Zooplankton Community Changes in Mille Lacs Lake, Minnesota after Zebra Mussel (*Dreissena polymorpha*) and Spiny Waterflea (*Bythotrephes longimanus*) Infestations

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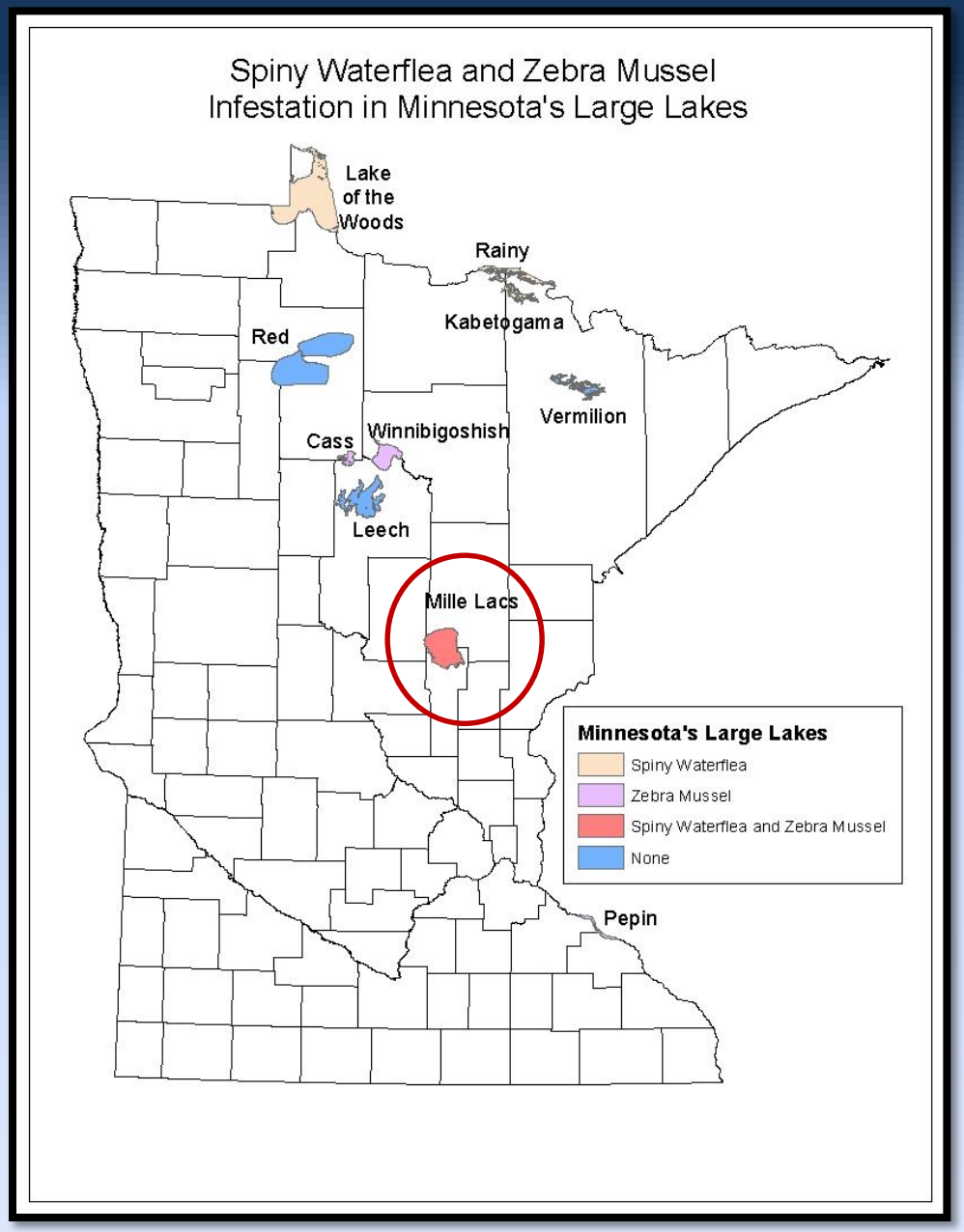
Large Lake Zooplankton Monitoring Program

- Evaluate impacts from AIS on native zooplankton communities and aquatic food webs

Mille Lacs Lake

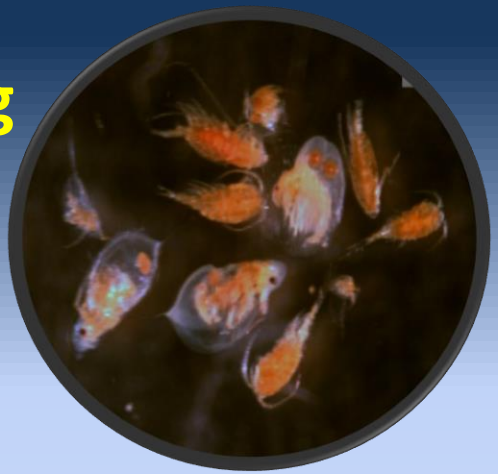
- Large(52,000 ha) shallow(13 m)lake
- Zebra mussels detected in 2005
- Spiny waterfleas detected in 2009



Mille Lacs Lake Zooplankton Sampling Field Methods

- Zooplankton samples collected since 2006 (8 years of data so far…..)
- Monthly sampling (May-Sept.) at 9 sites
- Full water column vertical tows with 30cm mouth, 80 μm mesh simple plankton net

Mille Lacs Lake Zooplankton Sampling Laboratory Methods



- Samples processed individually

- Zooplankton counted, identified and measured with image analysis system

- Biomass estimated from length/weight regression coefficients

- Results reported in densities (number/liter) and biomass (μg/liter)

Potential Impacts of Invasive Species on Zooplankton Communities

Spiny waterflea

Direct predation

Small cladocerans (grazers)
(Diaphanosoma spp., Bosmina spp., Chydorus spp., Daphnia retrocurva)

Zebra mussel

Competition

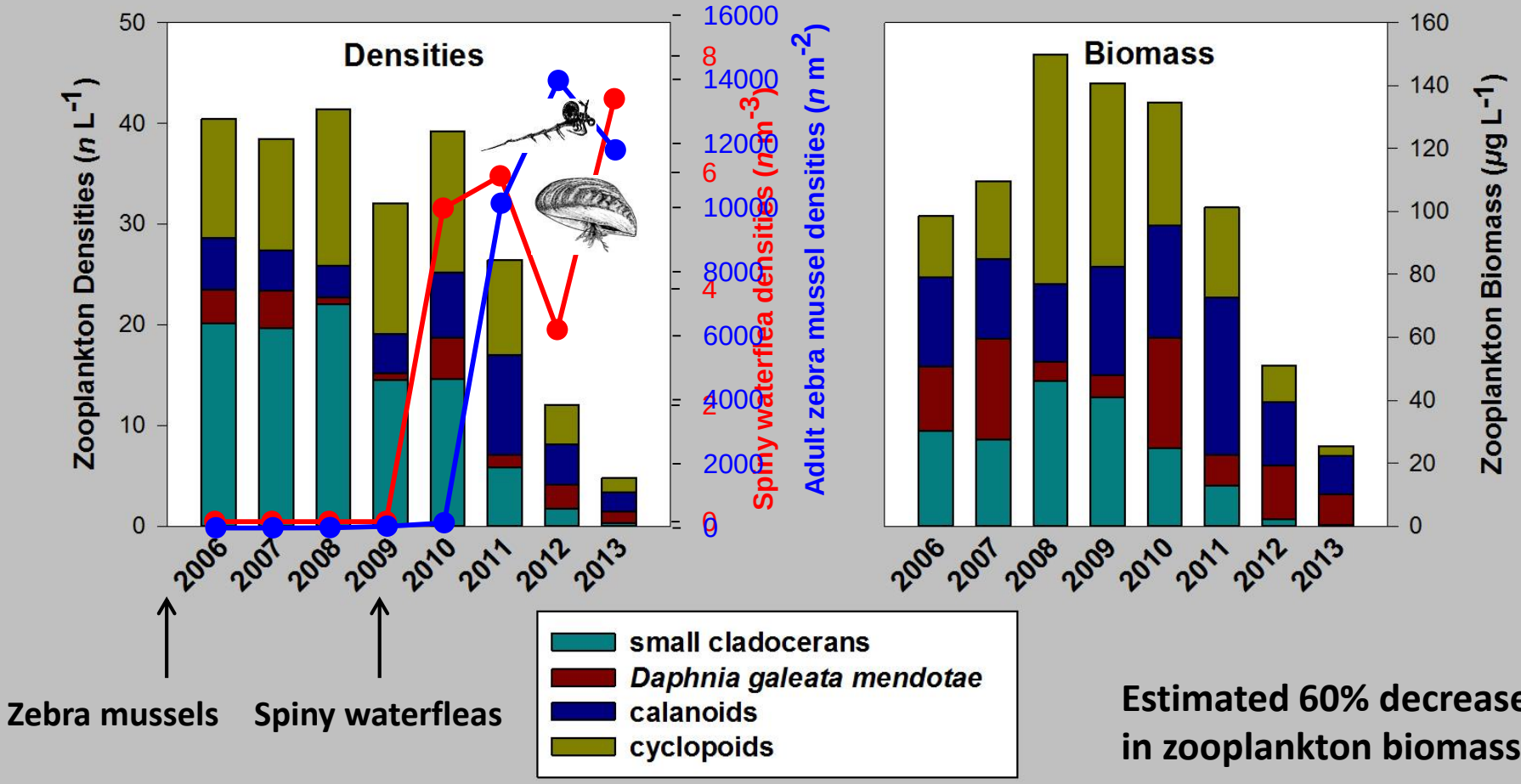
Larger grazers
(Daphnia galeata mendotae, calanoids)

cyclopoids (predators)

Spiny waterflea

Competition

Mille Lacs Lake Zooplankton
Annual Mean Densities and Biomass (2006-2013)



Estimated 60% decrease in zooplankton biomass

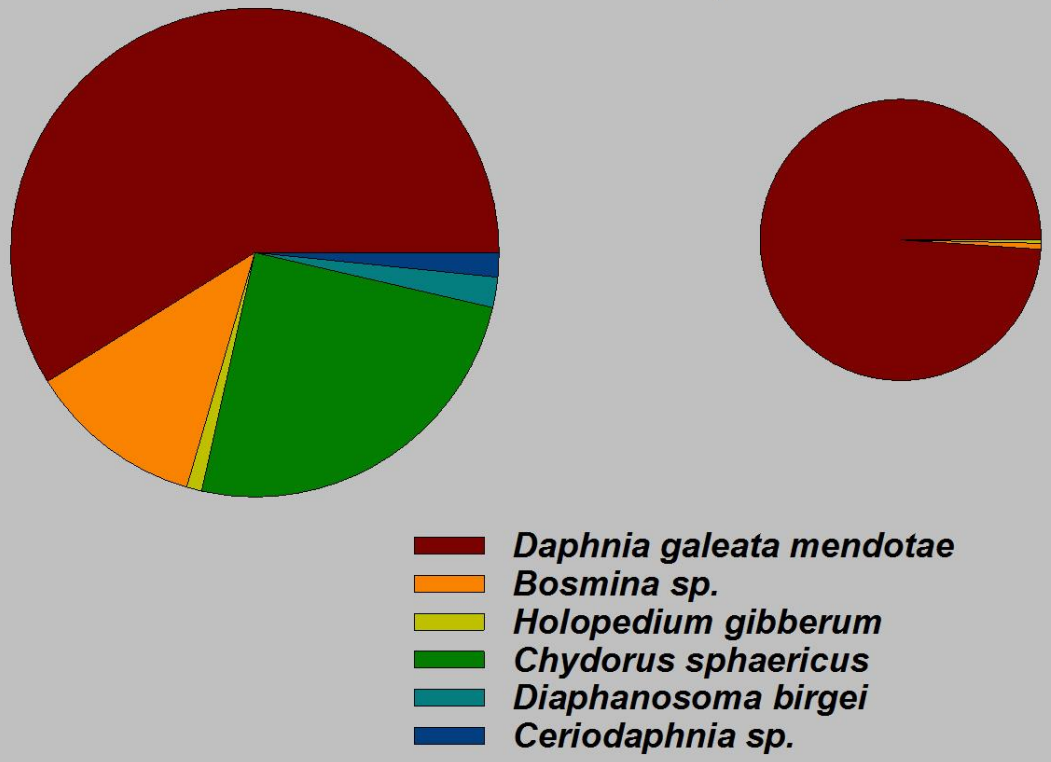
Mille Lacs Lake Native Cladoceran Species Richness

June 2006

Species Richness = 6 taxa
(15.6 individuals/liter)

June 2013

Species Richness = 3 taxa
(5.1 individuals/liter)



Zebra Mussels or Spiny Waterfleas – Who's the Culprit?

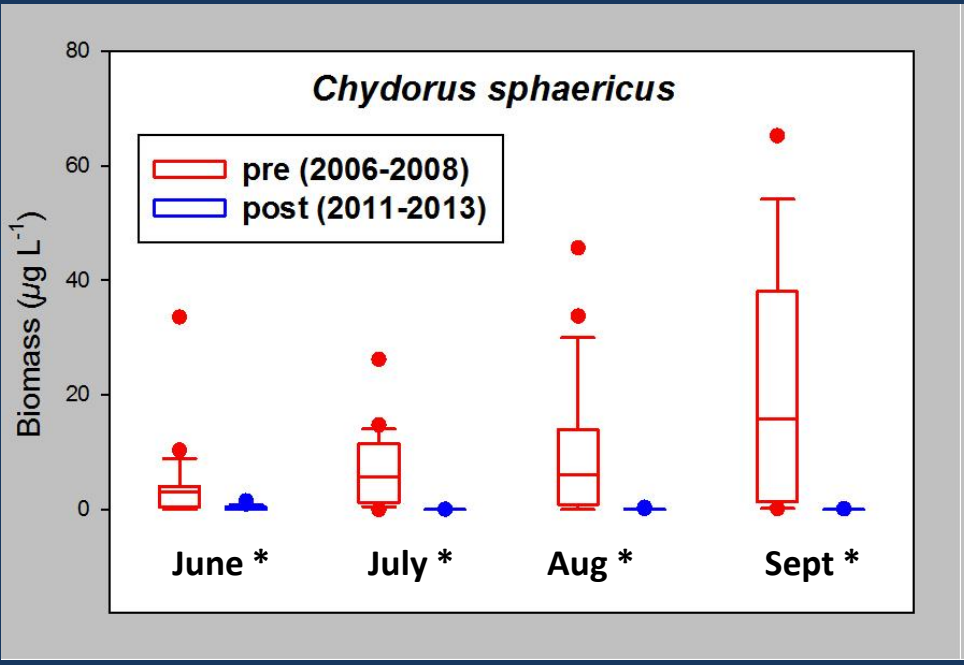
Statistical Analyses

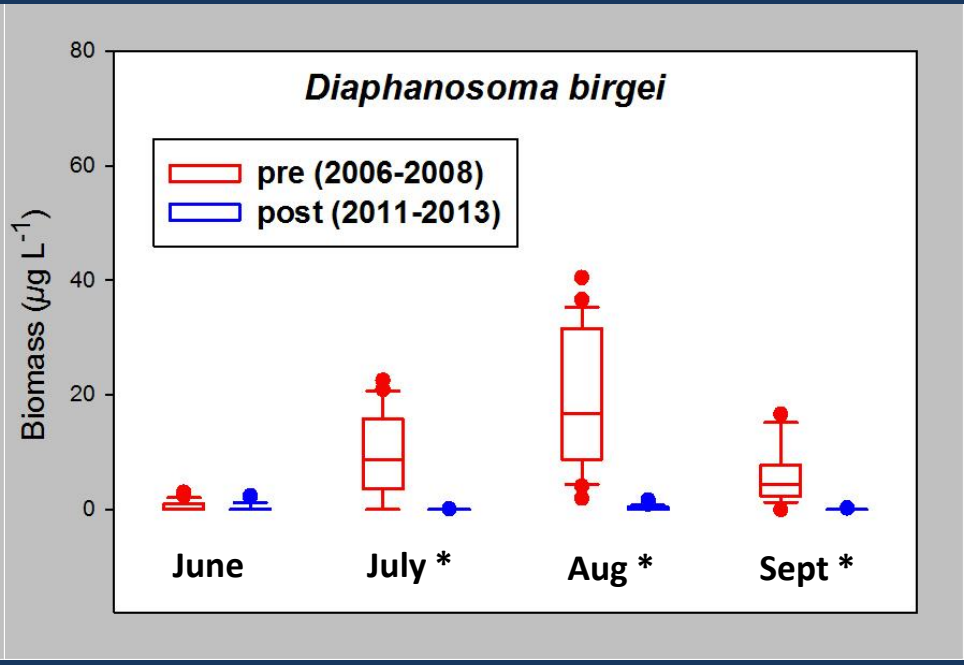
- Rank sum testing of functional groups, comparing early-zebra mussel, pre-spiny waterflea years (2006-2008) with post-infestation years (2011-2013)

- Multivariate analysis using non-parametric multidimensional scaling (MDS) to examine zooplankton community changes

Mille Lacs Lake

Biomass Boxplots-Small Cladocerans



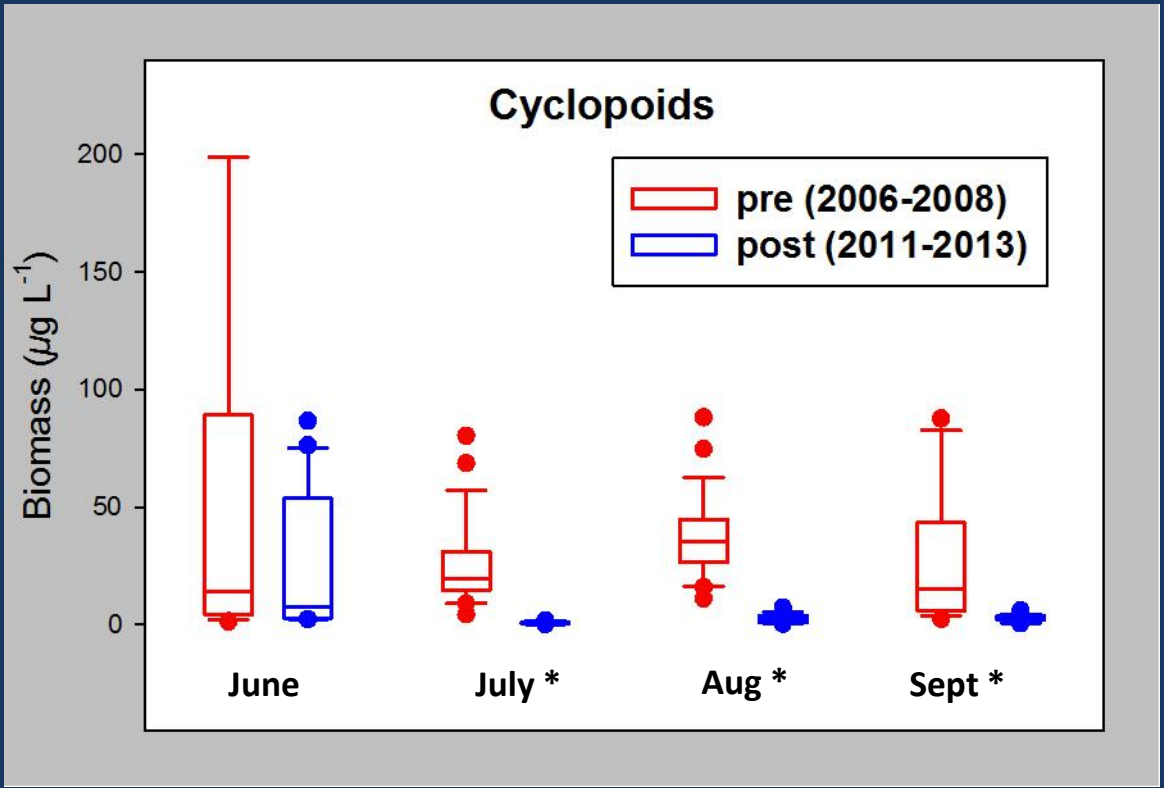


Asterisks (*) indicate significant difference between pre and post infestation years (p<.01) Mann Whitney Rank Sum Test

Direct Predation

Mille Lacs Lake

Biomass Boxplots- Cyclopoid Copepods (predators)



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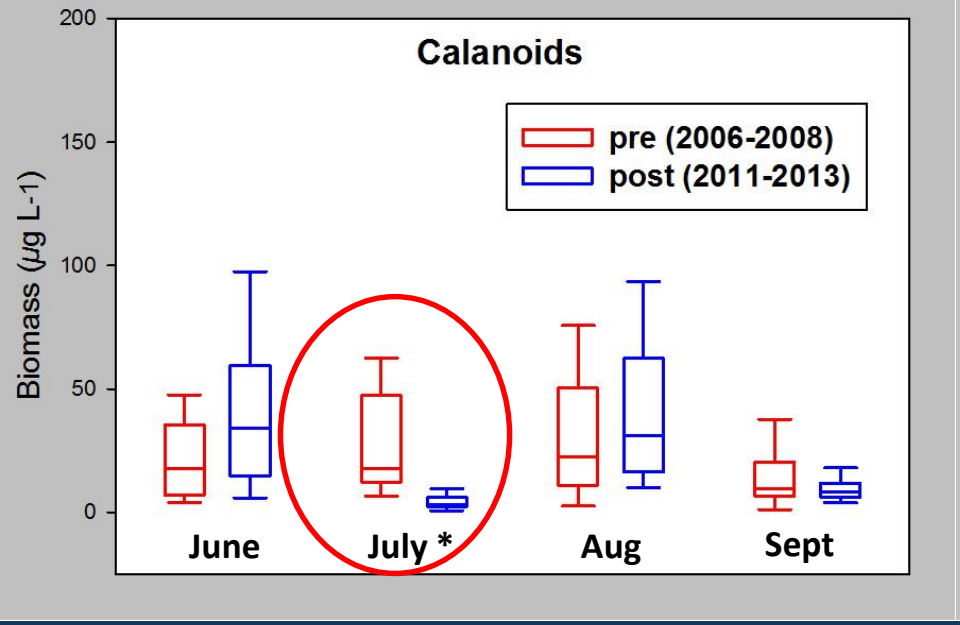
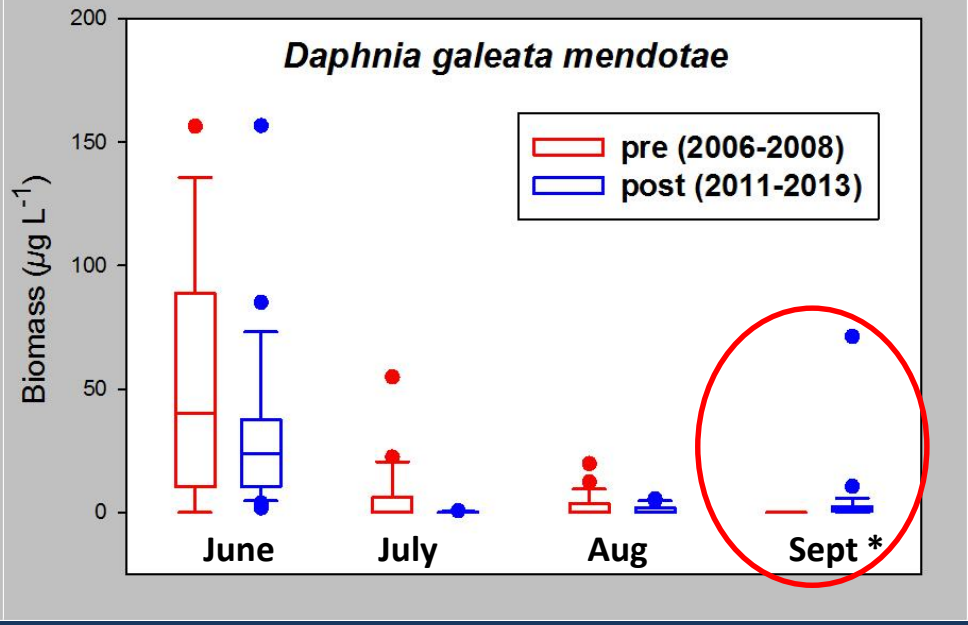
Competition

Mille Lacs Lake

Biomass Boxplots-Large Grazers





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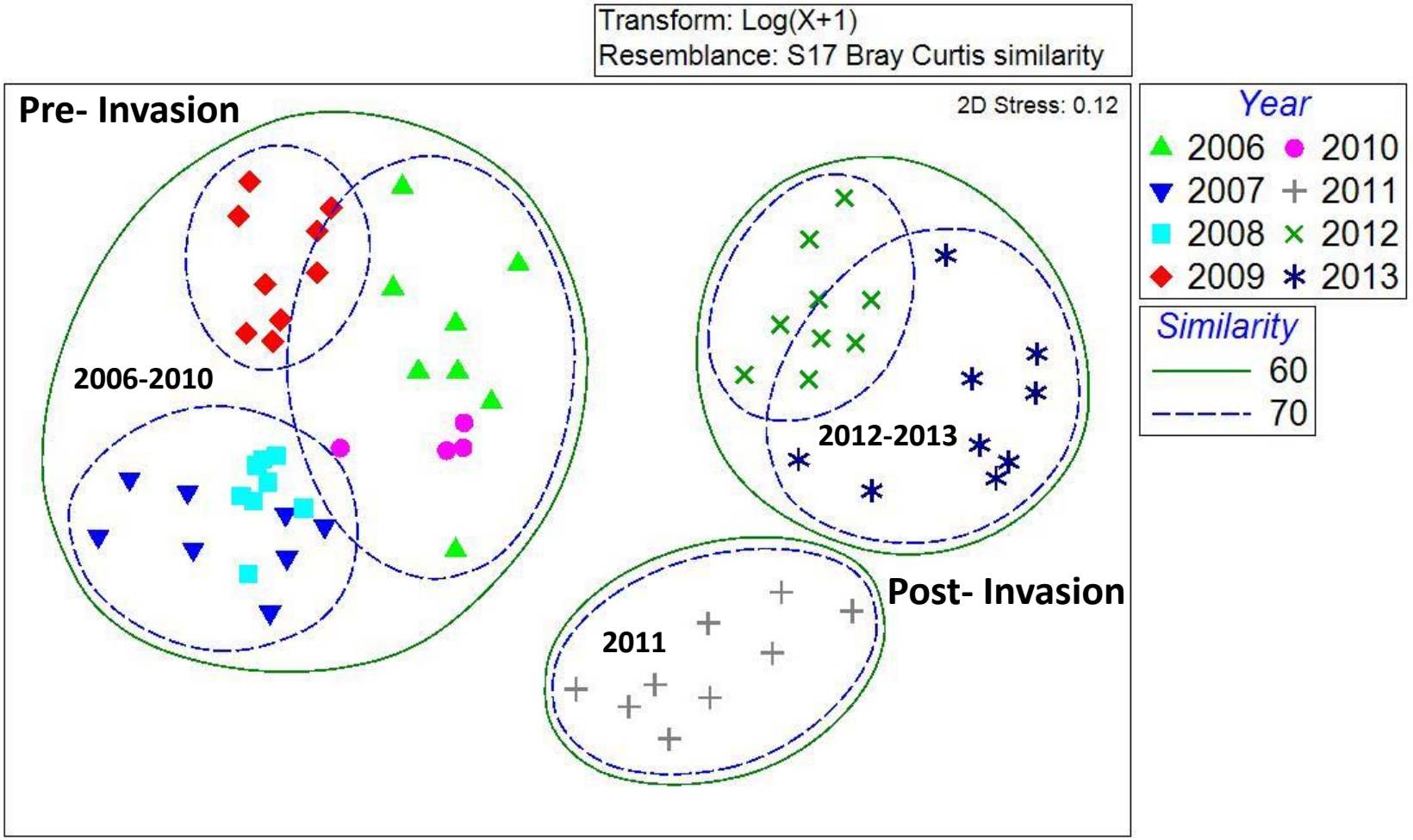
Competition

Mille Lacs Lake Zooplankton Assemblages

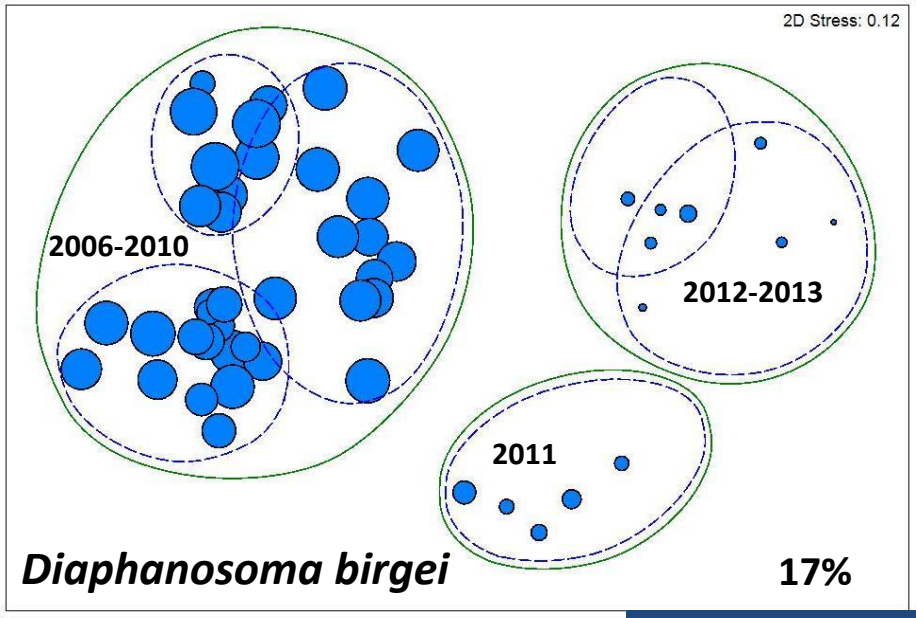
August Biomass (2006-2013)

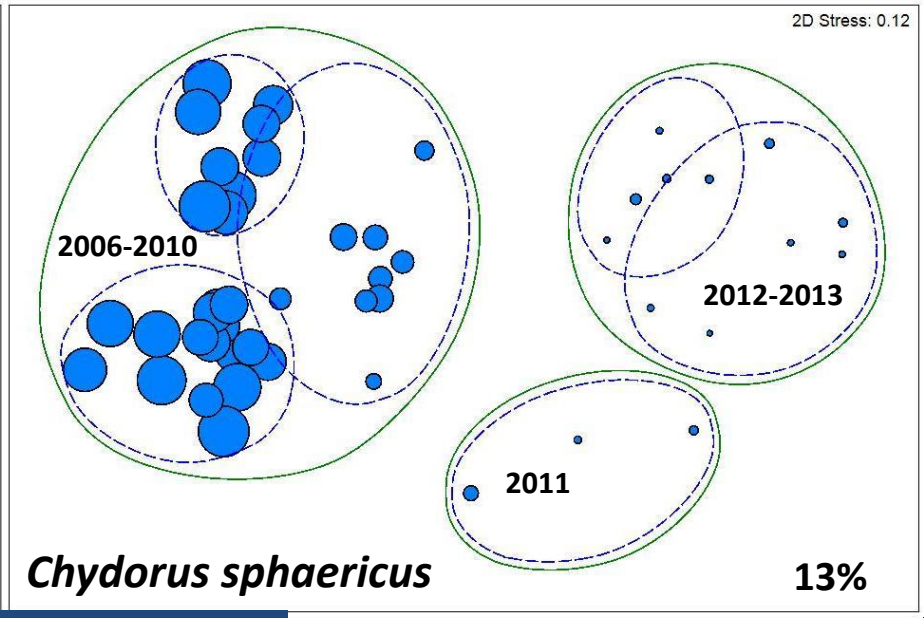


Non-metric Multidimensional Scaling (MDS)

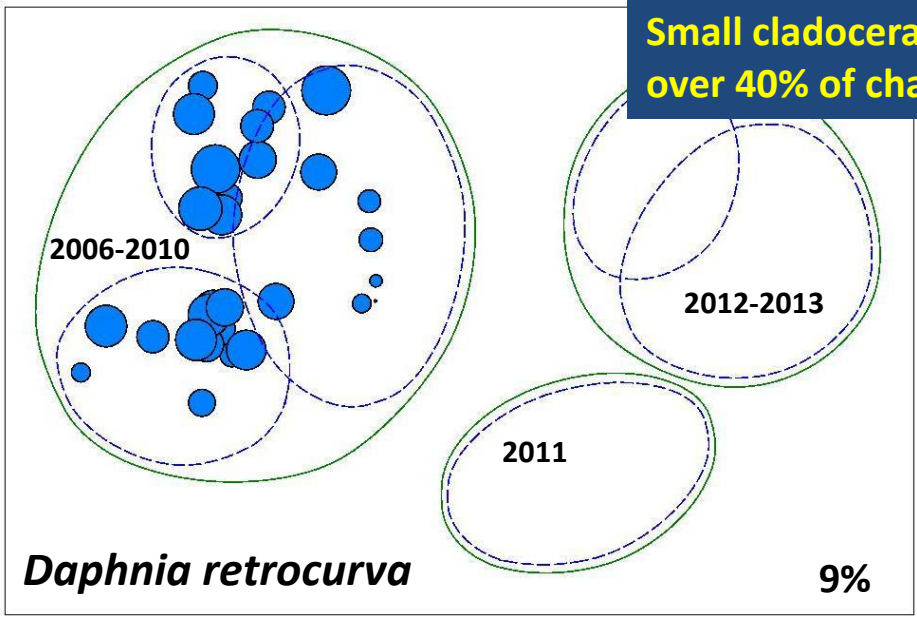
Mille Lacs Lake Zooplankton Biomass (August 2006-2013)

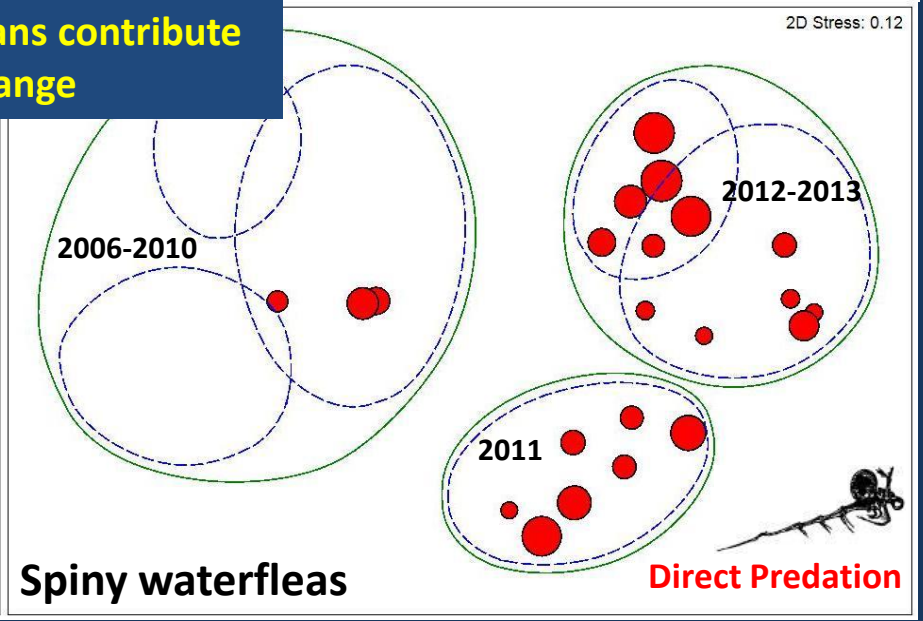
Non-metric Multidimensional Scaling (Small Cladocerans)





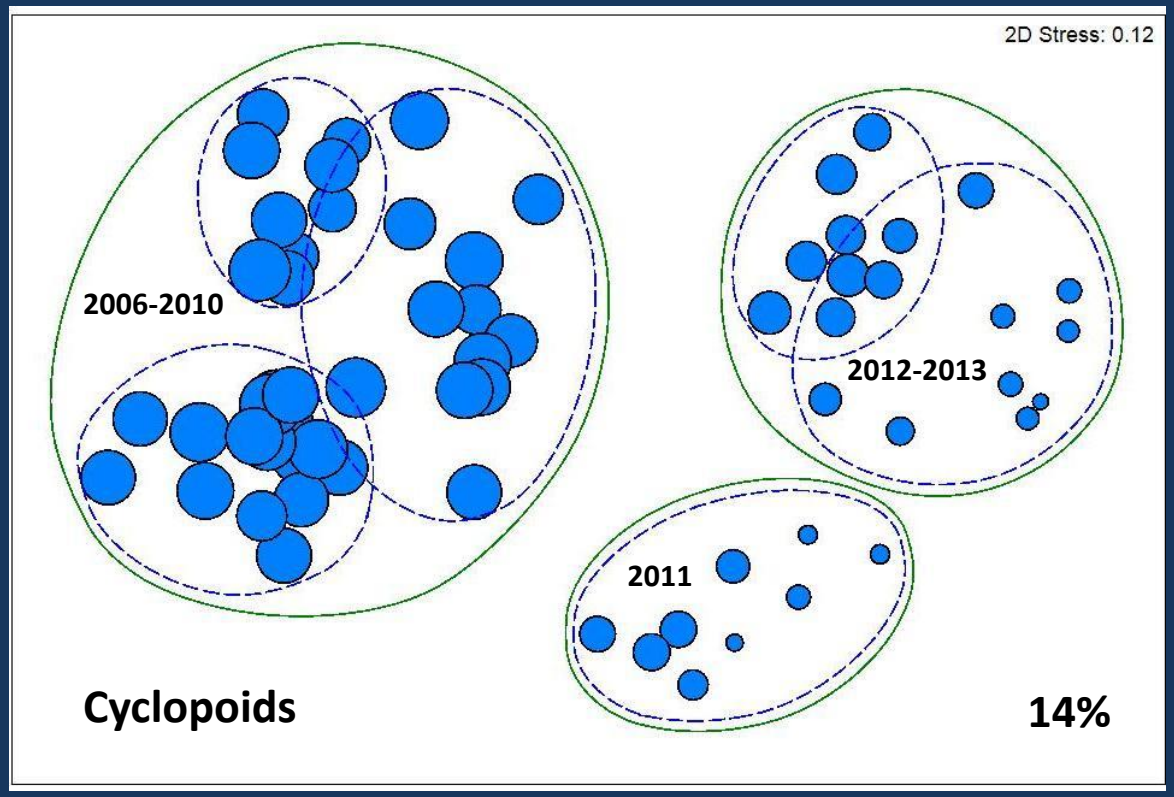
Small cladocerans contribute over 40% of change





Mille Lacs Lake Zooplankton Biomass (August 2006-2013)

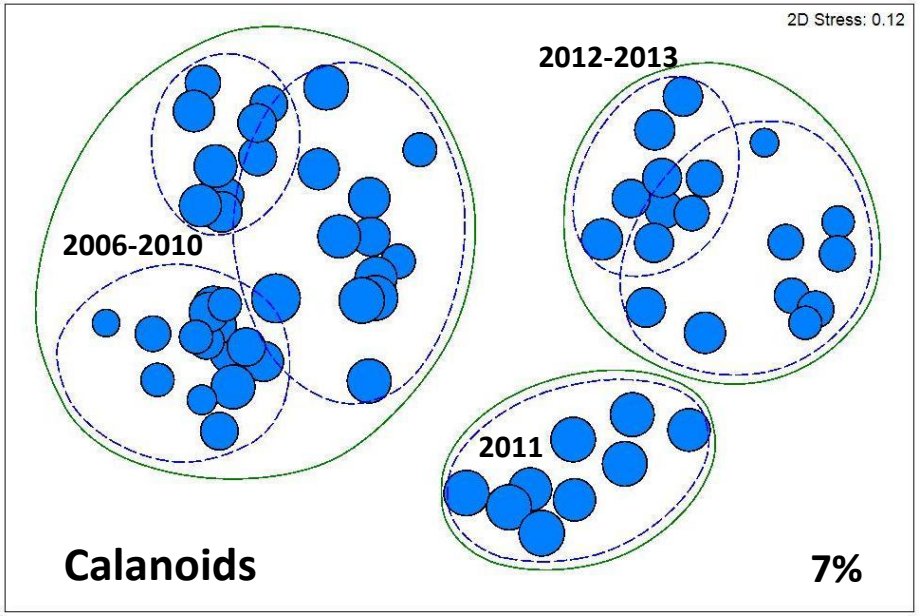
Non-metric Multidimensional Scaling (Cyclopoids)

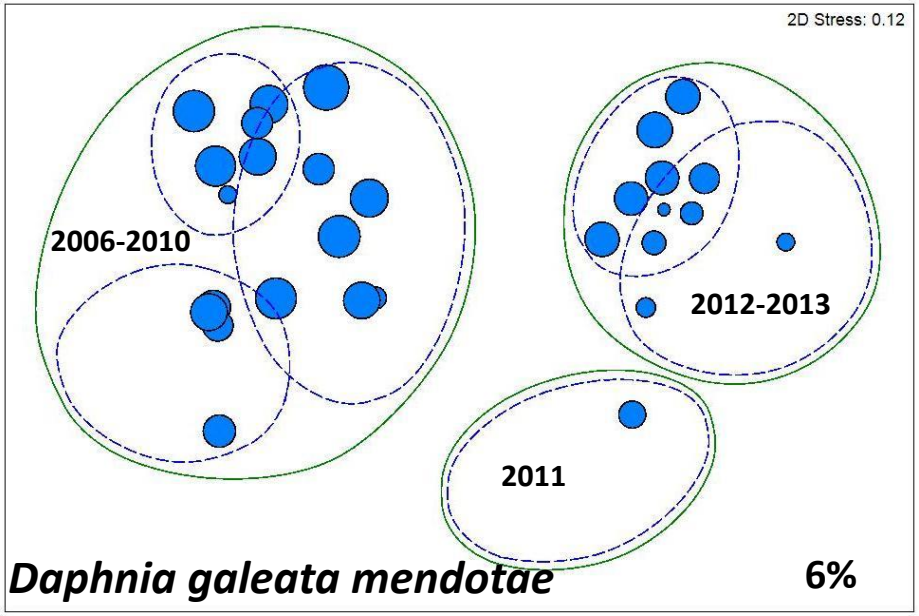


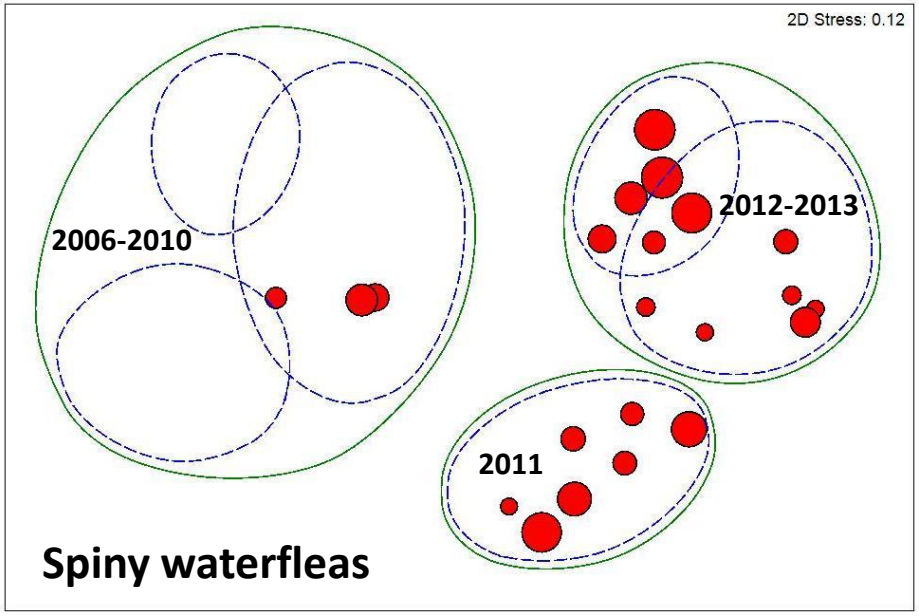
Competition

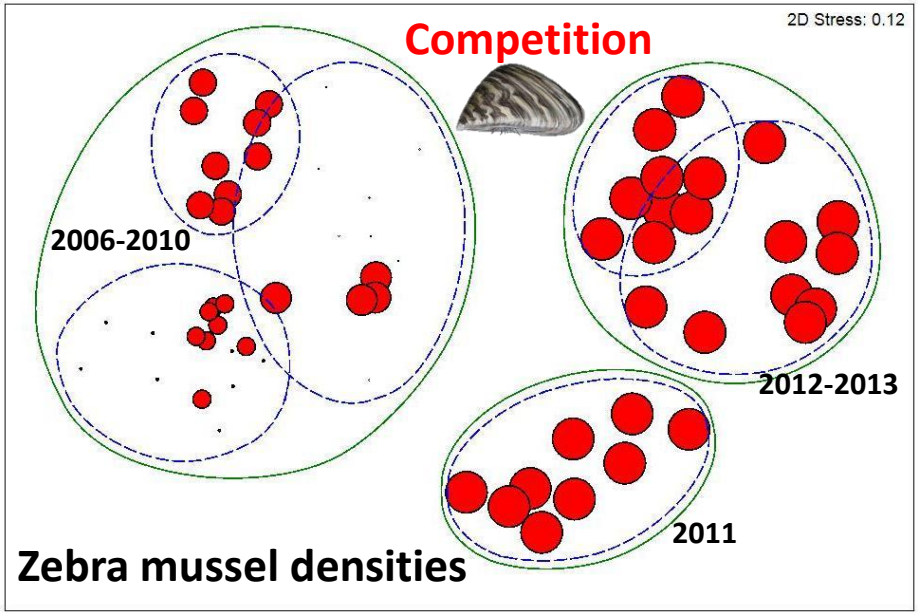
Mille Lacs Lake Zooplankton Biomass (August 2006-2013)

Non-metric Multidimensional Scaling (Large Grazers)









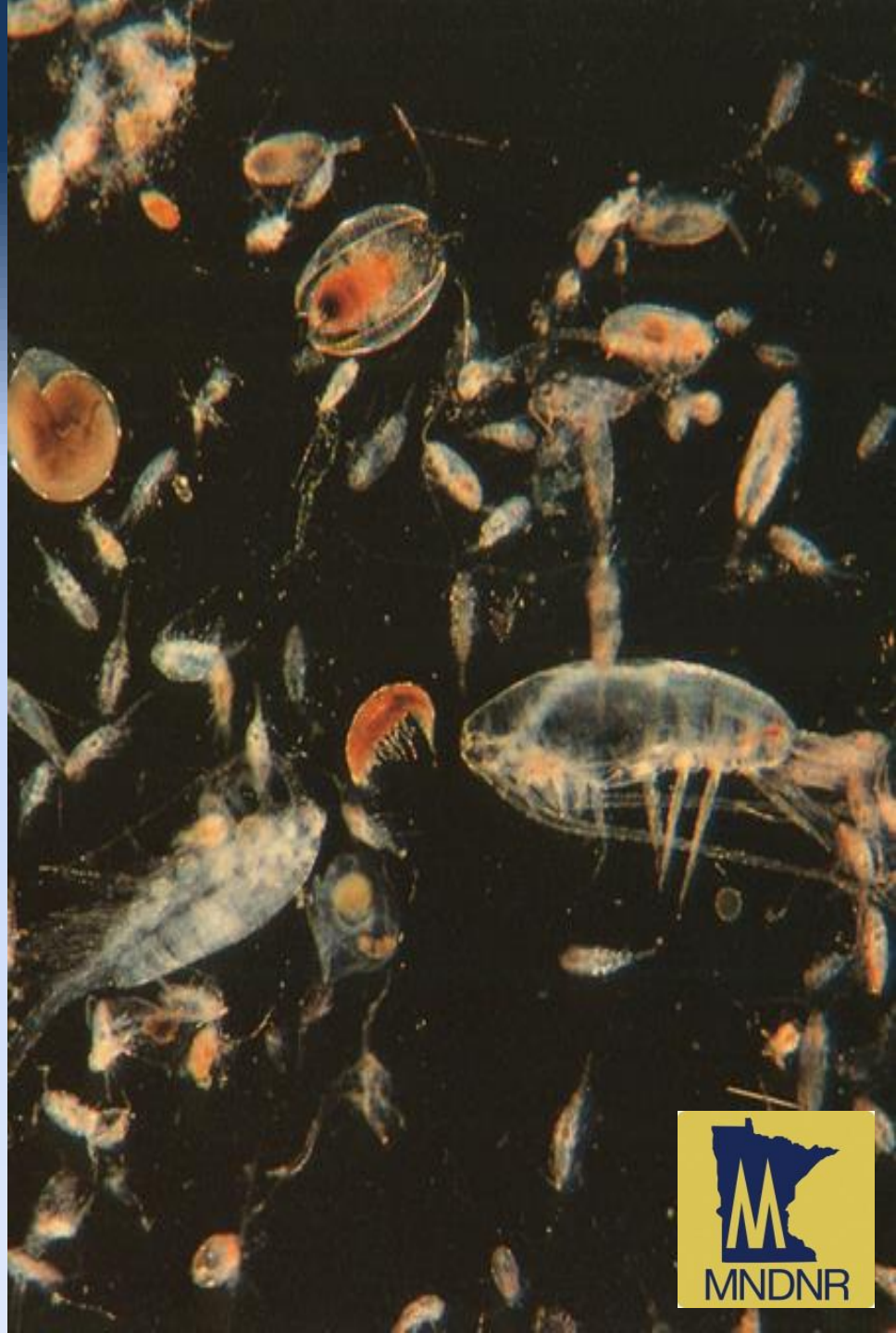
Mille Lacs Lake Zooplankton

Summary

- Estimated 60% loss of zooplankton biomass from pre- to post-infestation years
- Significant declines of small cladocerans and cyclopoid copepods suggest spiny waterflea impacts by direct predation and competition for food
- Mixed results with zebra mussel impacts, with no overall significant declines of larger grazers, although competition interactions may be slower to develop

Why the Concern?

- Primary food sources for both YOY game fish and forage fish
- Efficient phytoplankton grazers, keeping algae in check
- Loss of zooplankton in Mille Lacs Lake can have impacts throughout the aquatic food web



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Questions?

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