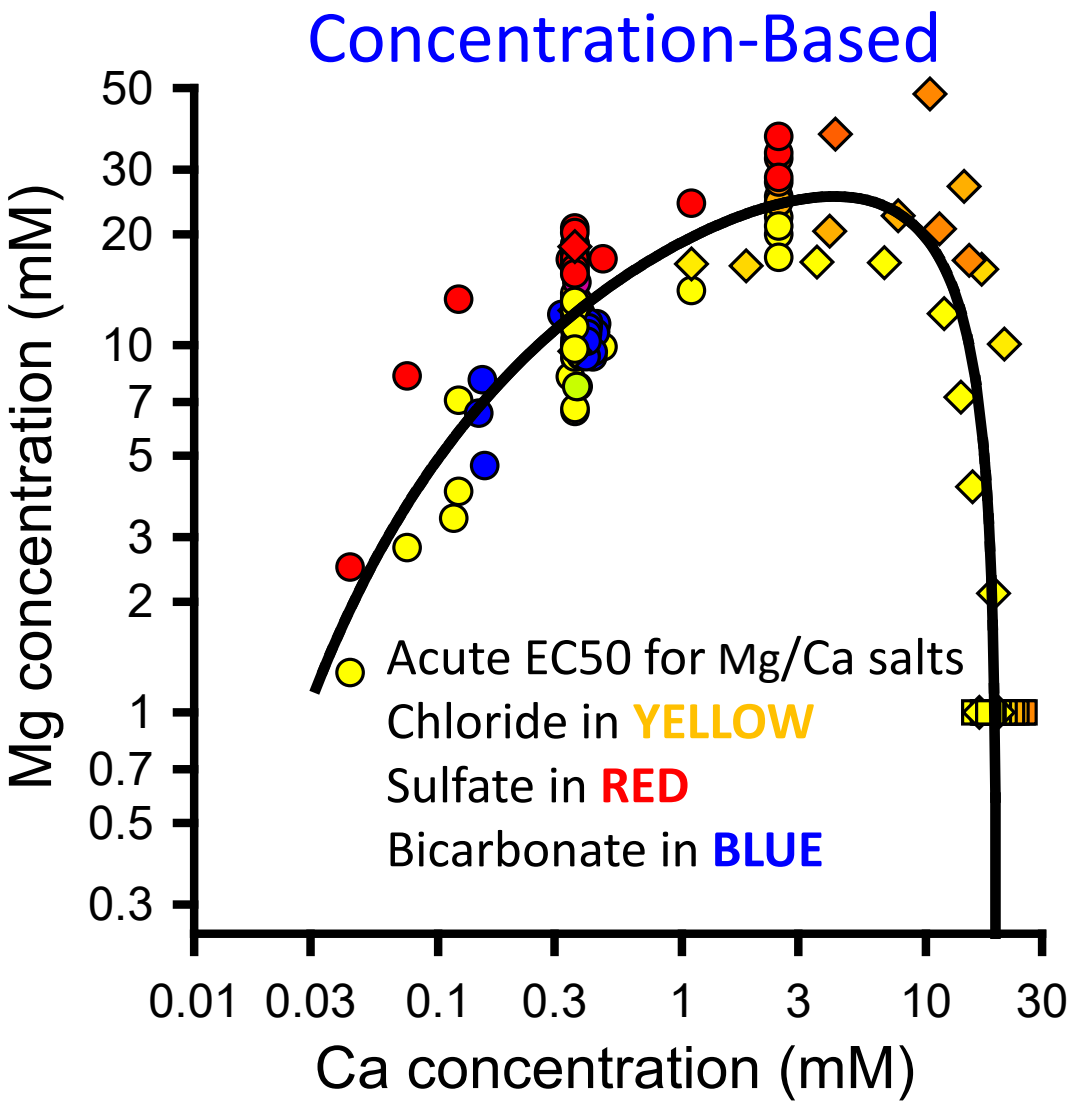
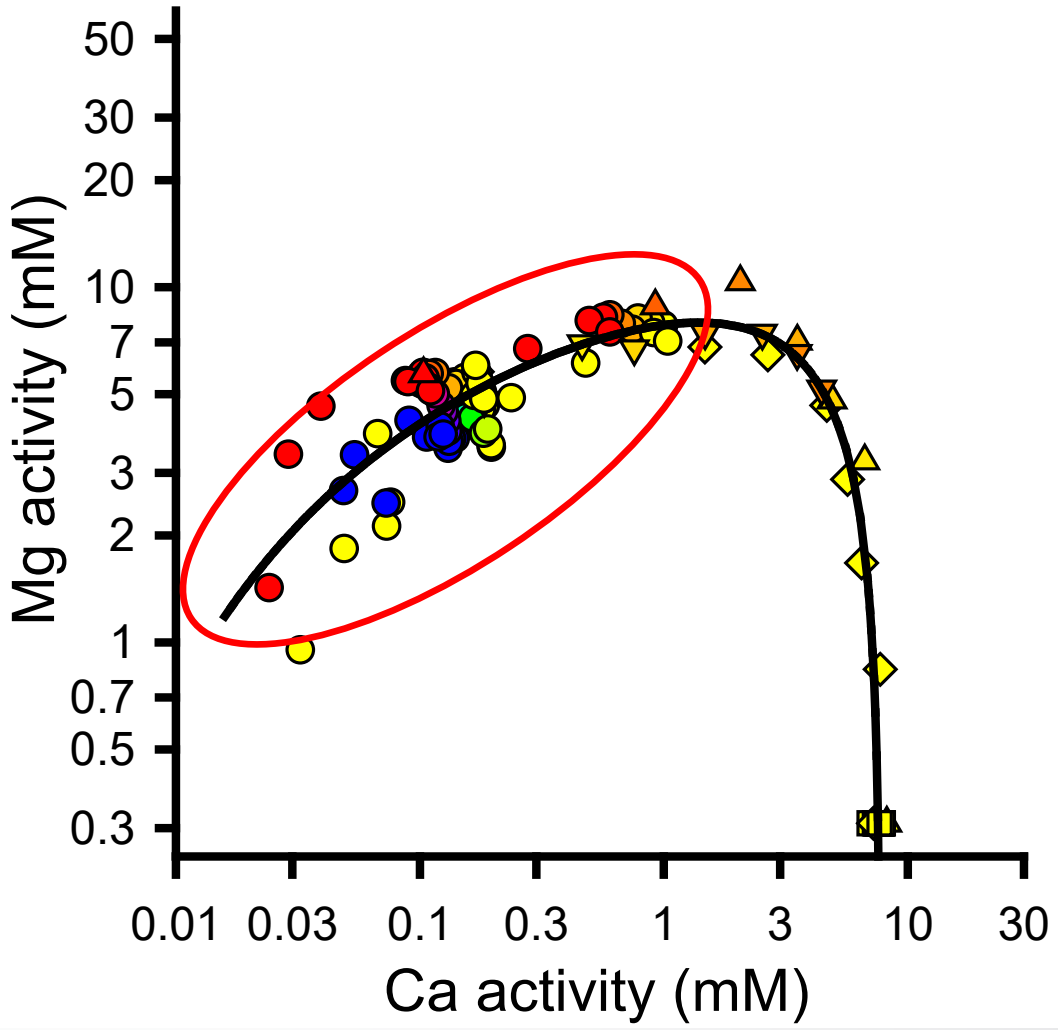




The Hazards of Testing Single Salts

- Most major ion tests are conducted using single salts that are added to comparatively low ionic strength dilution water



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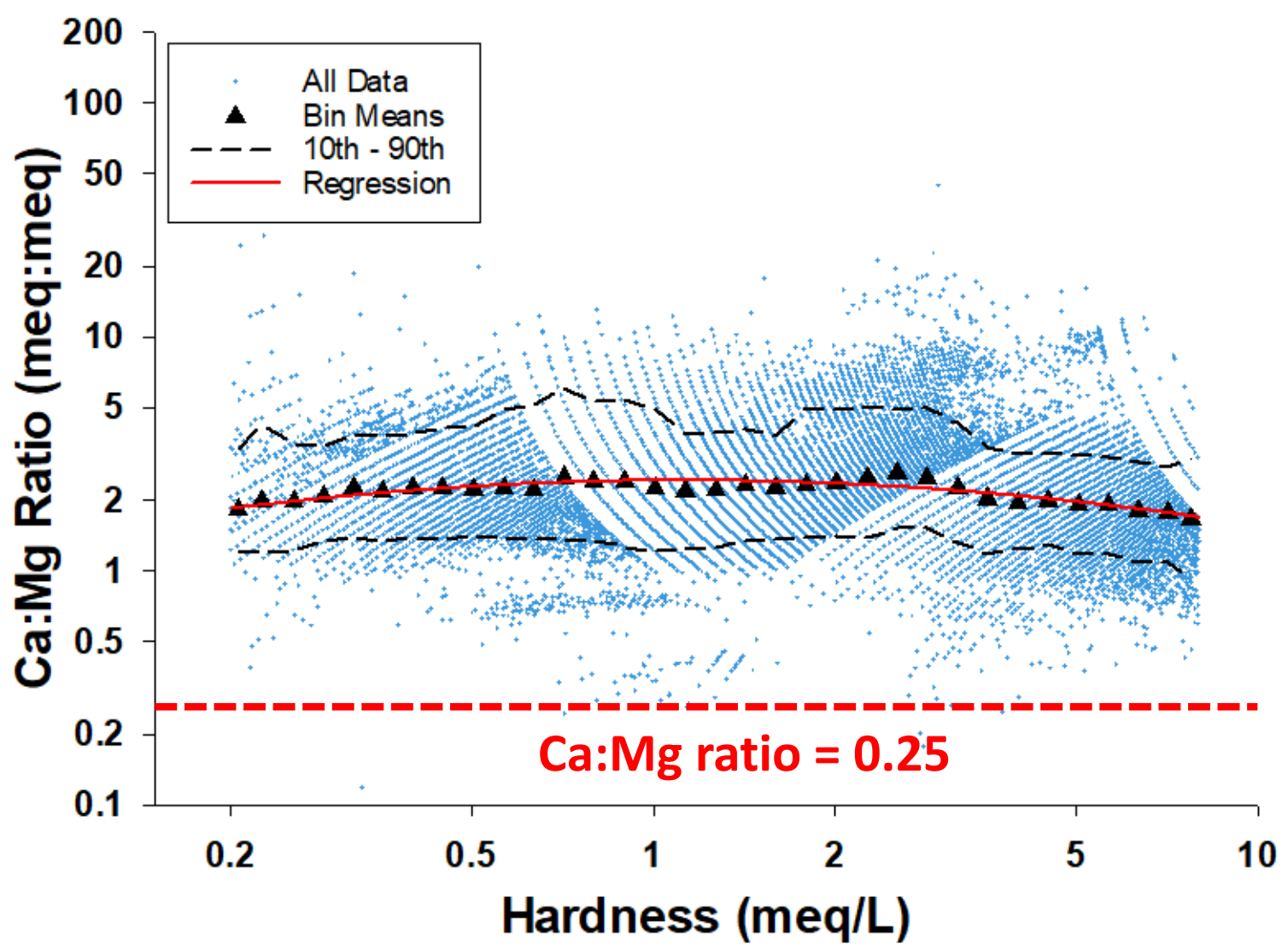

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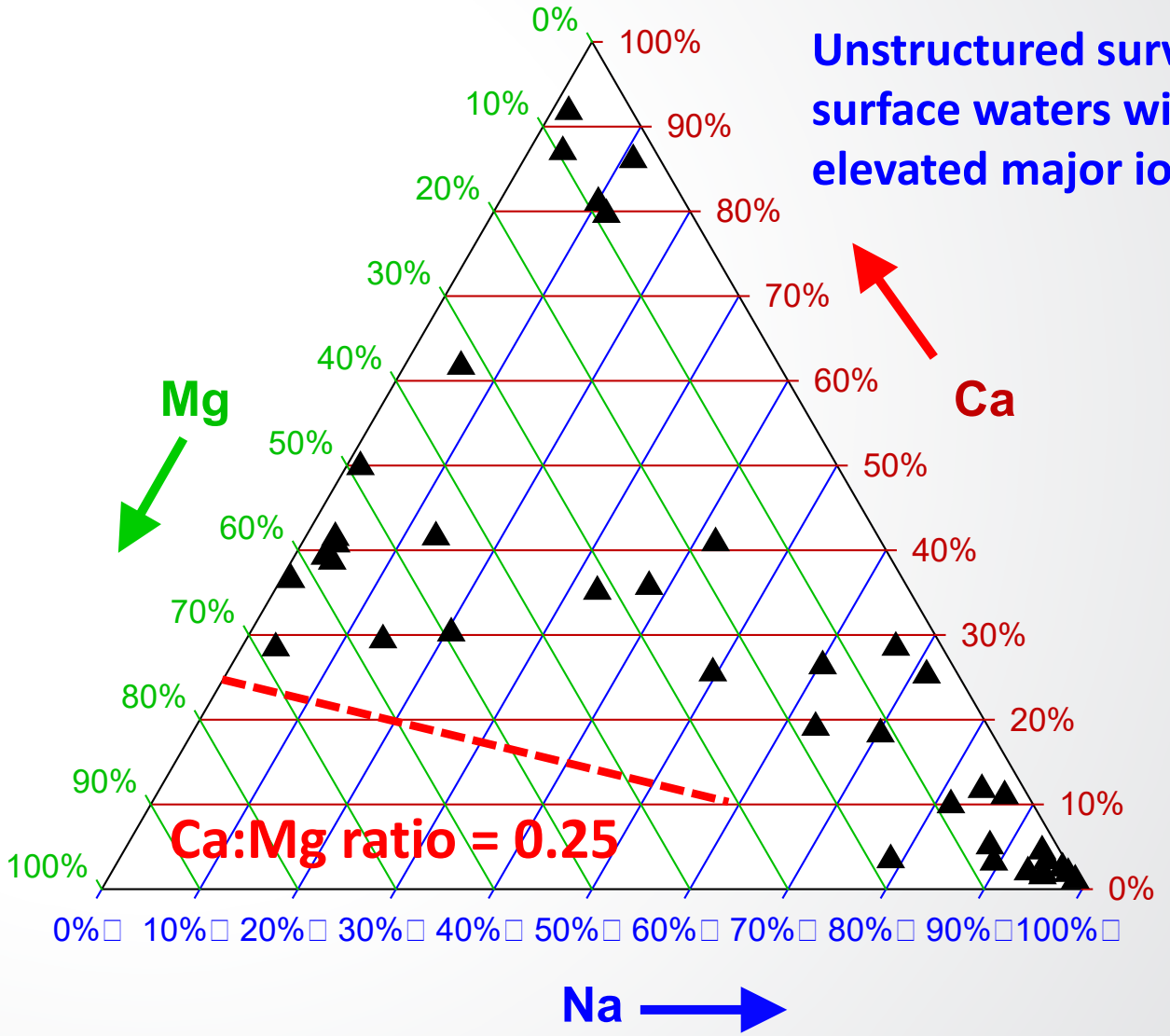

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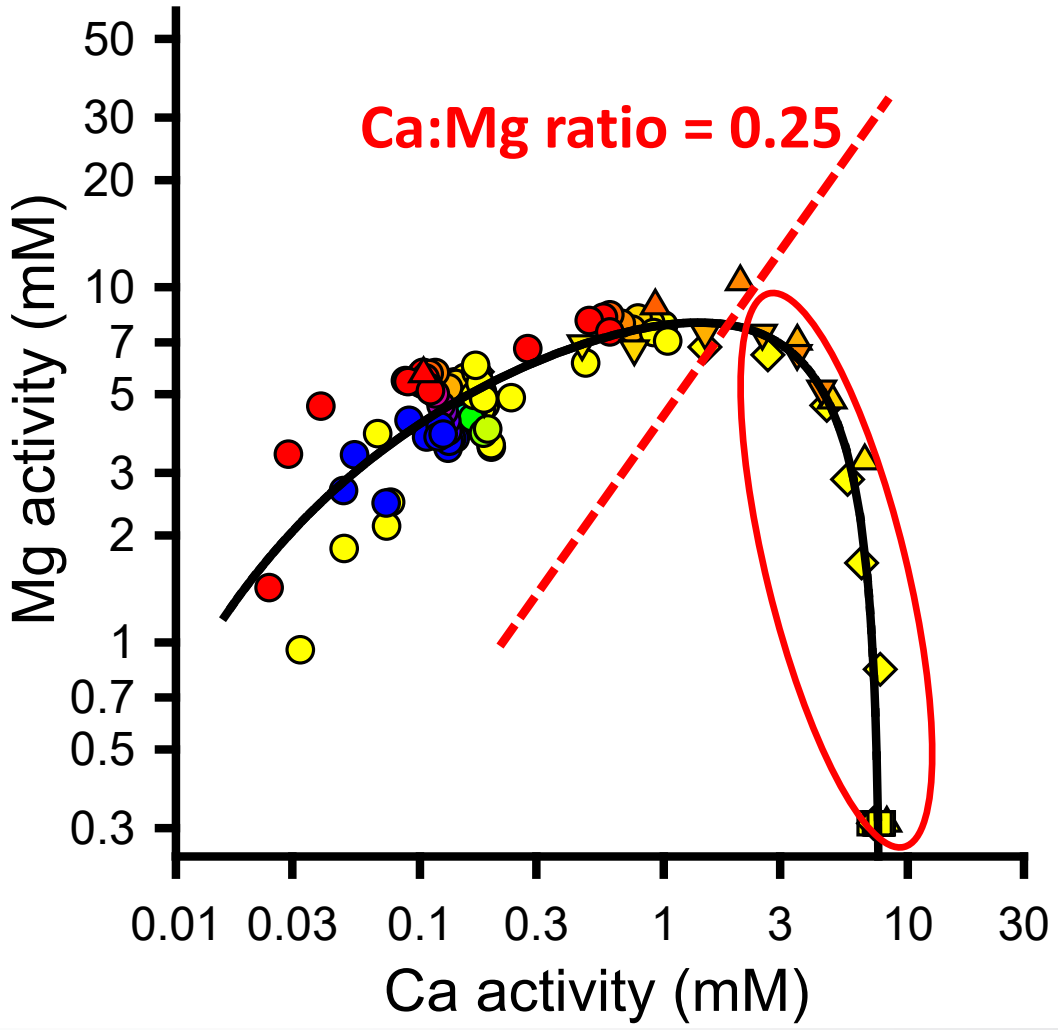
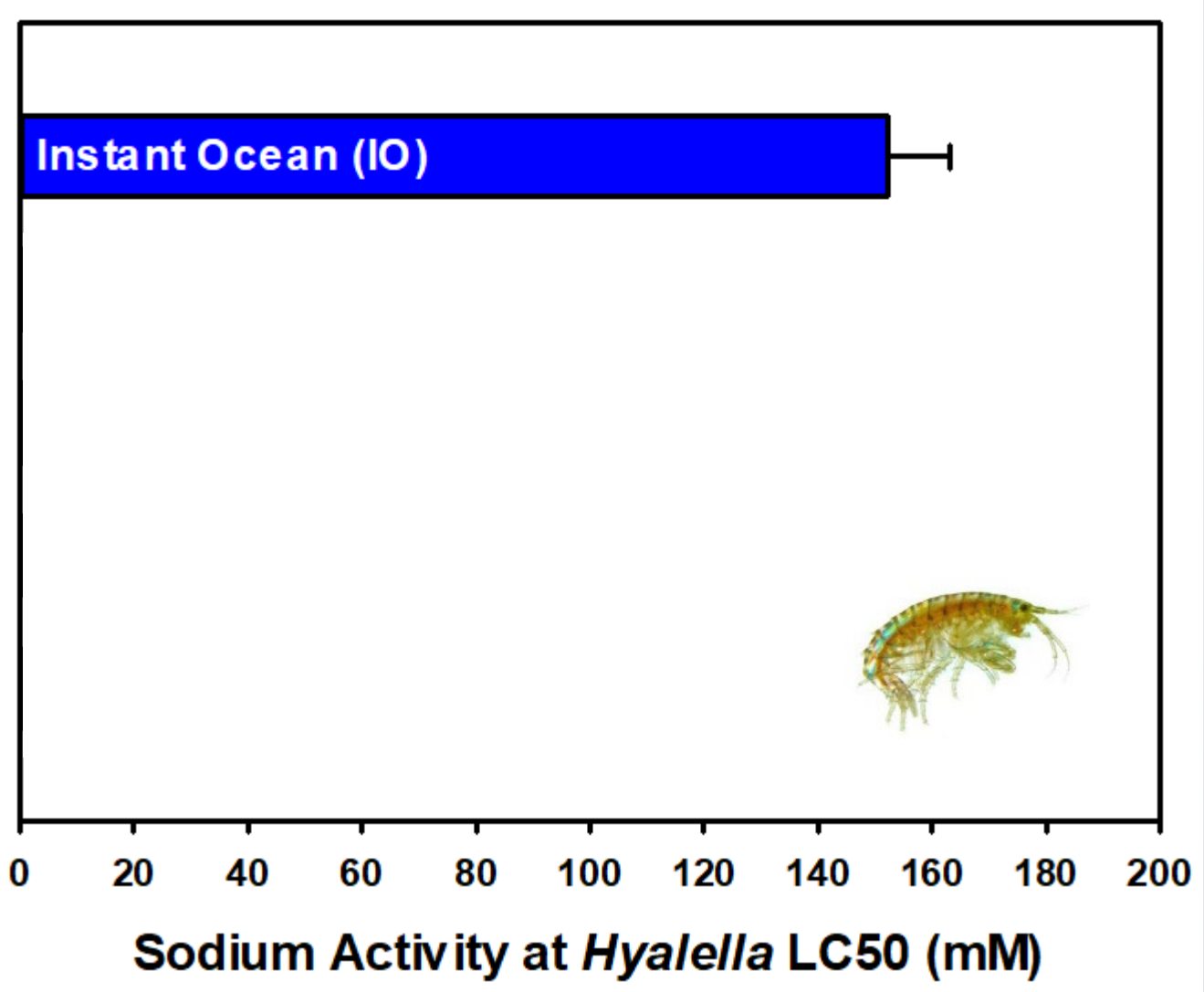
- Effects of Ca-Mg enriched waters with Ca:Mg > 0.25 is pretty small subset of sampling space



Hyalella Response to High NaCl

- *Hyalella azteca* acute LC50 for Instant Ocean nearly twice that for NaCl at comparable Ca



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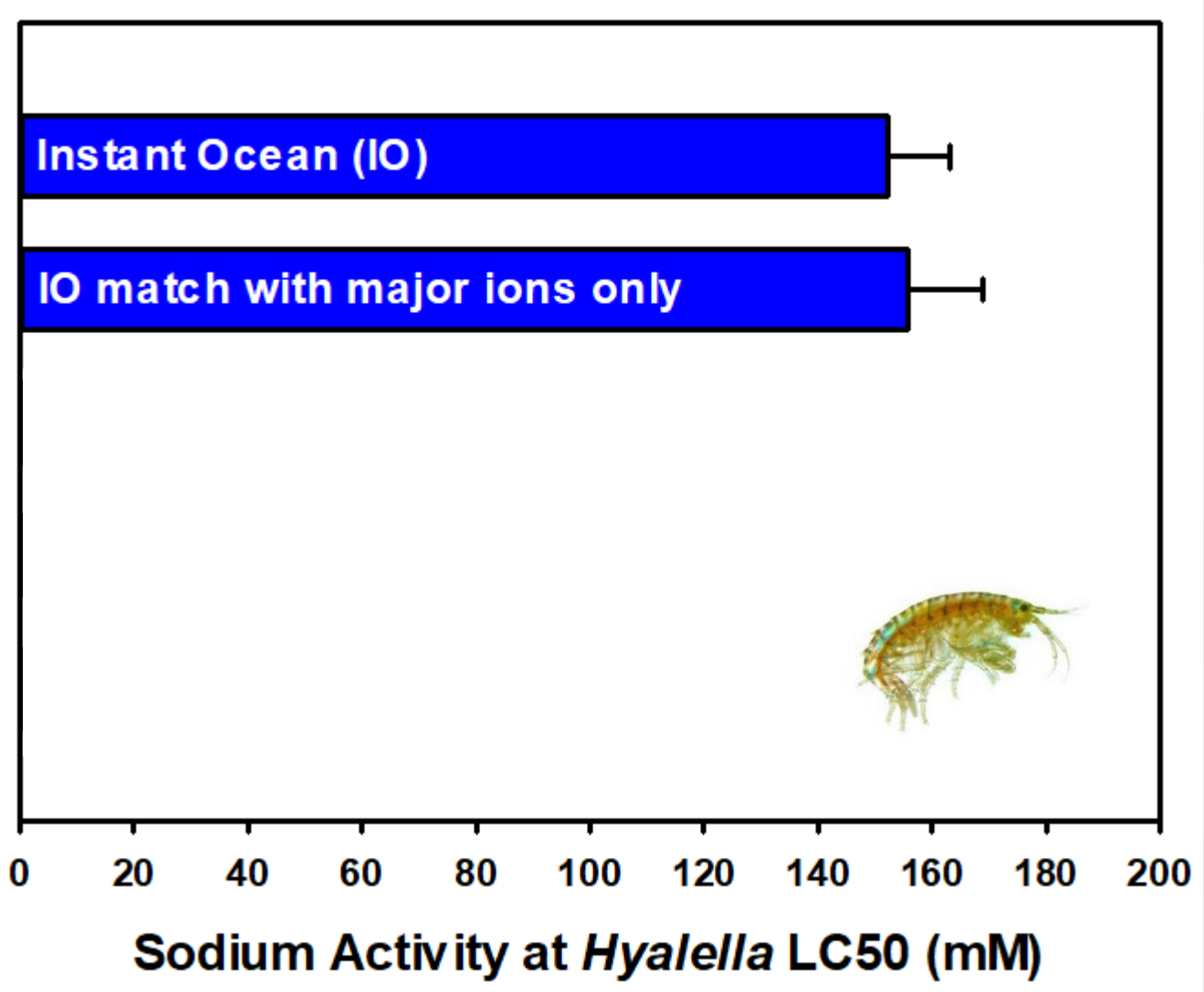

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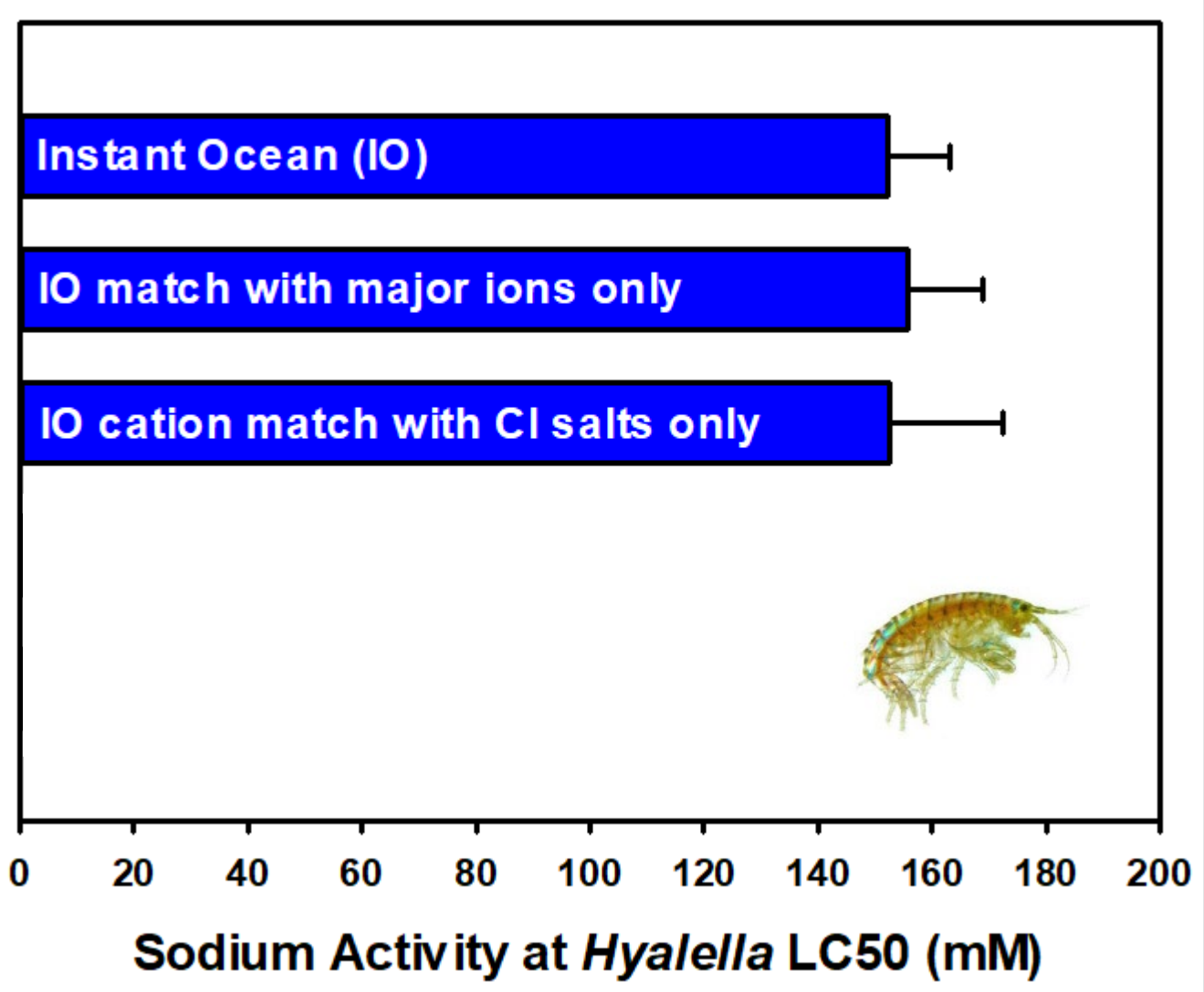

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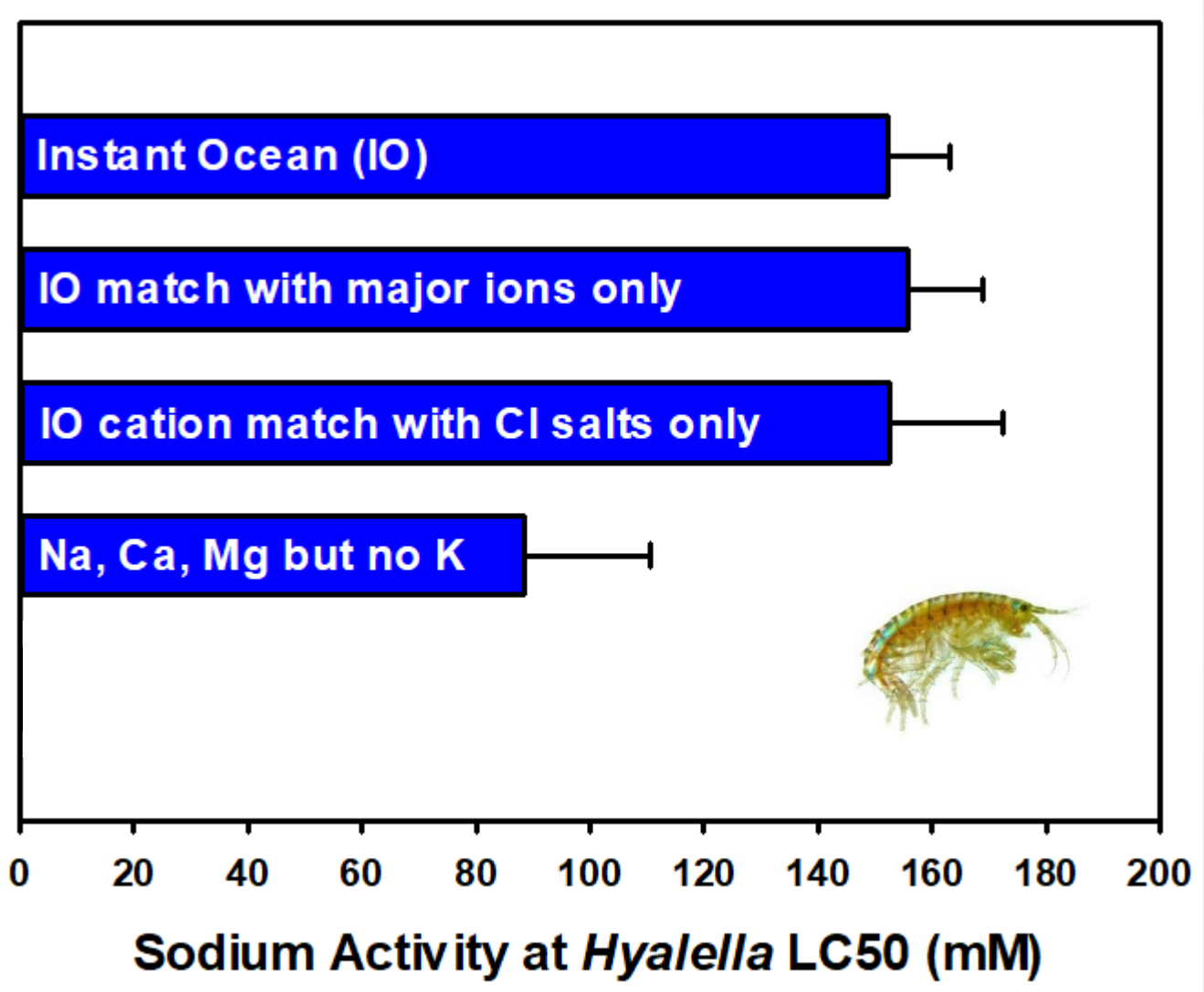

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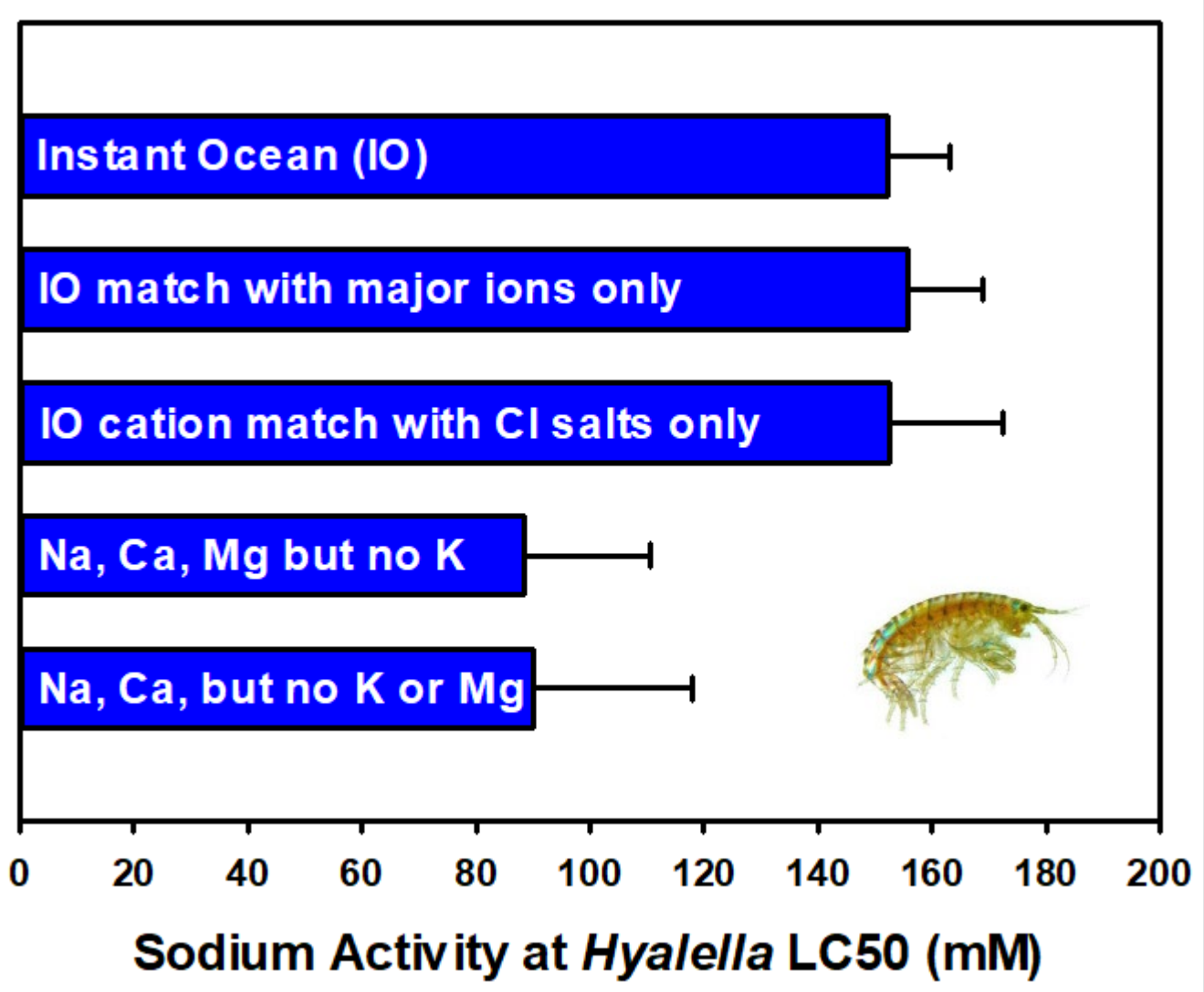
- Withholding Mg has no further effect



Chronic Tolerance of Salts Context-Sensitive

- At 53 mg/L hardness in our lab, we obtained a chronic EC20 of about 1500 mg NaCl/L
- The EPA sediment test manual says that *Hyalella* can be tested at 15 ppt salinity (roughly 12,600 mg NaCl/L)

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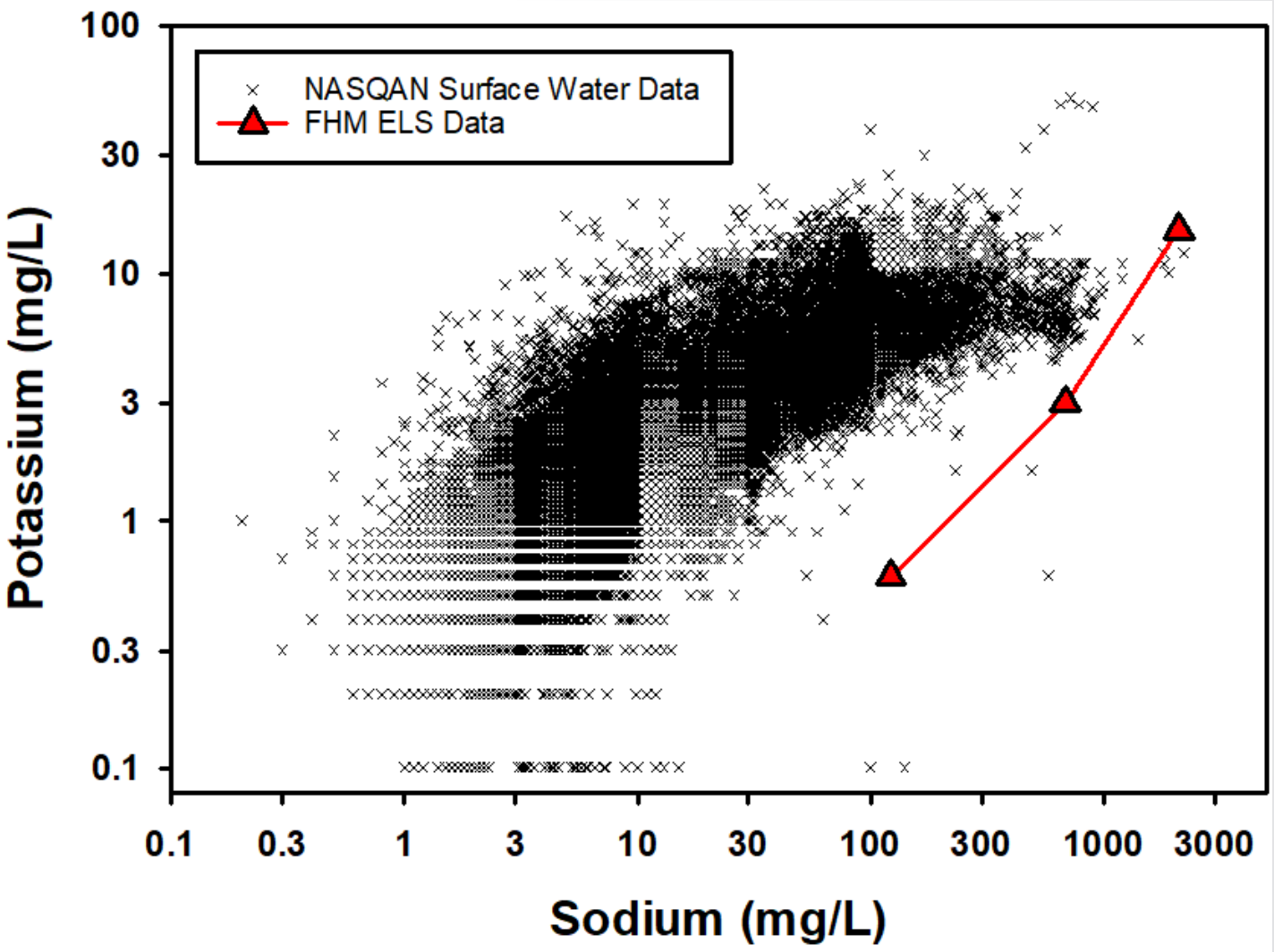
- In Lake Superior water, the fathead minnow ELS EC20 for sodium sulfate was about 250 mg Na_2SO_4/L
- Burnham and Peterka (1975) collected fathead minnows from a North Dakota lake with over 12,000 mg Na_2SO_4/L

FHM ELS Versus Field Geochemistry

- In natural waters of the U.S., the sodium:potassium ratio is virtually always low enough that high sensitivity of FHM ELS to Na at low K would not be a factor



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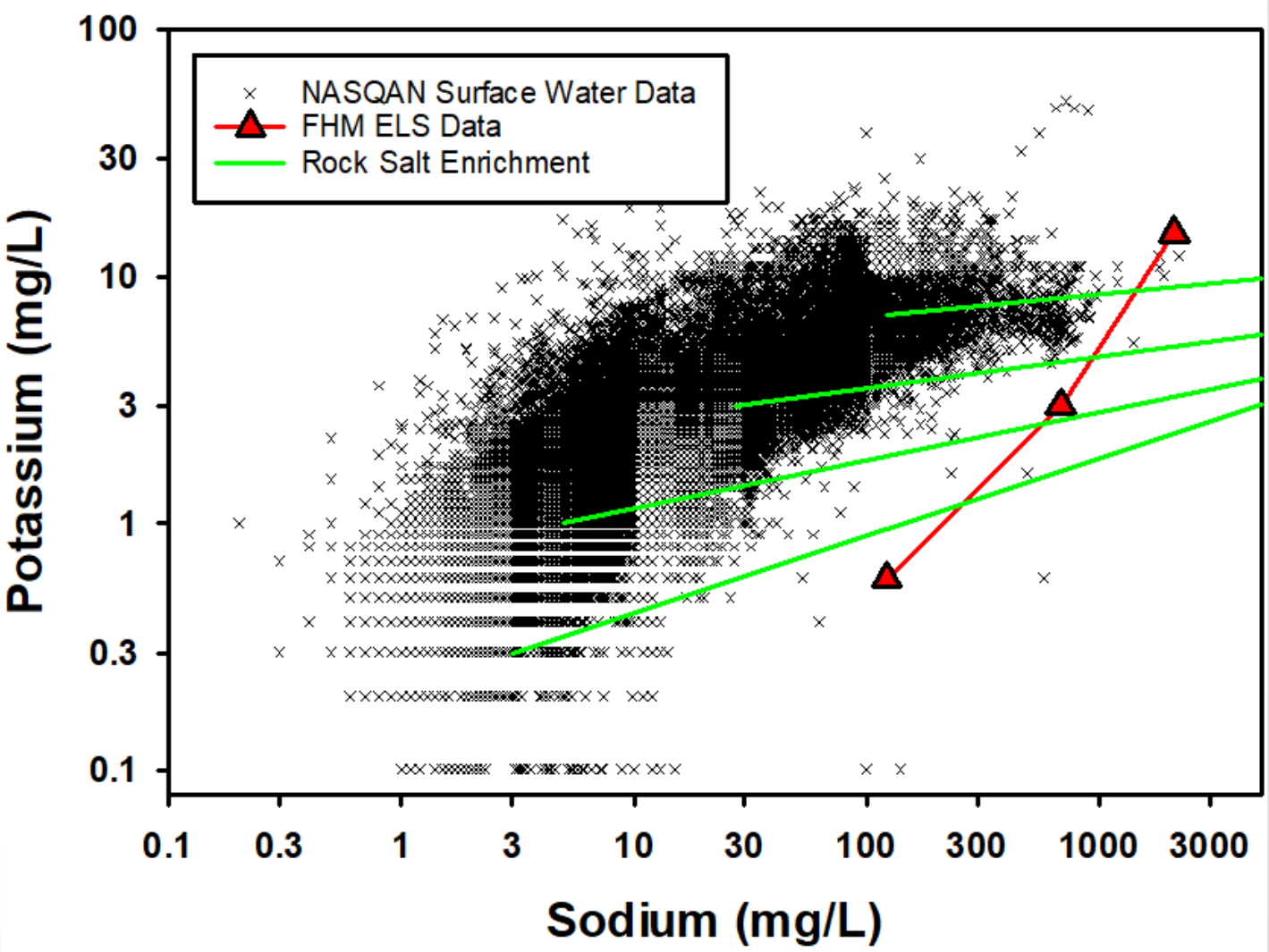
- That said, Na:K ratio in rock salt is about 2000:1; in theory adding rock salt to natural water chemistry could induce a problem



Concluding Thoughts

- Apparent drivers of toxicity may vary some across species, though overall relationships are not wildly different
- For the species studied, do not appear to be not drivers of toxicity, except as they influence osmolarity and cation activity
- Concentration-based models show greater uncertainty than activity-based models, but the gains in practicality may outweigh lost accuracy
- For Ceriodaphnia and Hyalella, chronic testing suggests relatively small acute-chronic ratios (e.g., factor of 2 to 4); important question is whether that is widely true
- Studies focusing on only single salts have the potential to mislead, if field exposures show changes in multiple ions