Placing physiochemical alterations of Lake Tahoe into biological context: eutrophication leads to large changes in sensitive, bottom-dwelling indicator taxa.

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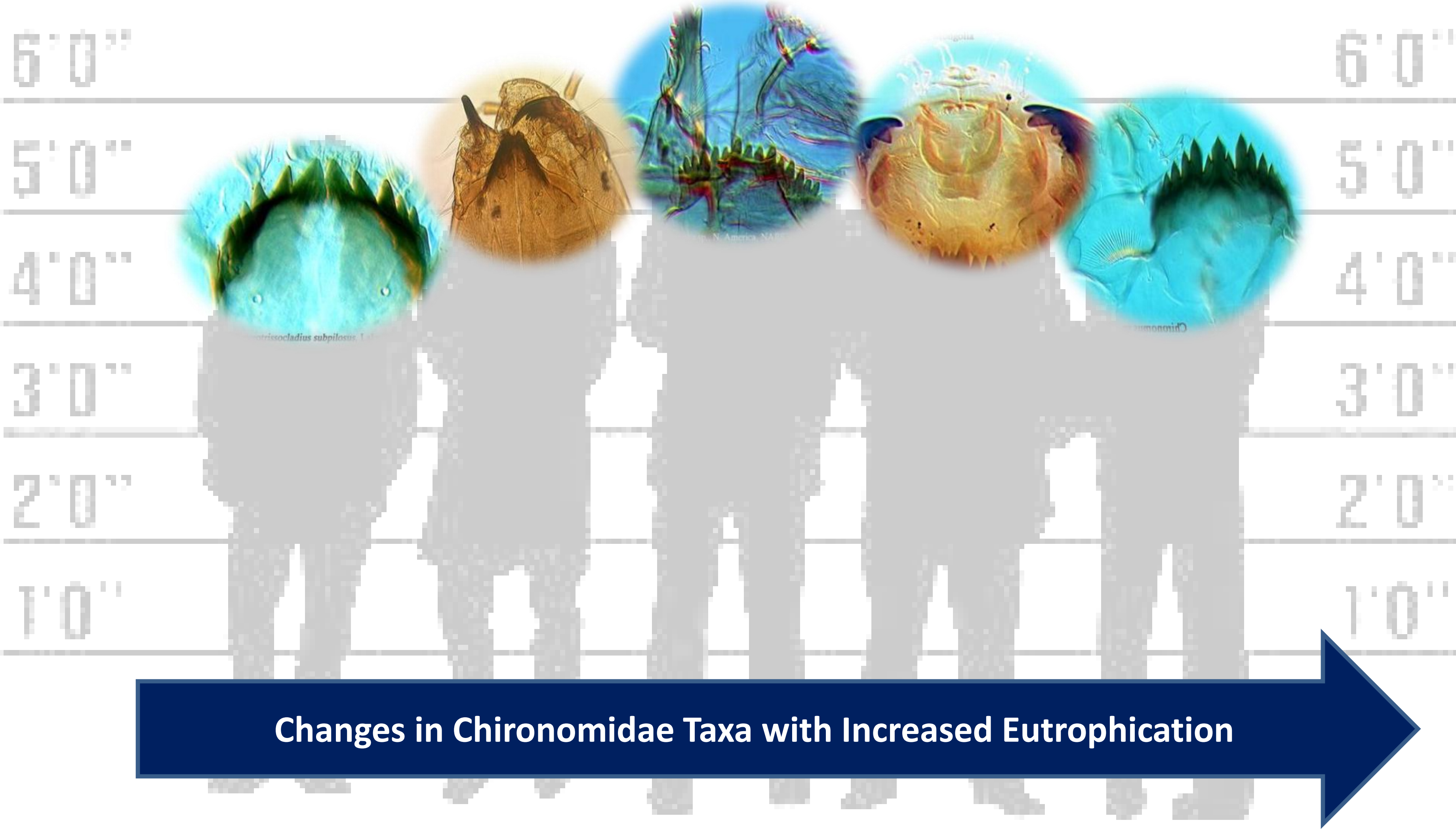
WSC Wildcats

Introduction

- **Lake Tahoe has undergone progressive, eutrophication over the last 45 years.**
- **Determined largely through measurements of clarity and pelagic primary productivity.**
- **Sensitive bottom dwelling insects may corroborate these changes.**
- **Through the relationship between lake trophic status and particular indicator species of non-biting midges (Chironomidae)**

Corynoneura sp., CA, Sierra Nevada

The Usual Suspects



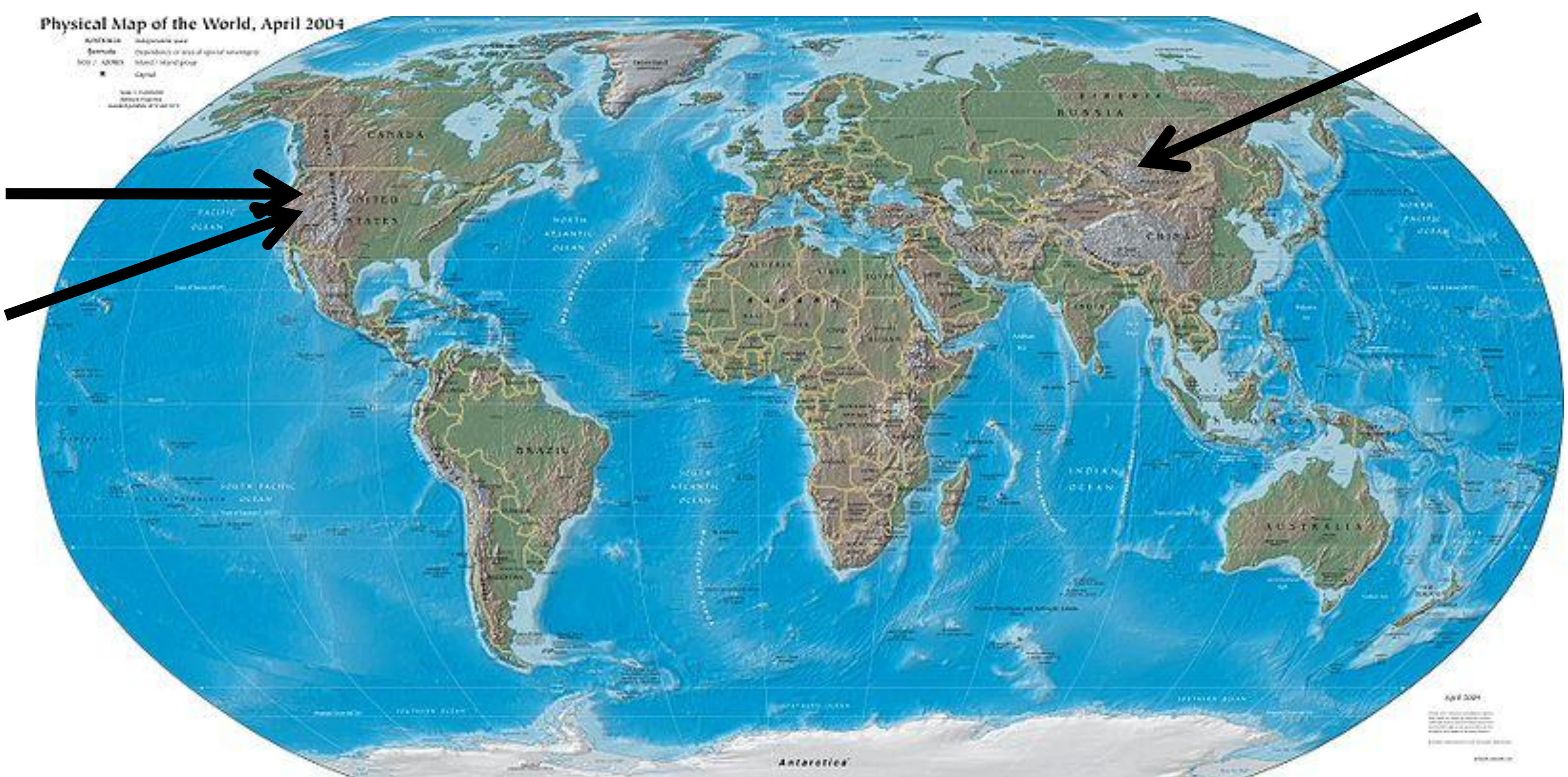
Examples in Sæther 1979, Chironomidae heads from Cranston (www.skullisland.info)

Tahoe Dominant Taxa Past and Present

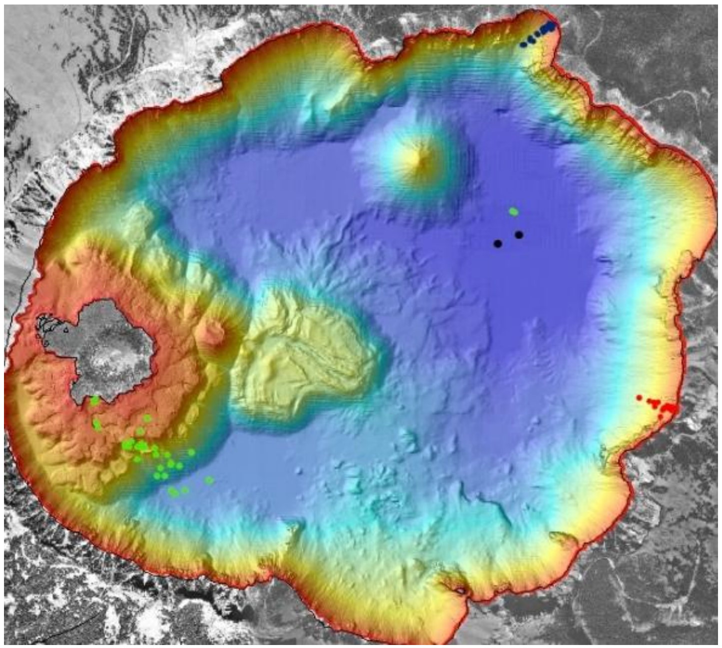
- Chironomid composition showed changes to more tolerant taxa in Lake Tahoe
- A shift from deep to shallow waters

Caires et al. *in review*	Dominant Taxa	Trophic Designation	Location
Tahoe Present	*Cladotanytarsus vanderwulpi* *Monodiamesa* *Tanytarsus* *Stictochironomus*	Wide Tolerance Oligo Wide Tolerance Oligo/Meso	< 30 m < 60 m < 40 m < 30 m
Tahoe 1960s	*Heterotrissocladius subpilosus* *Monodiamesa* *Paracladopelma* *Endochironomus*	Ultra/Oligo Oligo Ultra/Oligo No Information	Widely Distributed >30 m >150 m Widespread to 300 m

- COMPARISON ANALYSIS: But how do we compare change in Lake Tahoe, an old, deep, complex lake with other lakes?
- We compare the communities of chironomids with other deep, montane, lake ecosystems from the northern hemisphere that may serve as reference.



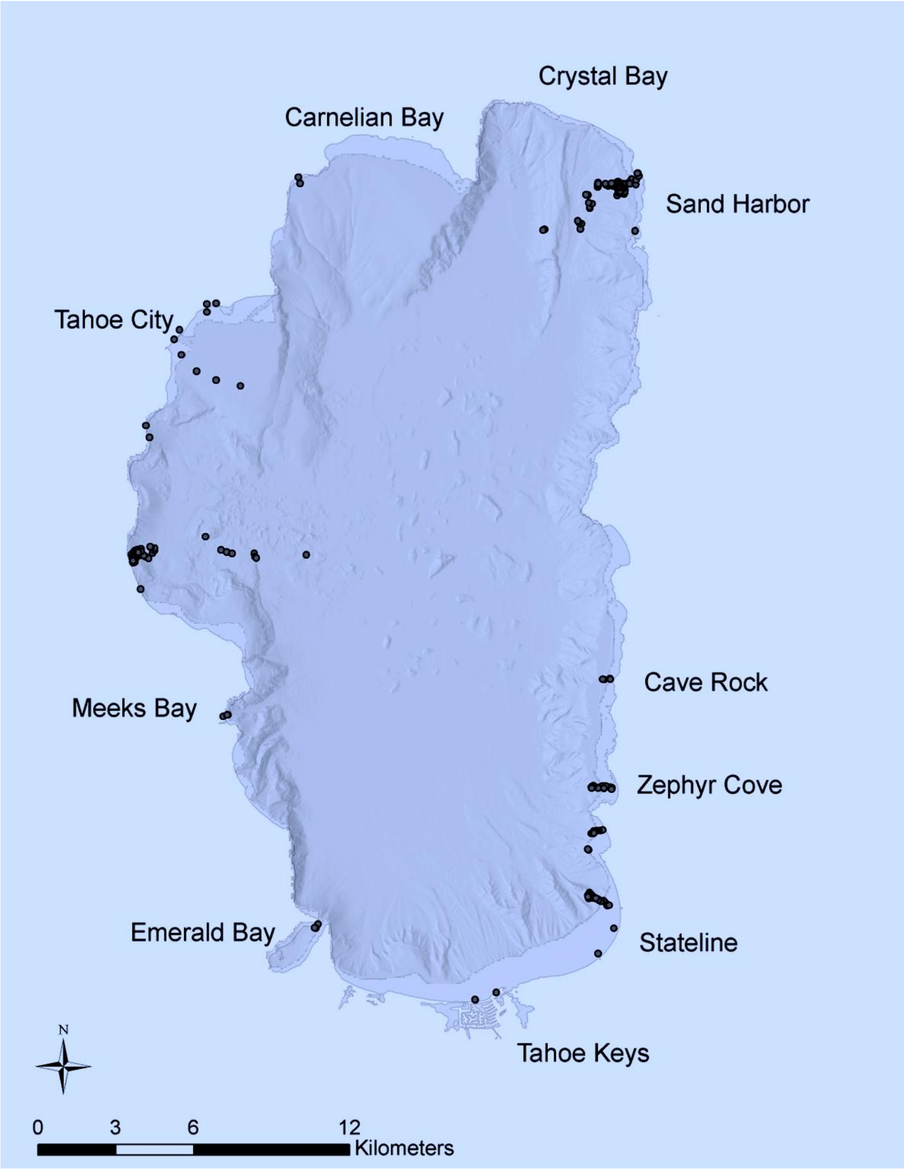
Purpose



(Sæther 1979, use in paleolimnology see Walker 1987, recent use see Langdon et al. 2006).

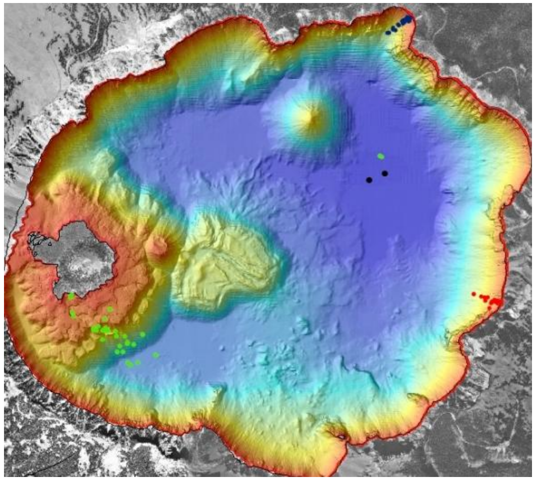
- If chironomid communities are similar between different depth zones between the three lakes, they may be suitable for comparison.
- If they are significantly different, then we can search for reasons for the differences.
- We tested for similarities between chironomid communities between three large, old, lakes.
- From near shore and deep regions of each lake.

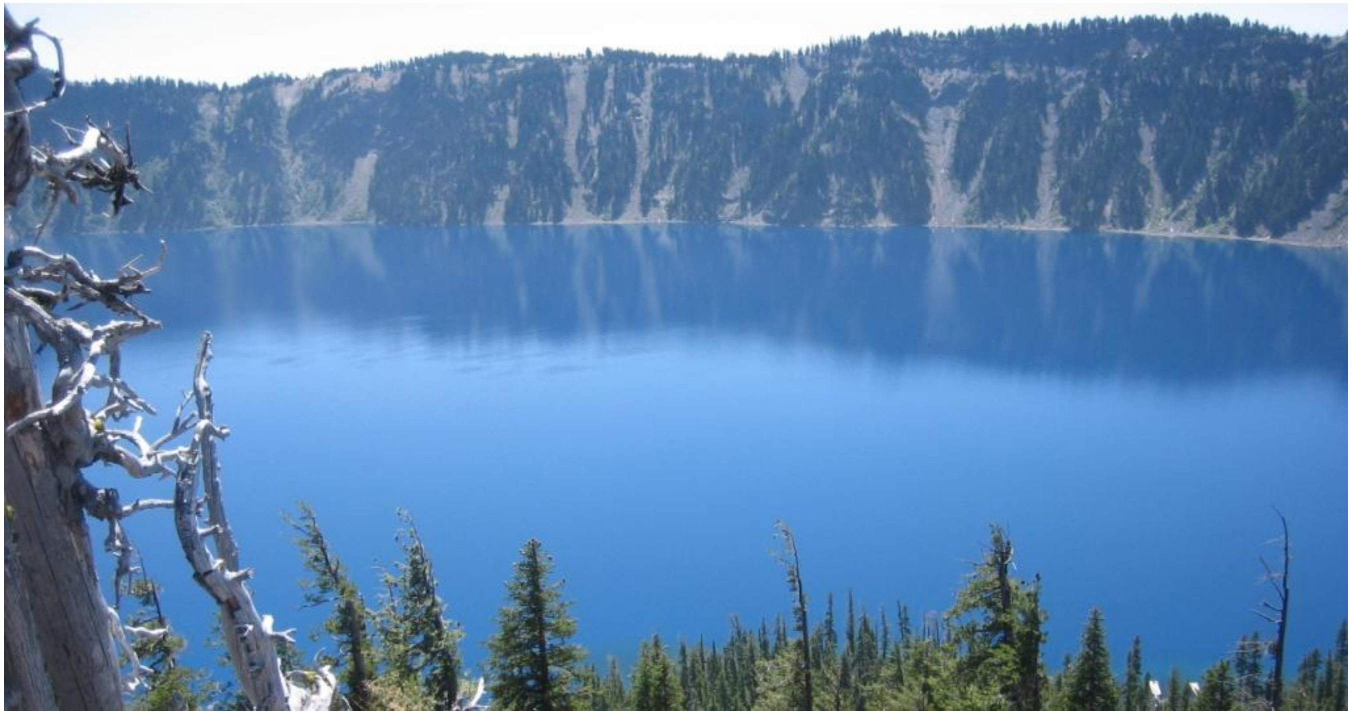
Lake Tahoe, California/Nevada, USA



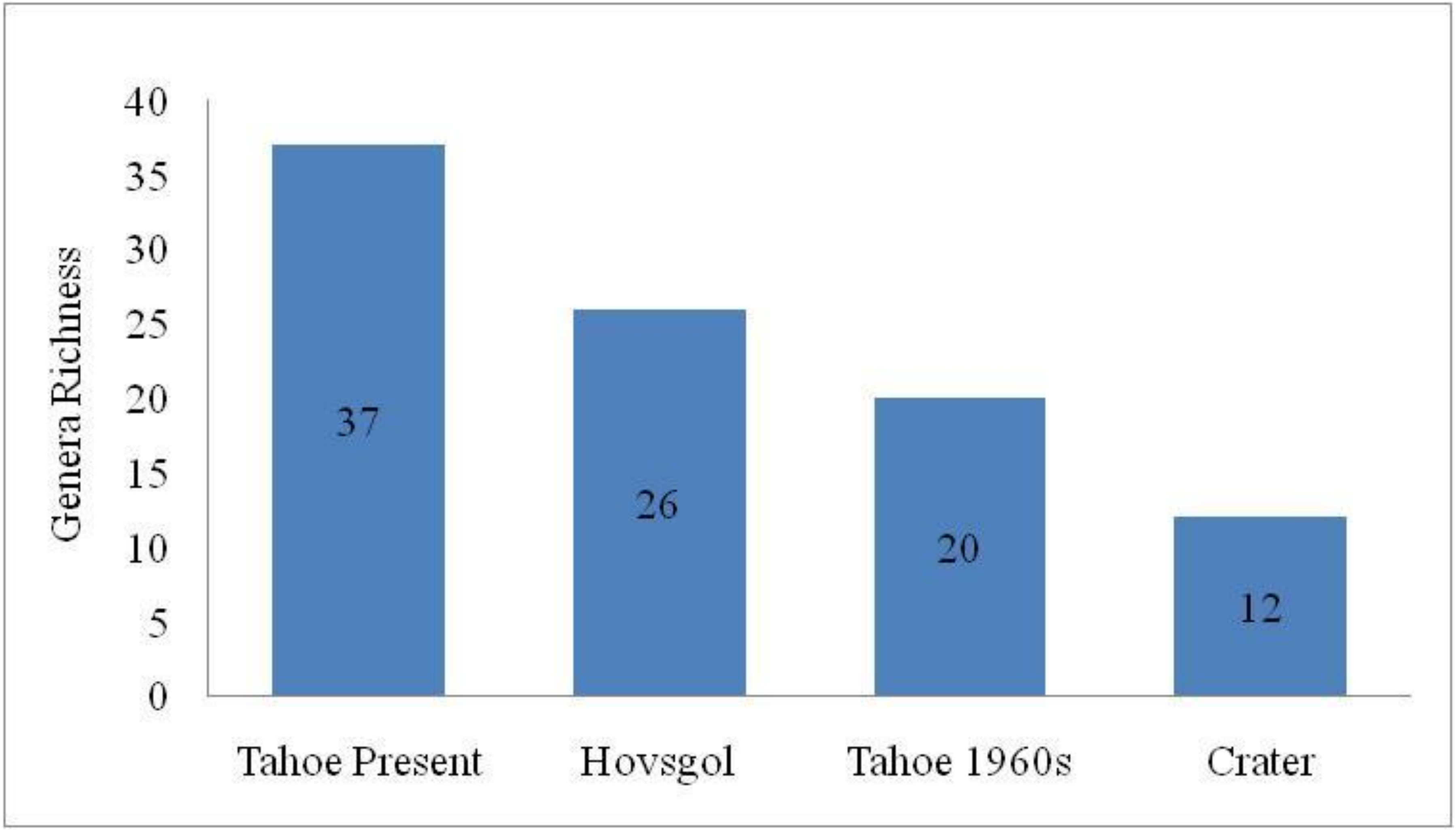
Lake Hövsgöl, Mongolia

Crater Lake, Oregon, USA





Results: Genera richness differences among lakes



Results

- 54 distinct taxa
- From 5 Subfamilies
- Dominant taxa varied between lake depth zones and lakes.
- Chironomid communities from near shore and deep zones of the lake varied at the subfamily and tribe level.

Trophic Status and Chironomidae

- *Heterotrissocladius* dominated Crater Lake, indicating ultra-oligotrophic conditions.
- Prominance of *Monodiamesa*, *Paracladius* and to a lesser degree *Stictochironomus* indicate oligotrophic conditions in Hövsgöl.
- Tahoe still has indicators for oligotrophy in large numbers, but shows a shift to more widely tolerant taxa indicating movement toward mesotrophic conditions.
- *Note that some species of *Tanytarsus* and *Procladius* do indicate oligotrophic conditions, but we lacked taxonomic resolution in this analysis.

Crater Lake Near Shore	Crater Deep
***Orthcladius* unique sp.**	***Heterotrissoacladius***
Psectrocladius (Psectrocladius)	***Orthocladius***
Heterotrissocladius	

Hövsgöl Near Shore	Hövsgöl Deep
Micropsectra	***Paracladius***
Orthocladius	***Stictochironomus***
Stictochironomus	***Monodiamesa***

Tahoe Near Shore	Tahoe Deep
Cladotanytarsus	***Polypedilum***
Tanytarsus*	***Monodiamesa***
Monodiamesa	***Procladius****
Stictochironomus	

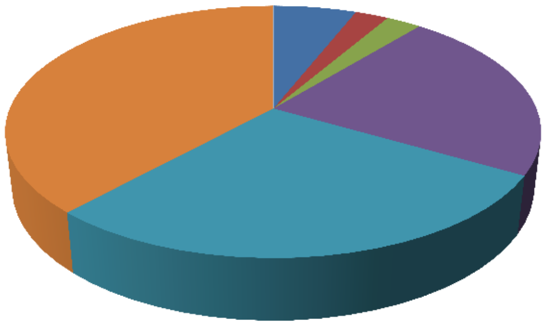
White=unknown, Blue=Ultra/Oligo, Green=Oligo/Meso, Red=wide tolerance

Near shore Communities

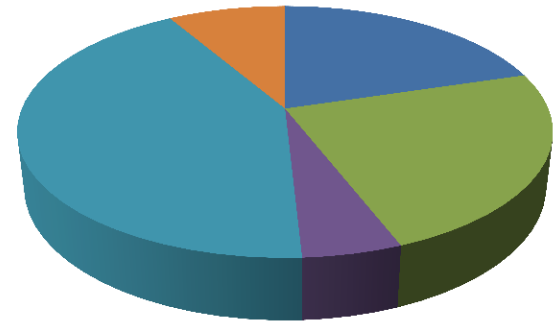
Deep Communities

Lake Tahoe

Relative Density



Relative Density



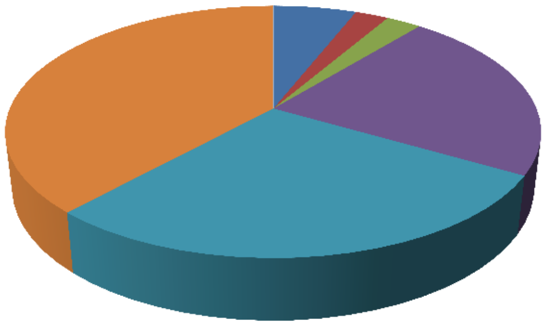
- Tanypodinae
- Diamesinae
- Prodiamesinae
- Orthocladiinae
- Chironomini
- Tanytarsini

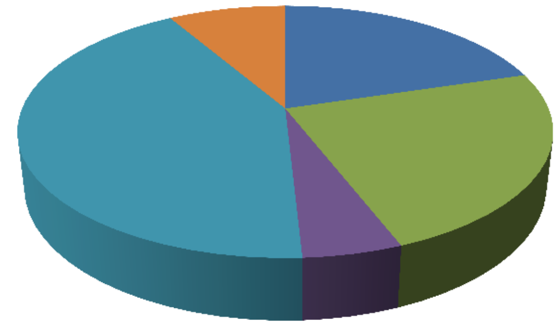
Near shore Communities

Deep Communities

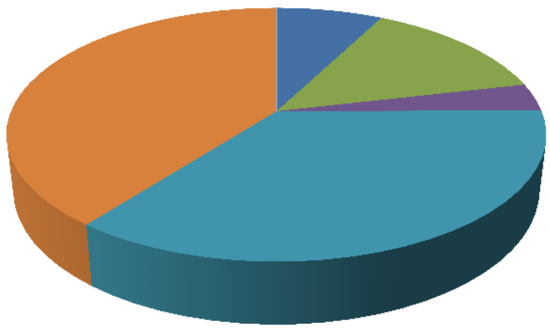
Relative Density (Near shore) | **Relative Density** (Deep)

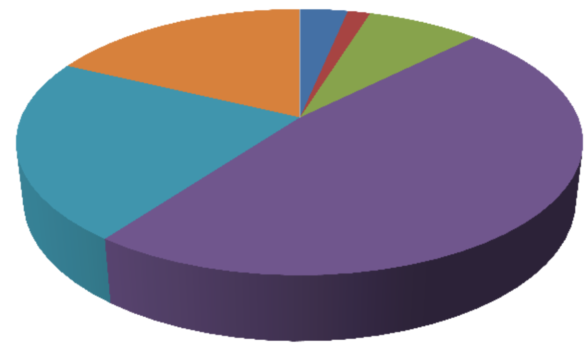
Lake Tahoe





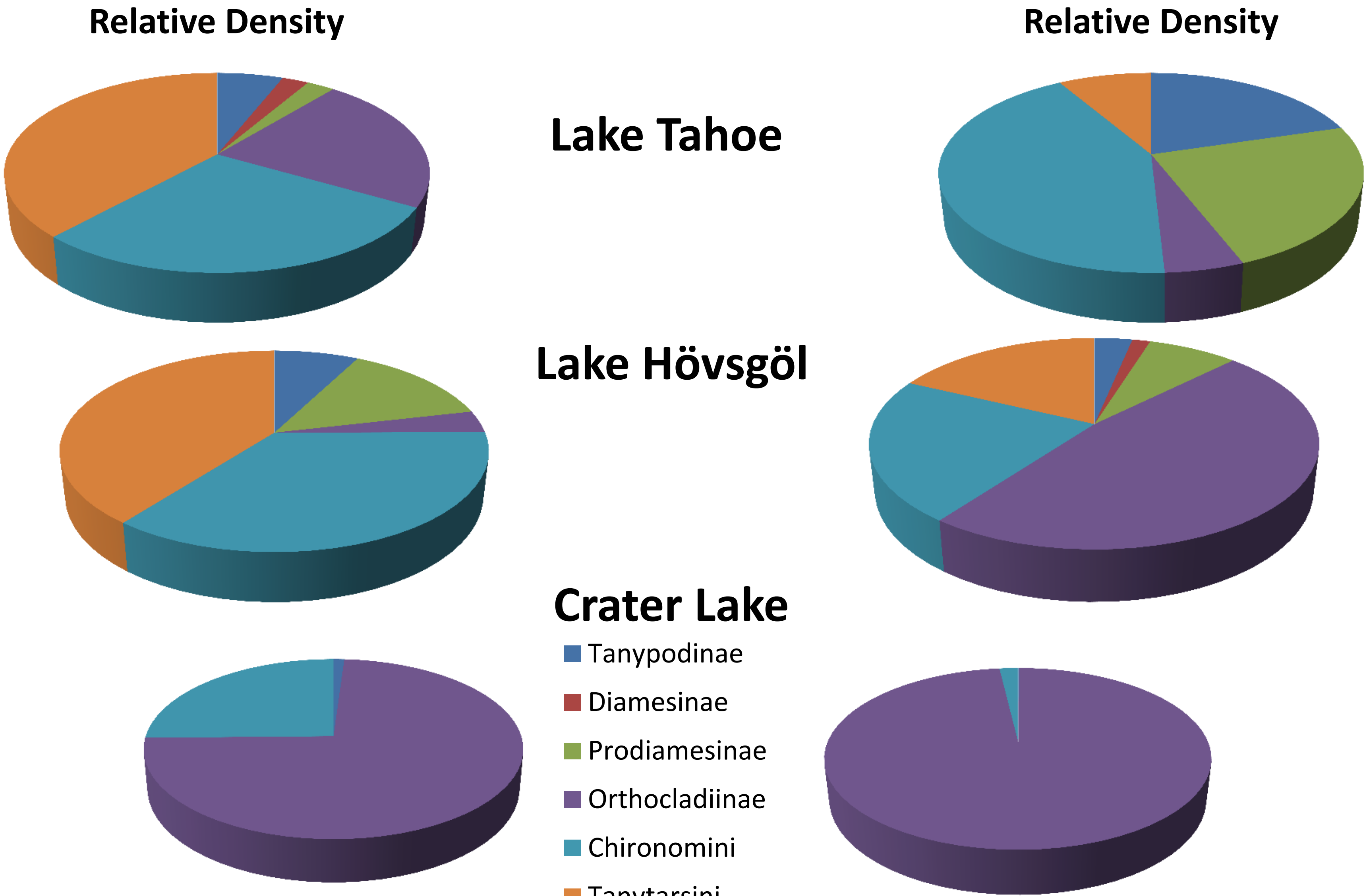
Lake Hövsgöl





Crater Lake

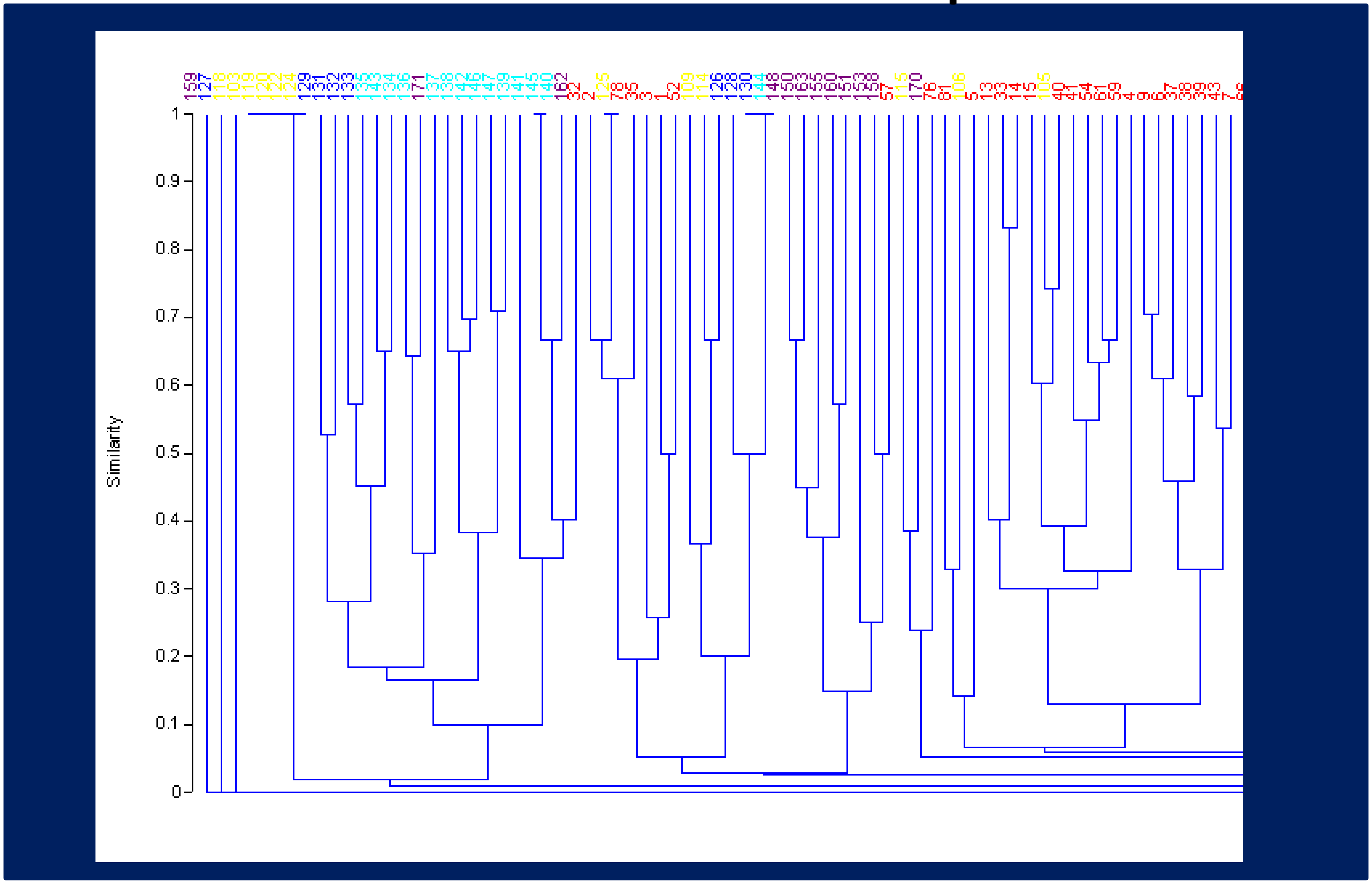
Near shore Communities Deep Communities



Analytical Methods

- Compared at genus level to reduce influence of biogeography.
- We tested for significant differences between near shore and deep zone communities for all taxa combined.
- Hierarchical cluster analysis using Bray-Curtis similarity using paired linkage.
- Cophenetic correlation coefficient was used as goodness of fit with values over .75 acceptable.
- Analysis of similarity (ANOSIM), a non-parametric test used to test for significant difference between communities, was used based on Bray-Curtis similarity.
- Results were compared to randomization routine with 9999 permutations.
- Analyses were run using PAST software Ver. 2.15 Hammer 1999-2012.

Results: One large dendrogram colors denote different depth zones



Based on 202 samples: Cophenetic Correlation Coefficient ~0.77

R values followed by significance values for communities of Chironomidae from nearshore and deep zones of Lake Tahoe, Crater Lake, and Lake Hövsgöl.

Differences between communities increase with increased R values.

	Tahoe near shore	Tahoe deep	Crater near shore	Crater deep	Hövsgöl near shore	Hövsgöl deep
Tahoe near shore		0.0015	0.0015	0.0015	0.0015	1
Tahoe deep	0.2843		0.006	0.0015	0.0015	0.1365
Crater near shore	0.5032	0.1658		0.0345	0.0015	0.0015
Crater deep	0.5641	0.2927	0.3232		0.0015	0.0015
Hövsgöl near shore	0.3045	0.4676	0.5923	0.6493		1
Hövsgöl deep	-0.02819	0.1431	0.8878	0.9232	-0.02532	

Lower half, R values, upper half, significance values.

Overall, most communities were significantly different from each other. However, the Hövsgöl deep community was not significantly different from Tahoe near shore or Tahoe deep communities.

R values followed by significance values for communities of Chironomidae from nearshore and deep zones of Lake Tahoe, Crater Lake, and Lake Hövsgöl. **Differences between communities increase with increased R values.**						
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Tahoe near shore chironomid communities were more similar to Tahoe deep shore community than to communities in other lakes.

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Tahoe deep community was more similar to Crater near shore community and less similar to Hövsgöl near shore community.

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Crater Lake communities were more similar to each other than they were to either the Hövsgöl near shore or deep communities.

Conclusions

- Chironomid indicator species indicate differences in trophic condition between the three lakes and depth zones.
- Hövsgöl deep and near shore communities were not significantly different from Lake Tahoe chironomid communities.
- This indicates that the Hövsgöl communities may be similar enough to serve as reference communities for Lake Tahoe.
- Communities from different lakes and different regions of Lake Tahoe and Crater Lake were significantly different from each other.
- Reflects difference in diversity and corresponds to difference in trophic indicator species.

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