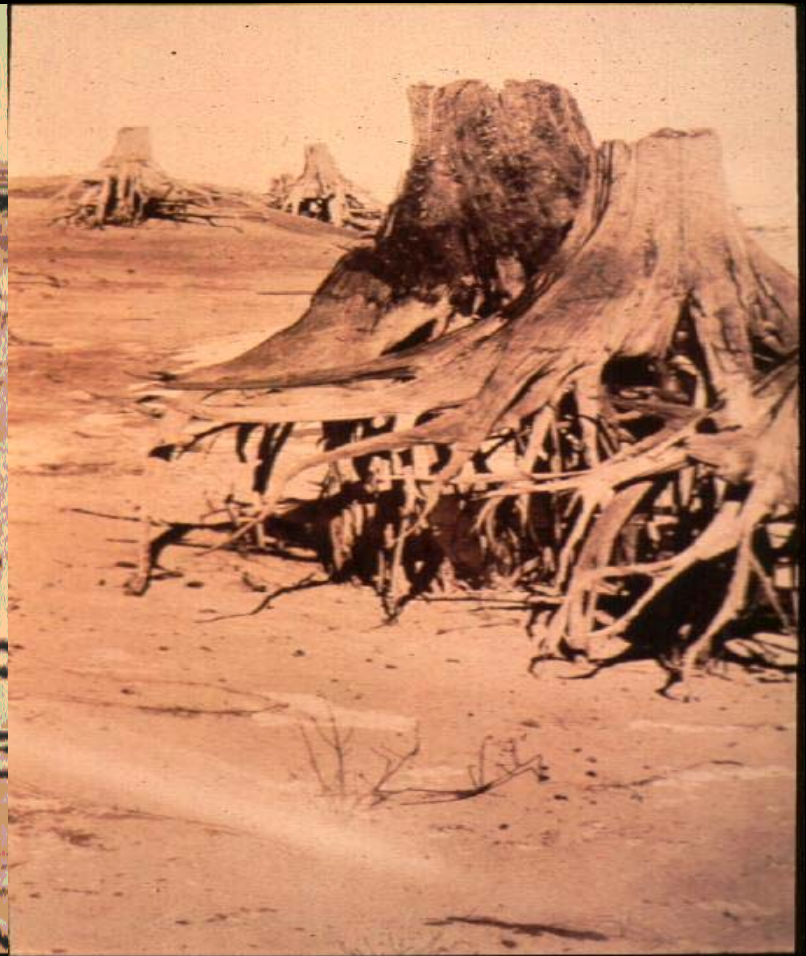


A map of the Muskegon Lake Area of Concern, showing a network of water bodies and rivers. The water bodies are colored in shades of blue and cyan, while the land is shown in a light grayish-brown. The map is oriented with the coastline on the left side.

Assessment of Benthic Invertebrate Populations in the Muskegon Lake Area of Concern

**Richard R. Rediske
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1800s – Timber harvesting, saw mills, heavy sedimentation, littoral zone filling with wood chips.



Muskegon 1889



Muskegon 1940s



Muskegon Lake



Initial BUIs for Muskegon Lake

Impairment	Rationale
Restrictions on Fish and Wildlife Consumption	Elevated PCBs in carp and mercury in walleye and bass
Degradation of Fish and Wildlife Populations	Fish Tainting, loss of sport fish, proliferation of rough fish, anoxia, and contaminated sediments
Degradation of Benthos	Low diversity, low numbers, dominance by worms, anoxia, and contaminated sediments
Restrictions on Dredging	Contaminated Sediments
Loss of Fish and Wildlife Habitat	Degradation due to contaminated sediments, poor water quality, and historic filling of the shoreline

BUIs for Muskegon Lake Added in 2002

Impairment	Rationale
Beach Closings	Sewer breaks and pump failures resulting in contact advisories (no summer beach closings reported)
Drinking Water Contamination	Abandoned oil wells and contaminated groundwater plumes
Eutrophication and Undesirable Algae	Nonpoint source pollution concerns in Muskegon and Bear Lakes
Degradation of Aesthetics	Metal and concrete debris



Importance of Benthic Macroinvertebrates

- Important part of the aquatic food web
- Fish food and processing organic matter
- Contact with sediment and water
- Good indicators of ecosystem health
- Three part target developed for delisting the Degradation of Benthos BUI for Muskegon Lake AOC



Target for Delisting the Degradation of Benthos BUI and Current Status

The Degradation of Benthos BUI will be considered restored when SWAS Procedure #51 yields a score for the benthic metrics which meets the standards for aquatic life in 2 successive monitoring cycles for Ruddiman Creek (stream channel), Ryerson Creek, Little Bear Creek (including the unnamed tributary, and the Muskegon River (South Branch near Teledyne and North Branch at the mouth).

- Ryerson Creek was removed from the 303(d) in 2008 due to improvement in the benthic community. Need one more monitoring event in 2011**
- TMDL scheduled for 2009/2010 for Ruddiman Creek to evaluate impairments and develop a plan to improve the benthic community. Need 2 monitoring events after restoration.**
- First monitoring event needs to be scheduled for Little Bear Creek (including the unnamed tributary, and the Muskegon River (South Branch near Teledyne and North Branch at the mouth). Possible 2011.**

Target for Delisting the Degradation of Benthos BUI and Current Status

In cases where MDEQ procedures are not applicable and benthic degradation is caused by contaminated sediments, this BUI will be considered restored when all remedial actions for known contaminated sediment sites with degraded benthos are completed (except for minor repairs required during operation and maintenance) and monitored according to the approved plan for the sites. The known contaminated sediment sites in the Muskegon Lake AOC are the Division Street Outfall, Ruddiman Creek, and Ryerson Creek.

- Ruddiman Creek Remediation 2007. Confirmation study conducted in the fall of 2008. Results in 2009.
- DSO remediation 2010?
- Ryerson Creek - unknown if remediation is necessary

Target for Delisting the Degradation of Benthos BUI and Current Status

SWAS Procedure #51 is not applicable to lakes and while completing sediment remediation projects at individual sites is important, Muskegon Lake has been impacted on a system-wide basis by chemical and nutrient pollution. Bear Lake is currently undergoing TMDL development for excess nutrients. Since water quality improvements are eventually reflected in the composition of the benthic community, the implementation of the recommendations in the TMDL can be considered as “remediation” in the MDEQ guidance. Because of the importance Muskegon Lake as a recreational resource and public concern related to sustaining the current trend of improving water quality, the Muskegon Lake Public Advisory Council (MLPAC) voted to adopt a target for delisting the Degradation of Benthos BUI that exceeds the State of Michigan criteria.

Target for Delisting the Degradation of Benthos BUI

- In addition, average benthic macroinvertebrate populations in Muskegon Lake should reflect the following conditions:

	1972	1999	Target
Sediment Toxicity	+	+	Amphipod Survival >60%
<i>Hexagenia</i>	-	-	Present in river mouth littoral zone
% Oligochaeta	89(±3)	68(±4)	< 75%
Chironomidae (#/m²)	158(±45)	677(±75)	> 500
Diversity (SW)	0.68(±0.11)	1.88(±0.17)	> 1.5

Important Benthic Macroinvertebrates in Muskegon Lake



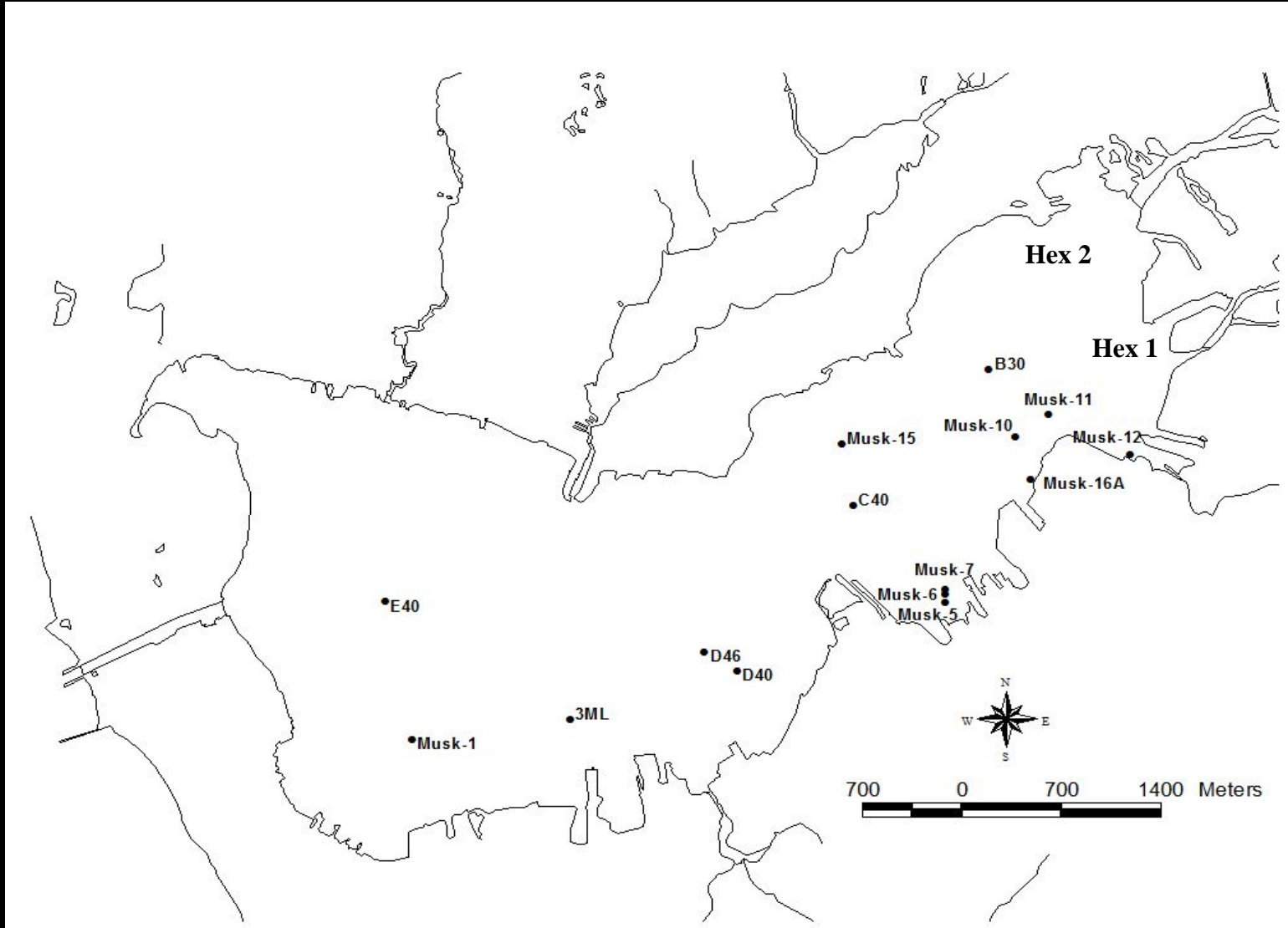


2006 Benthic Macroinvertebrate Assessment of Muskegon Lake

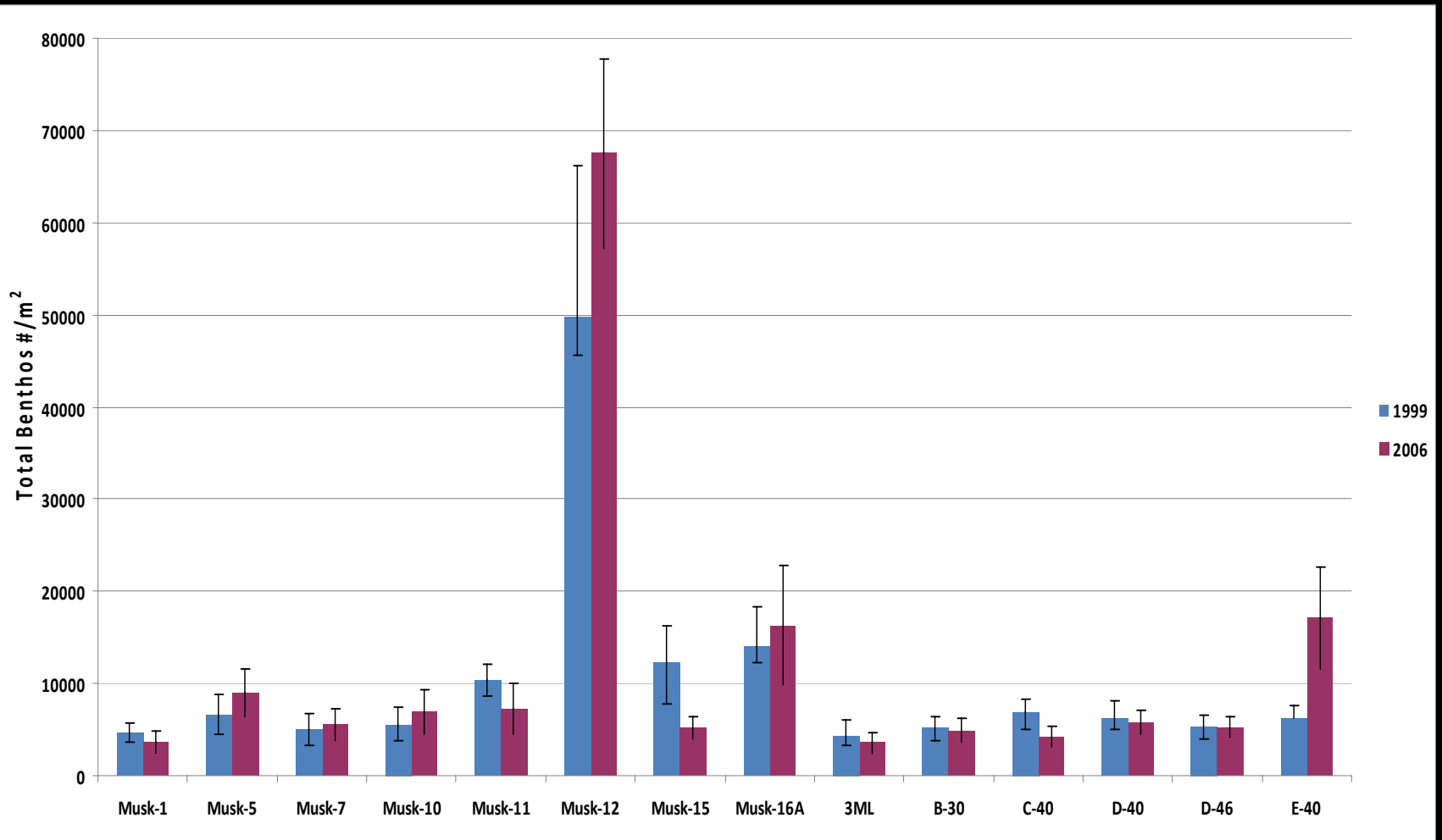
- Funded by an MDEQ Local monitoring Grant
- 15 locations sampled in Muskegon Lake in triplicate for benthic macroinvertebrates. Same locations as sampled in 1999.
- 2 locations sampled near the river mouth in triplicate for *Hexagenia*.



Sampling Locations

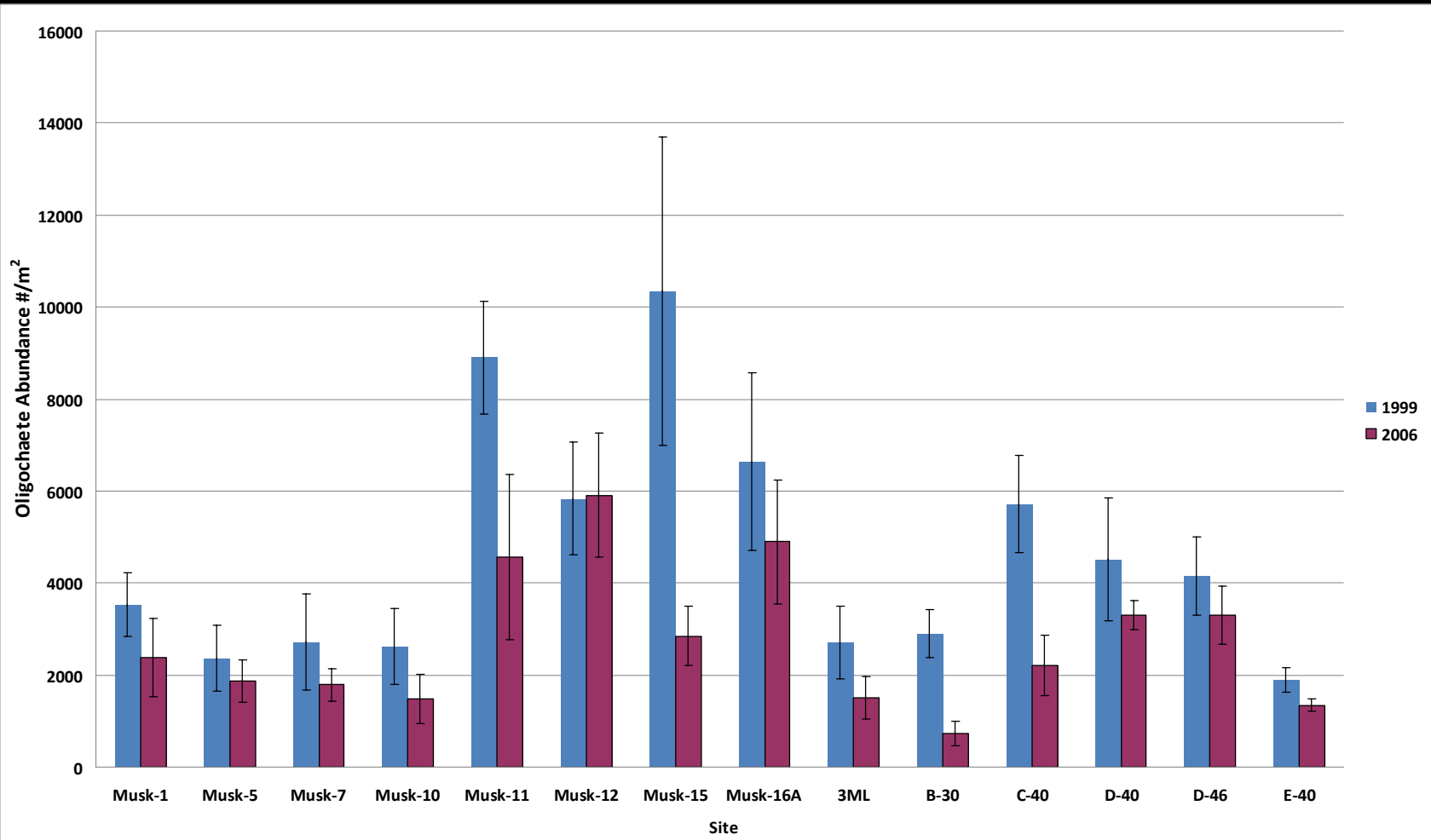


Total benthos abundance from Muskegon Lake in 1999 and 2006. Mann-Whitney U (1999-2006); $\rho=0.96$.



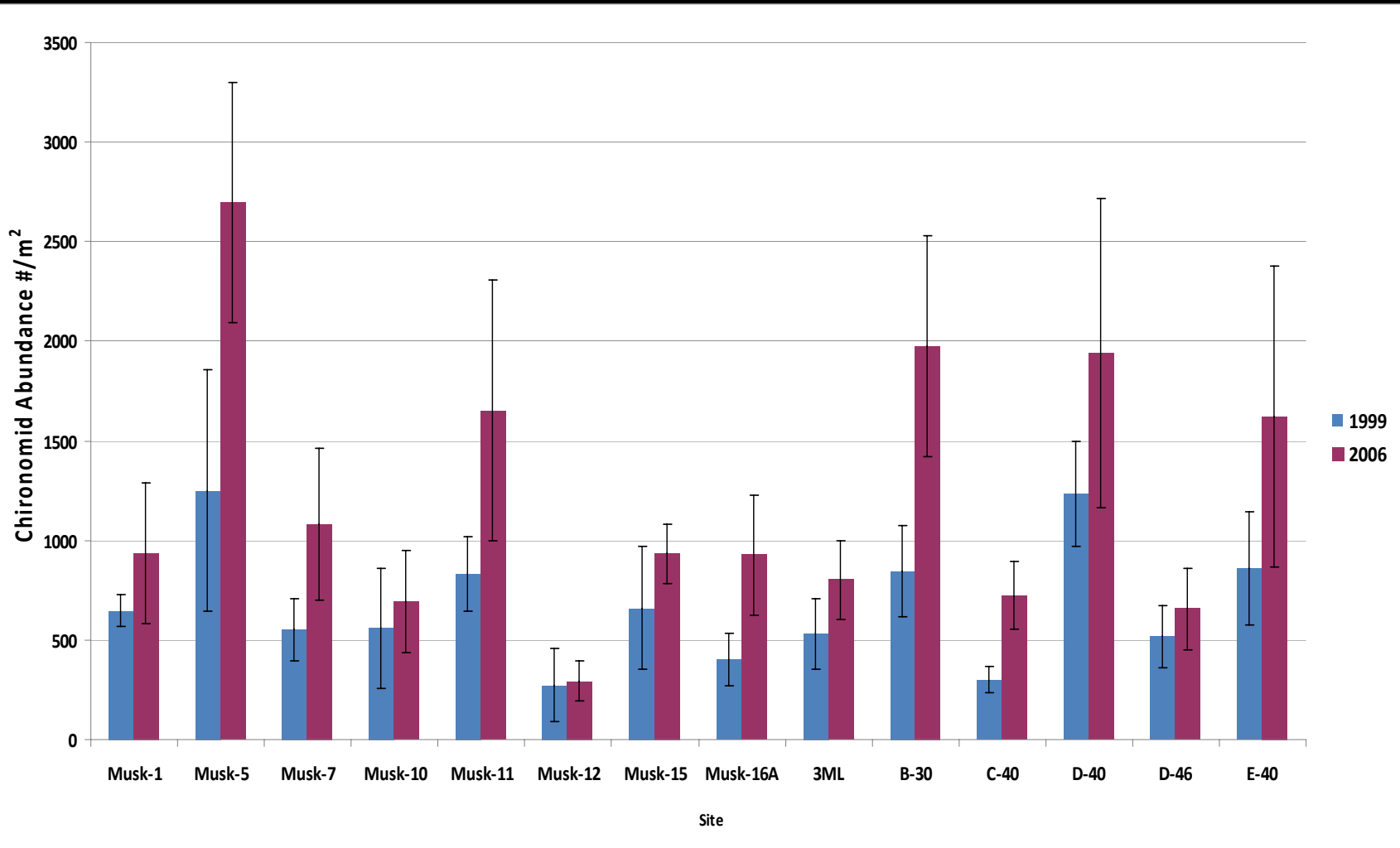


Oligochaete abundance from Muskegon Lake in 1999 and 2006. Mann-Whitney U (1999-2006); $\rho=0.024$.





Chironomid abundance from Muskegon Lake in 1999 and 2006. Mann-Whitney U (1999-2006); $\rho=0.009$.





Mean (S.E.) and Mann-Whitney U-test p-values for selected benthic taxa and parameters of 15 matched pairs of sites.

	1999	2006	p-value
Total Benthos	9,652(2918)	11,579(2872)	0.96
Total Oligochaeta	4,562(664)	2,725(700)	0.024
Total Chironomidae	677(75)	1,209(390)	0.009
Oligochaete/Chironomid	84(2)	66(5)	0.005
Chironomid Trophic Index	8.71(0.38)	8.80(0.45)	0.86
Shannon Weaver Diversity	1.88(0.17)	2.08(0.22)	0.137





Target 1: Sediment Toxicity

- **The only location in Muskegon Lake with Amphipod Survival <60% is the Division Street Outfall.**
- **Areas with low survival are within the currently proposed remediation boundary**
- **This target should be achieved after remediation**





Target 2: Hexagenia present in the littoral zone near the river mouth

- ***Hexagenia*** was present at locations Hex 1 and Hex 2. A total of 30 individuals were collected from a 10 m² area at Fisherman's Landing (Hex 1) and 21 individuals were taken from a similar sized area at Hex 2.






Targets 3-5

Indicator	Target	1999	2006
3. % Oligochaeta (w/o ZM)	< 75%	69	45
4. Chironomidae (#/m²)	> 500	677	1209
5. Diversity (Shannon Weaver)	> 1.5	1.88	2.08

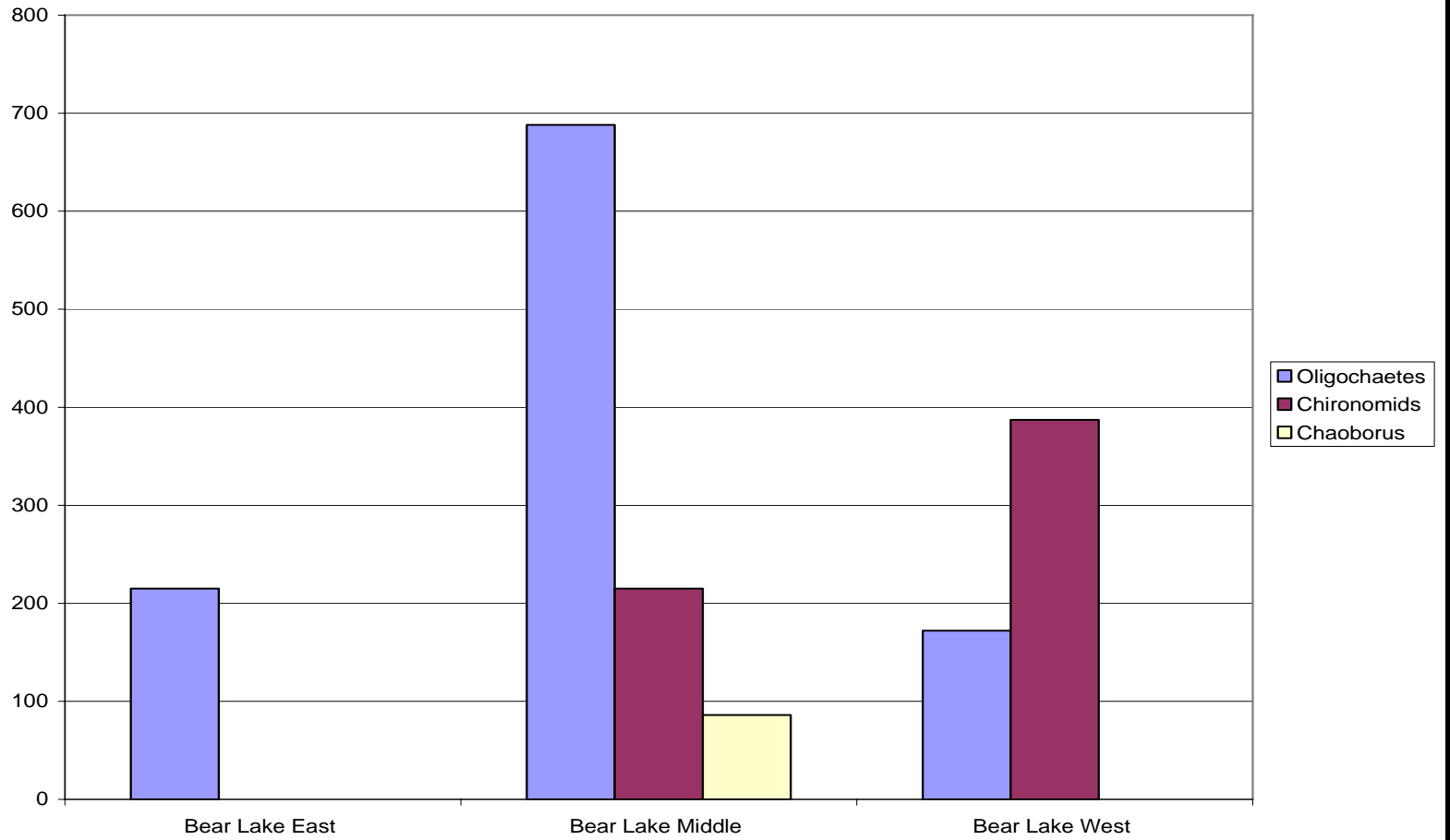




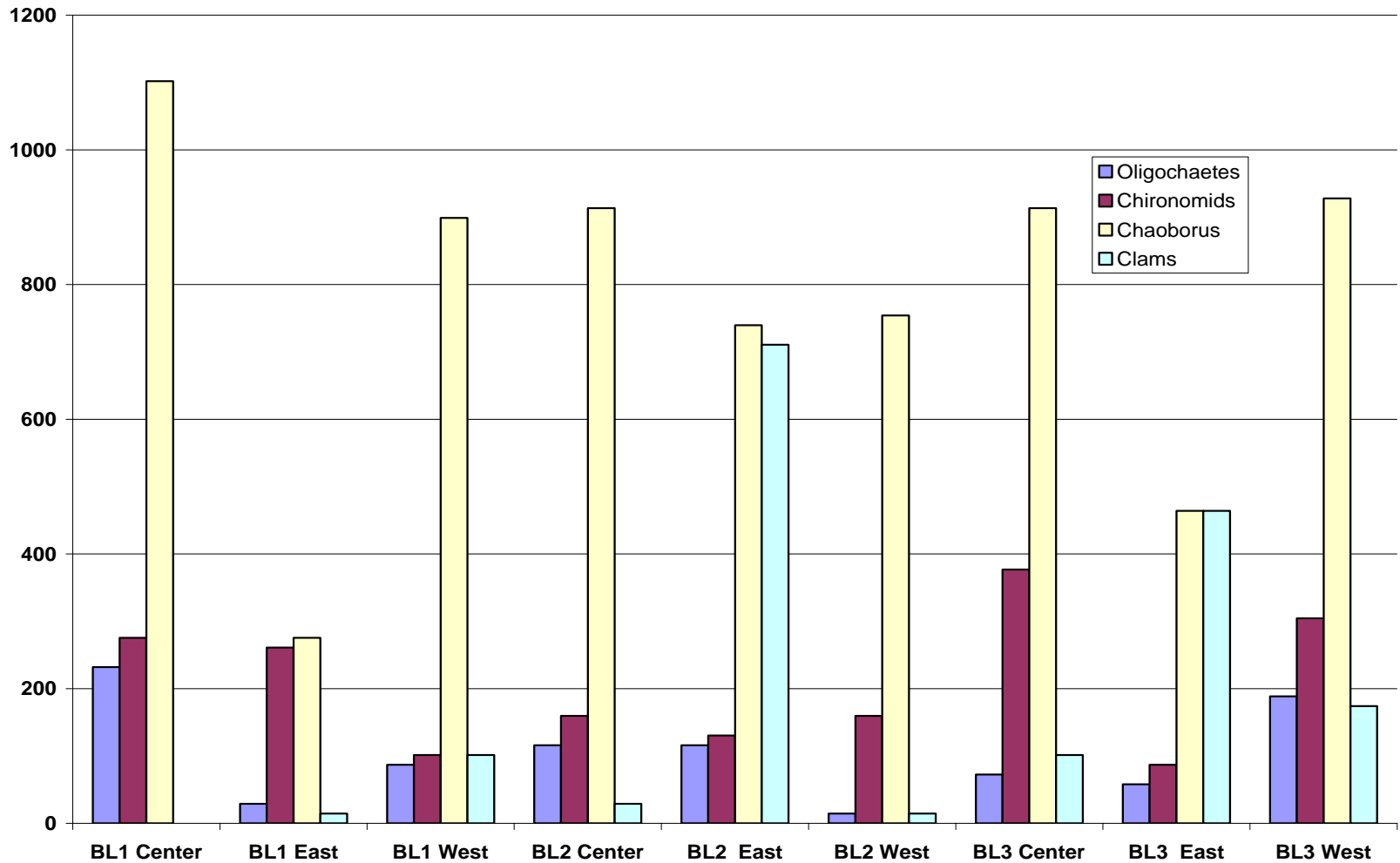
Summary

- A significant increase in chironomids and decrease in oligochaetes was observed in 2006, indicating that the benthic invertebrate community in Muskegon Lake continued to improve from 1999 conditions.
 - Shannon Weaver diversity, total benthic organisms, and the chironomid trophic index were not significantly different between years, indicating stable benthic conditions.
 - All of the metrics either indicated stable or improving conditions in the benthic macroinvertebrate community.
 - **The data support the removal of the Degradation of Benthos BUI from Muskegon Lake after remediation of the Division Street Outfall**
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Bear Lake 1972



Bear Lake 2007



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