DOMINANCE OF EXOTIC INVERTEBRATES CHANGES THE LAKE ERIE BENTHIC COMMUNITY

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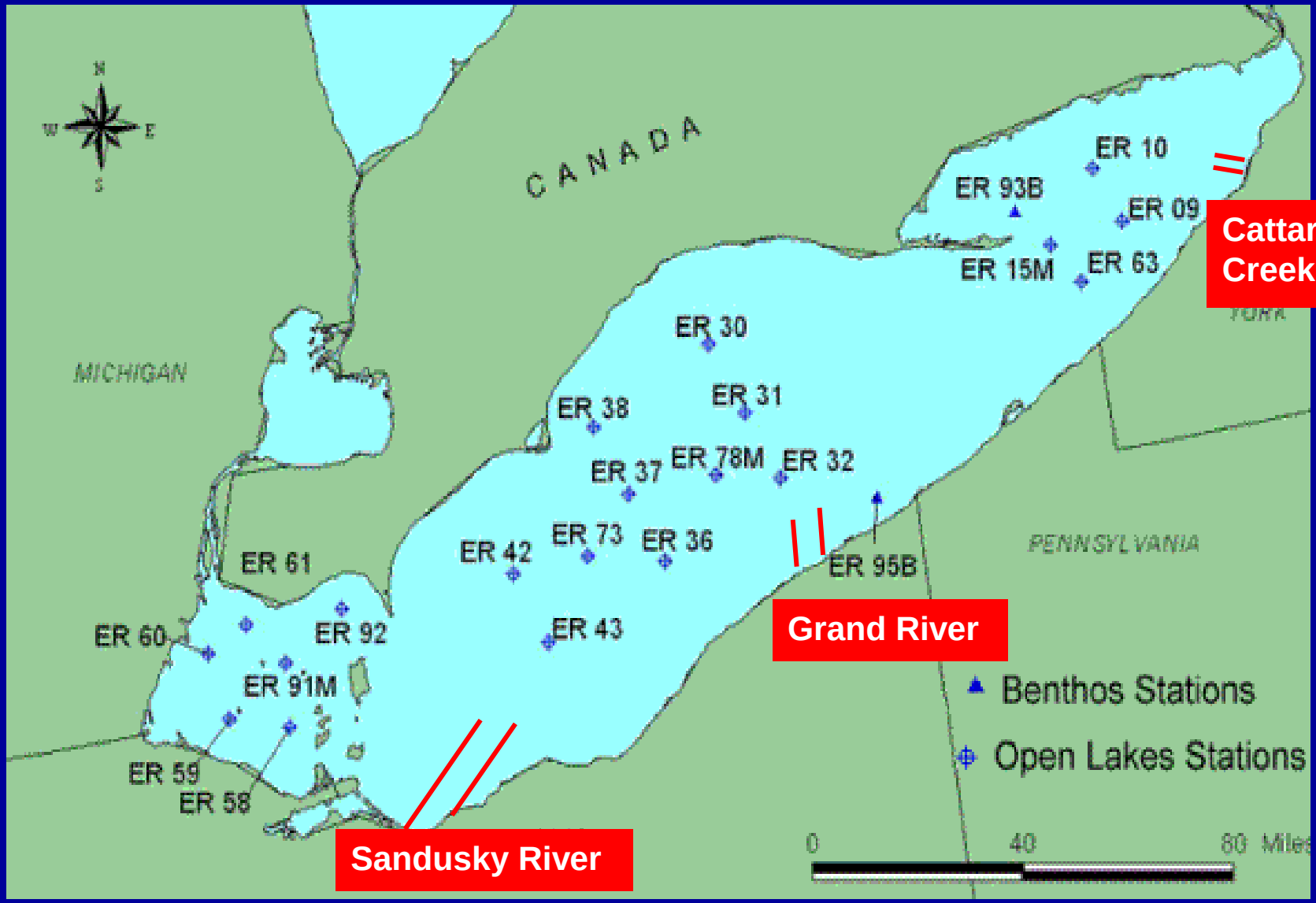
Methods:

- This study was funded by U.S. EPA and was a part of “The Nearshore and Offshore Lake Erie Nutrient Study”

- 125 benthic samples were collected in June 2009, including nearshore (6 transects, petite Ponar and airlift) and offshore (22 EPA sites, Ponar).
- Washed through a 500 µm mesh and fixed with formalin
- Identified to the lowest possible level, counted, blotted dry on absorbent paper and weighted (total wet mass)
- We compared our data with 1979 sampling (Dermott 1997), using a similar, common level of taxonomic resolution


N
W
E
S
CANADA
MICHIGAN
PENNSYLVANIA
ER 10
ER 93B
ER 09
ER 15M
ER 63
Cattaraugus Creek
ER 30
ER 38
ER 31
ER 37
ER 78M
ER 32
ER 42
ER 73
ER 36
ER 95B
Grand River
ER 61
ER 60
ER 92
ER 43
ER 91M
ER 59
ER 58
Sandusky River
Benthos Stations
Open Lakes Stations
0
40
80 Miles

Benthic Diversity in the Lake Erie in 2009:

- 48 species and higher taxa were found in the samples, including 9 invaders
- Invaders were overrepresented by molluscs and crustaceans, and absent in the most diverse group of benthic invertebrates - insects

Taxon richness	Total	Invaders	% Invaders
Insects	21	0	0
Molluscs	19	7	36
Crustaceans	3	1	33
Hirudinea	2	0	0
Other	3	1	33
TOTAL	48	9	19

Density of Lake Erie Benthos in 2009 (Lake Guardian samples only):

- Exotic invertebrates formed from 10 to 67% of total benthic density
- The role of invaders varied among lake basins, being the highest in the Western and lowest in the Central Basin

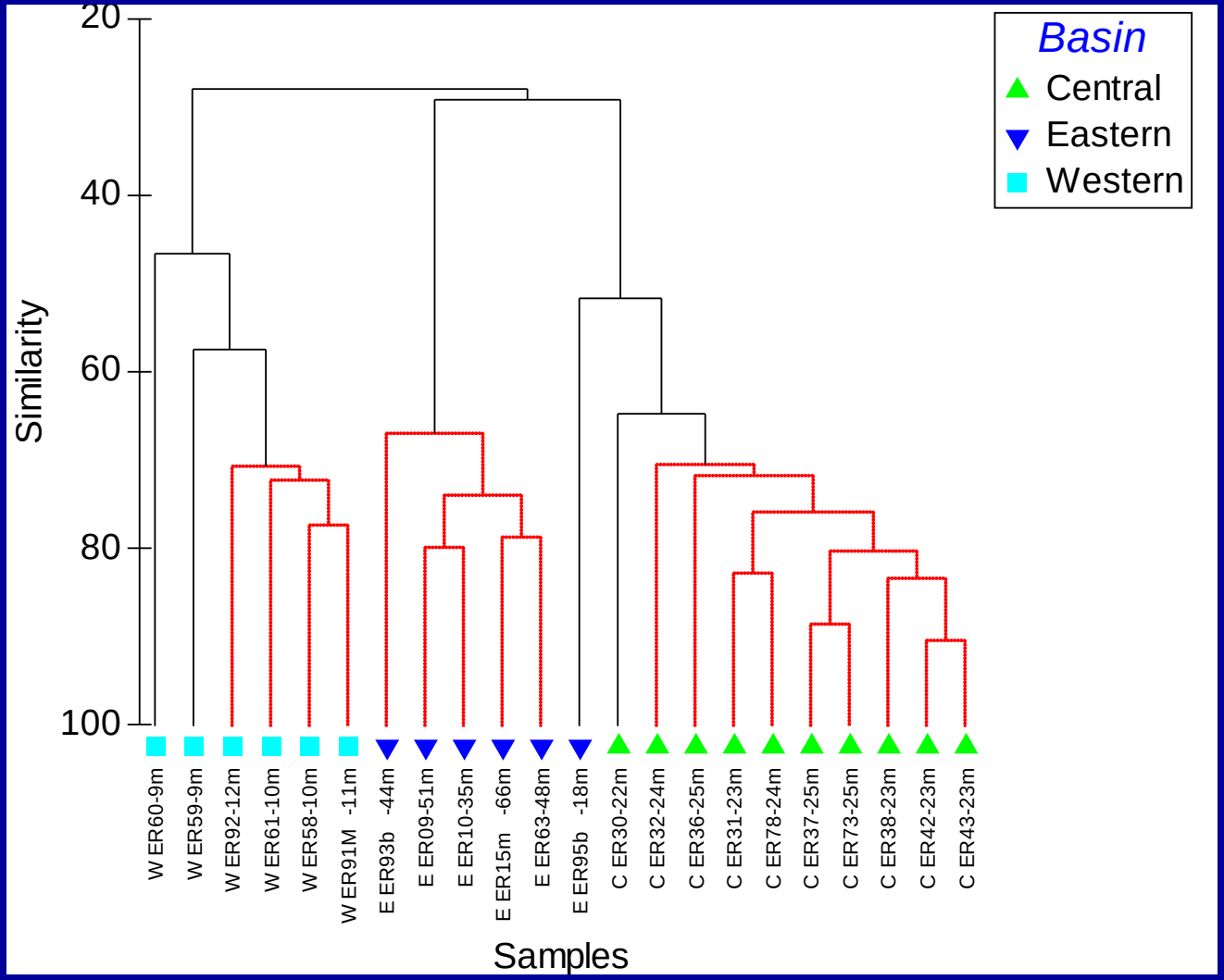
	Eastern basin		*Central basin*		*Western basin*	
Class	All species	**% of invaders**	All species	**% of invaders**	All species	**% of invaders**
Bivalvia	904	**>99**	507	**32**	1561	**89**
Gastropoda	1	**40**	6	**19**	155	**4**
Oligochaeta	327	**0**	1186	**0**	198	**9**
Insecta	224	**0**	493	**0**	310	**0**
Crustacea	6	**46**	97	**70**	319	**100**
Hirudinea	3	**0**	6	**0**	23	**0**
TOTAL	**1465**	**62**	**2295**	**10**	**2565**	**67**

Invaders in Lake Erie Benthos in 2009:

- Invasive species formed from 79 to 99.9% of the total wet biomass
- The role of invaders was larger in biomass than in the density, indicating that invaders generally have higher body mass than native species, **and therefore may be more important in the functioning of the ecosystem**

	Eastern basin		*Central basin*		*Western basin*		***Lakewide***	
Parameters	All species	**% of invaders**	All species	**% of invaders**	All species	**% of invaders**	All species	**% invaders**
Density, m^{-2}	**1465**	**62**	**2295**	**10**	**2565**	**67**	**2108**	**45**
Biomass, g m^{-2}	**751**	**99.9**	**97**	**86**	**163**	**79**	**337**	**95**

Cluster Analysis of Benthic Communities in Different Basins in 2009 Lake Guardian samples only (by density):

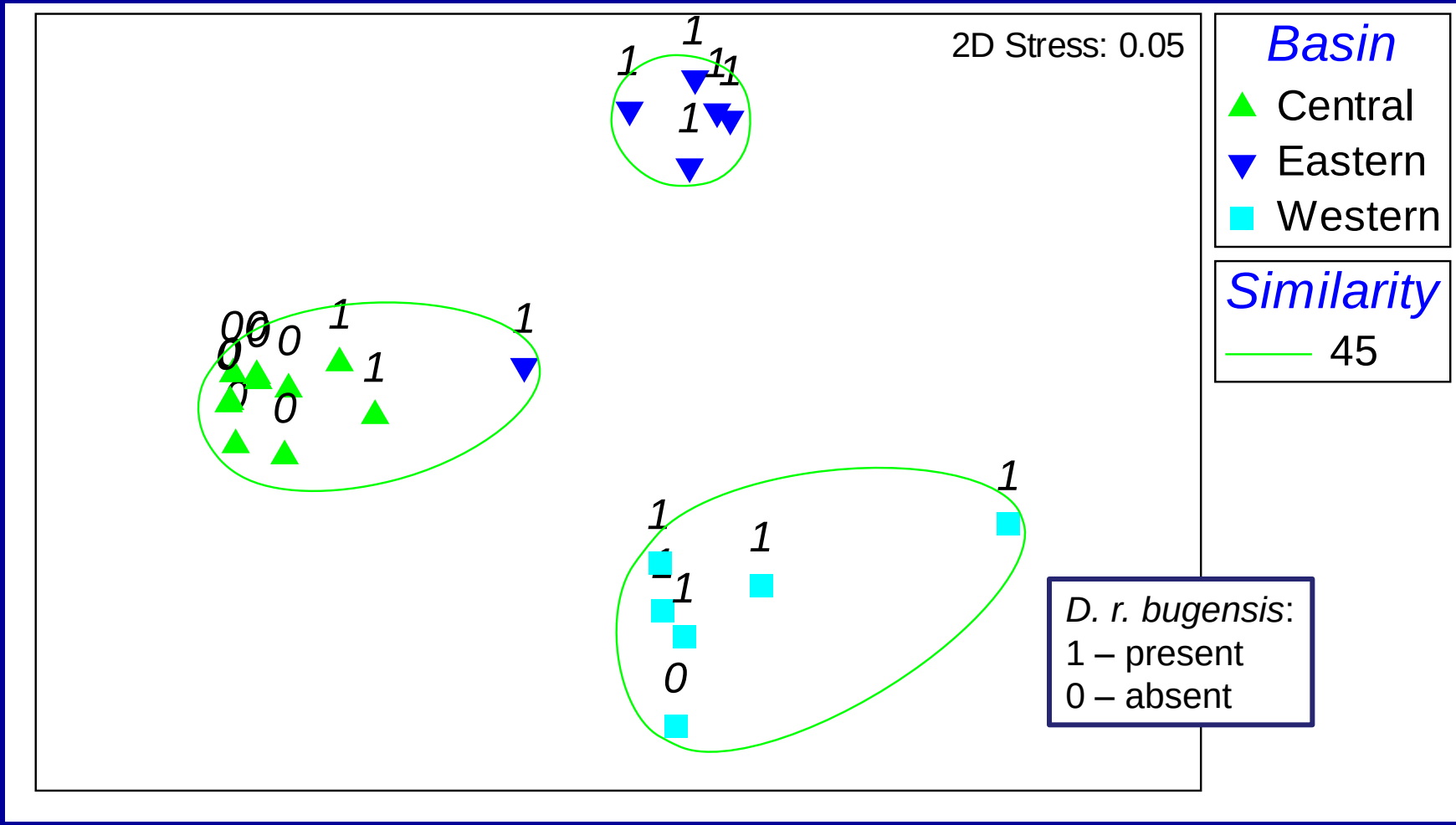


Lake Erie benthic communities were significantly different in all lake basins

black lines – clusters are significant at P < 0.02 (SIMPROF test)

Multi-Dimensional Scaling Plot of Differences in the Benthic Communities in Different Basins in 2009 (density):

Benthic communities were significantly different (P= 0.001, ANOSIM) in all basins, regardless of the presence of quagga mussels



Lake Guardian samples only

Density (m^{-2}) of Zoobenthos in the Lake Erie in 2009:

- Exotic molluscs and crustaceans were found in the nearshore zones, while only molluscs were found among exotics in the offshore
- Invasive species formed from 40 to 47% of the total density in the nearshore zone and from 2 to 75% in the offshore zone
- The role of invaders varied among lake basins

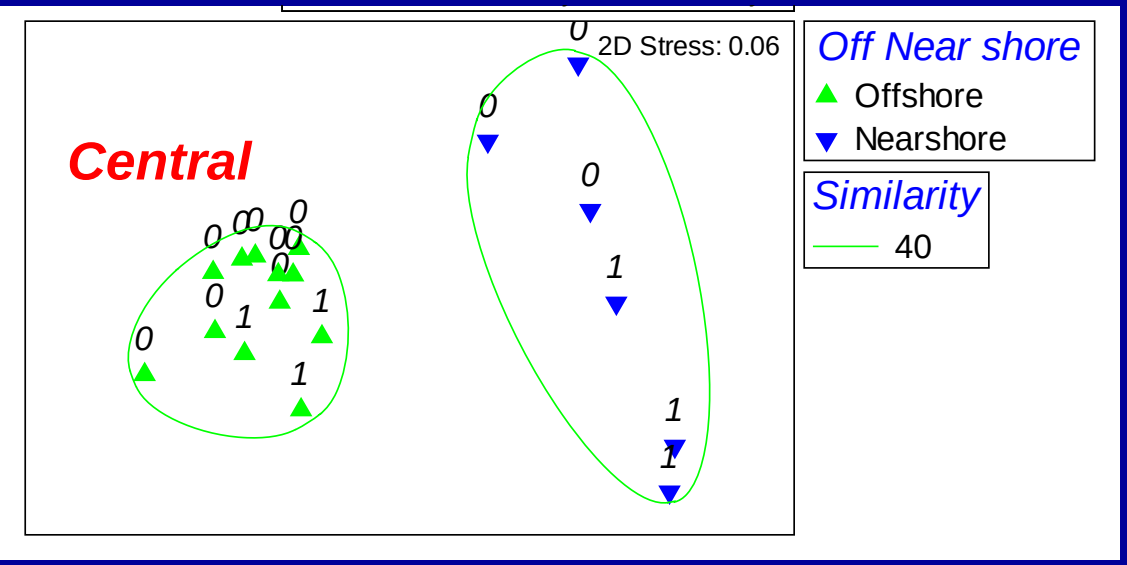
Nearshore

	Eastern basin		*Central basin*	
Class	All species	**% of invaders**	All species	**% of invaders**
Bivalvia	660	**>99**	402	**100**
Gastropoda	1	**0**	0	**0**
Oligochaeta	402	**0**	226	**0**
Insecta	320	**0**	680	**0**
Crustacea	12	**46**	204	**100**
Hirudinea	4	**0**	0	**0**
TOTAL	**1399**	**47**	**1512**	**40**

Offshore

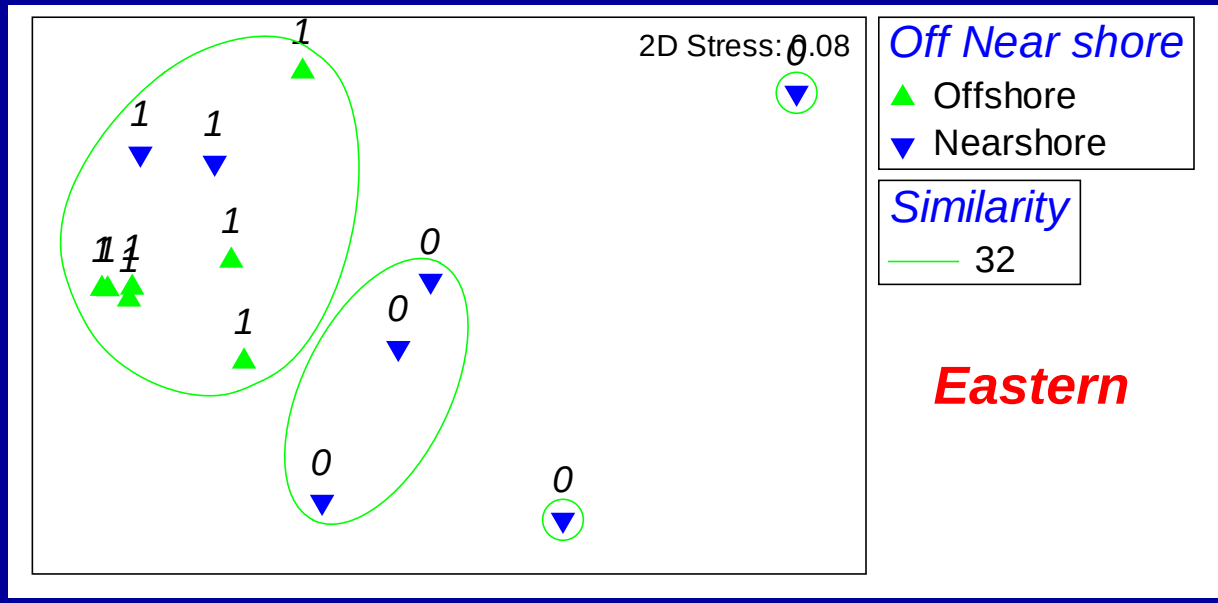
	Eastern basin		*Central basin*	
Class	All species	**% of invaders**	All species	**% of invaders**
Bivalvia	1147	**>99**	560	**7**
Gastropoda	1	**100**	8	**19**
Oligochaeta	255	**0**	1665	**0**
Insecta	129	**0**	399	**0**
Crustacea	0	**0**	44	**0**
Hirudinea	2	**0**	10	**0**
TOTAL	**1534**	**75**	**2701**	**2**

MDS Plot of Differences in the Benthic Communities in Nearshore and Offshore zones in 2009:



- Significant difference (P=0.001) was found between nearshore and offshore communities in the Central basin
- Presence/absence of dressenids did not change the result

- However, in the Eastern Basin, the presence of dreissenids had a stronger effect than depths (Global R = 0.73 vs. R = 0.24, ANOSIM)
- **Dreissenids contribute to the homogenization of the benthic community?**



Population Dynamics of Dreissenids in Lake Erie

(Data for 1992 – 2002 from Patterson et al. 2005, Data for 2004 from Ciborowski et al 2007)

Density, m^{-2}	**1992 (n=47)**	**1993 (n=37)**	**1998 (n=30)**	**2002 (n=107)**	**2004 (n=283)**	**2009 (n=40)**
Eastern Basin: All *Dreissena*	**~6000**	**~4875**	**~6000**	**9481**		**791**
% of *D. bugensis*	**~25**	**~74**	**~92**	**100**		**99.9**
Central Basin: All *Dreissena*	**~1000**	**~2425**	**~3000**	**635**		**90**
% of *D. bugensis*	**~13**	**~72**	**100**	**97**		**97**
Western Basin: All *Dreissena*	**~875**	**~1375**	**~375**	**601**		**885**
% of *D. bugensis*	**0**	**0**	**~33**	**43**		**88**
Lake-wide: All *Dreissena*	**2600**	**2658**	**3791**	**2025**		**532**
% of *D. bugensis*	**19**	**66**	**88**	**92**		**94**

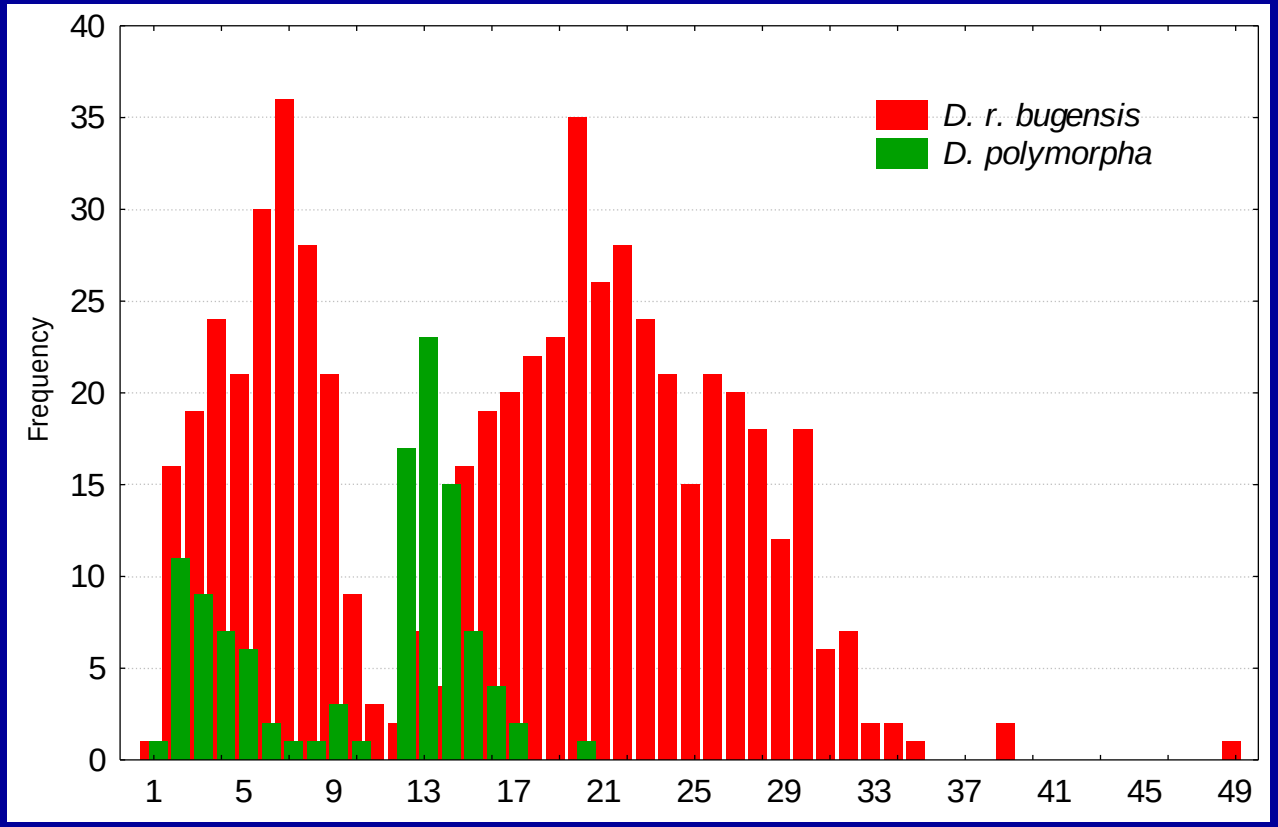
Wet biomass g m^{-2}	**1992**	**1993**	**1998**	**2002**	**2004**	**2009**
Eastern Basin: All *Dreissena*				**~4826**		**642**
% of *D. bugensis*	**~26**	**~72**	**~94**	**~100**		**99.9**
Central Basin: All *Dreissena*				**~659**		**54**
% of *D. bugensis*	**~25**	**~44**	**~99**	**~99**		**98**
Western Basin				**~269**		**79**
% of *D. bugensis*	**0**	**0**	**~50**	**~69**		**95**
Lake-wide: All *Dreissena*	**640**	**370**	**999**	**1146**	**~300**	**241**
% of *D. bugensis*				**88**		**99**

Size-frequency Distribution of Dreissenids in Lake Erie, 2009

- Both species had two distinct maximums
- *Dreissena r. bugensis* was significantly larger (P < 0.001)

D. polymorpha	
Sample size	**111**
Mean Length (mm)	**10.5 ± 0.47**

D. r. bugensis	
Sample size	**580**
Mean Length (mm)	**17.1 ± 0.38**



What is coming out of Lake Erie?

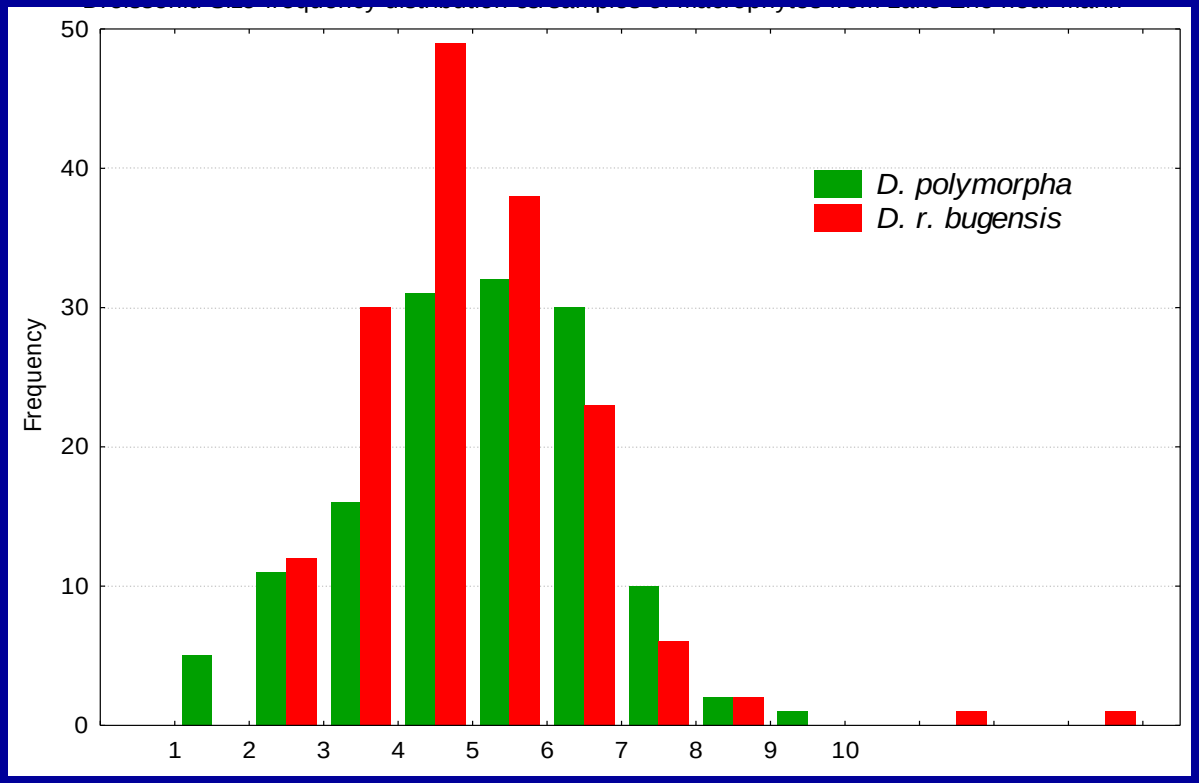
(Vadim Karatayev et al. 2010)

- Over 100 private boats from Lake Erie were examined for dreissenids during winterization in marinas in Buffalo area
- 11 boats were found to contain attached live dreissenids

Size-Frequency Distribution of Dreissenids from Macrophytes Attached to Trailers and Small Boats from Lake Erie

(Vadim Karatayev et al. 2010)

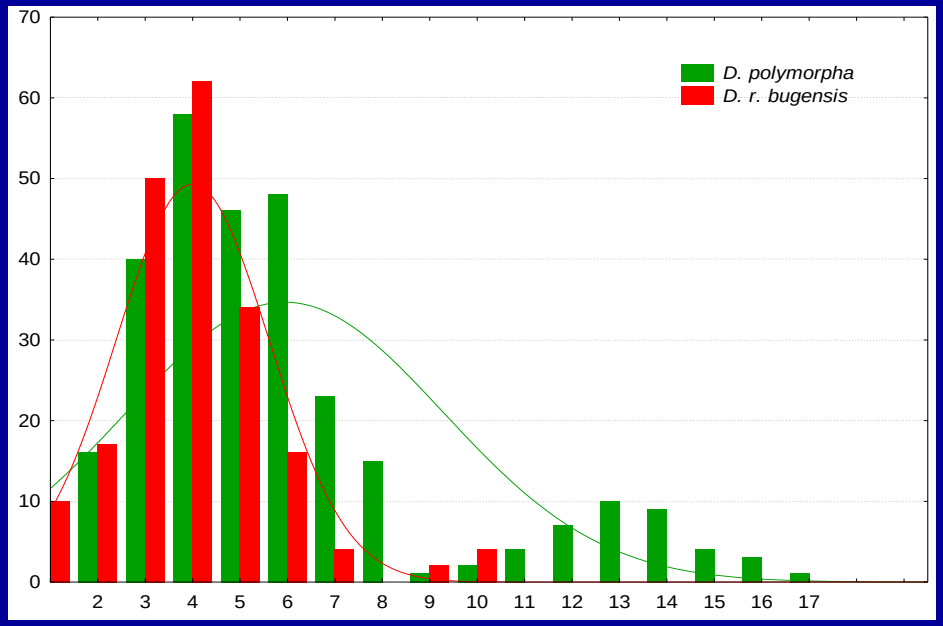
Sample #	1		2		3	
Species	ZM	QM	ZM	QM	ZM	QM
Sample Size	**8**	**8**	**56**	**97**	**74**	**57**
Mean Length (mm)	**4.88**±0.75	**5.66**±0.67	**4.41**±0.20	**4.65**±0.17	**5.63**±0.15	**5.40**±0.15



Dreissenids on Power Boats from Lake Erie

(Vadim Karatayev et al. 2010)

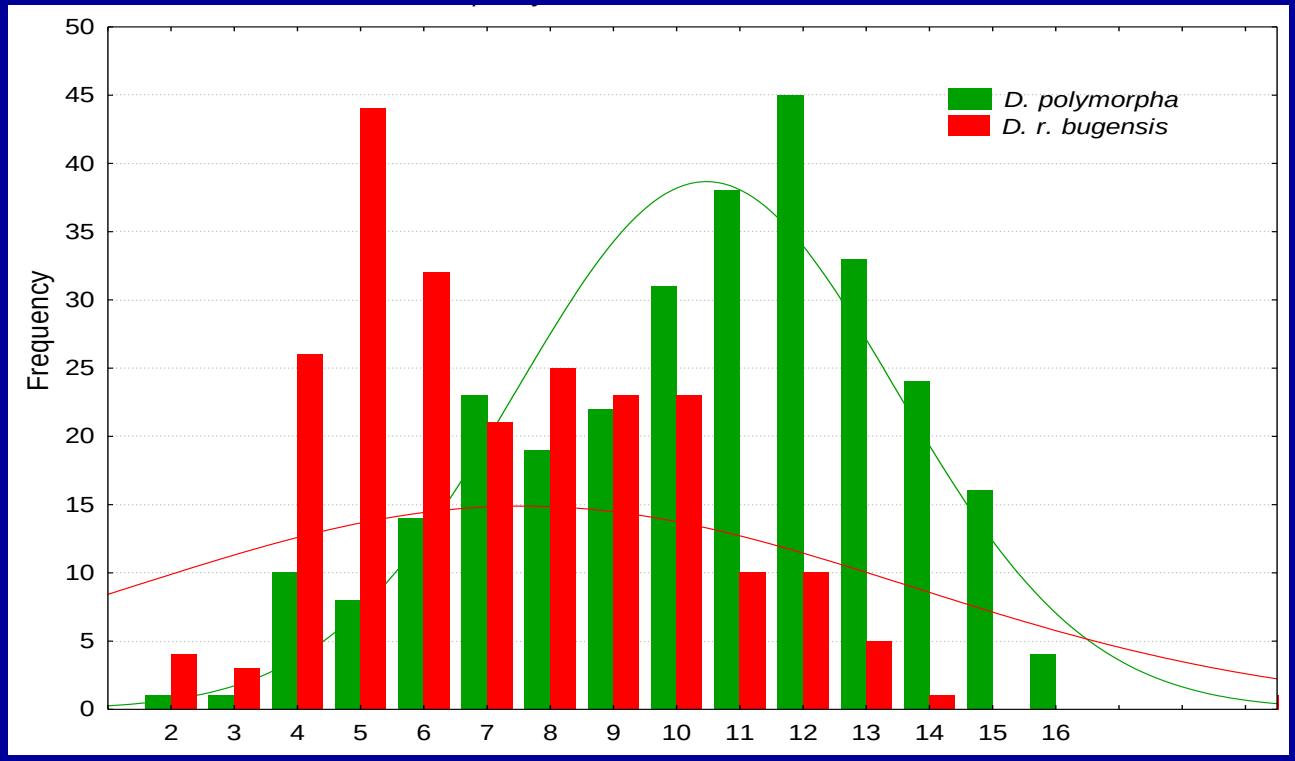
Sample #	1		2		3	
Species	ZM	QM	ZM	QM	ZM	QM
Sample Size	145	33	144	159	0	7
Mean Length (mm)	7.7±0.4	3.8±0.5	5.1±0.1	4.5±0.1		7.4±0.9



Size-Frequency Distributions: Sail Boats from Lake Erie

(Vadim Karatayev et al. 2010)

Sample #	1		2		3	
Species	ZM	QM	ZM	QM	ZM	QM
Sample Size	**32**	**112**	**48**	**14**	**151**	**44**
Mean Length (mm)	**10.9**±0.5	**8.5**±0.8	**11.1**±0.4	**8.9**±0.5	**11.8**±0.2	**8.4**±0.3



COMPARISON WITH 1979

Role of Exotic Species in the Benthic Diversity of Lake Erie:

has increased from 7 to 19% of the total species richness of benthic invertebrates over the last 30 years

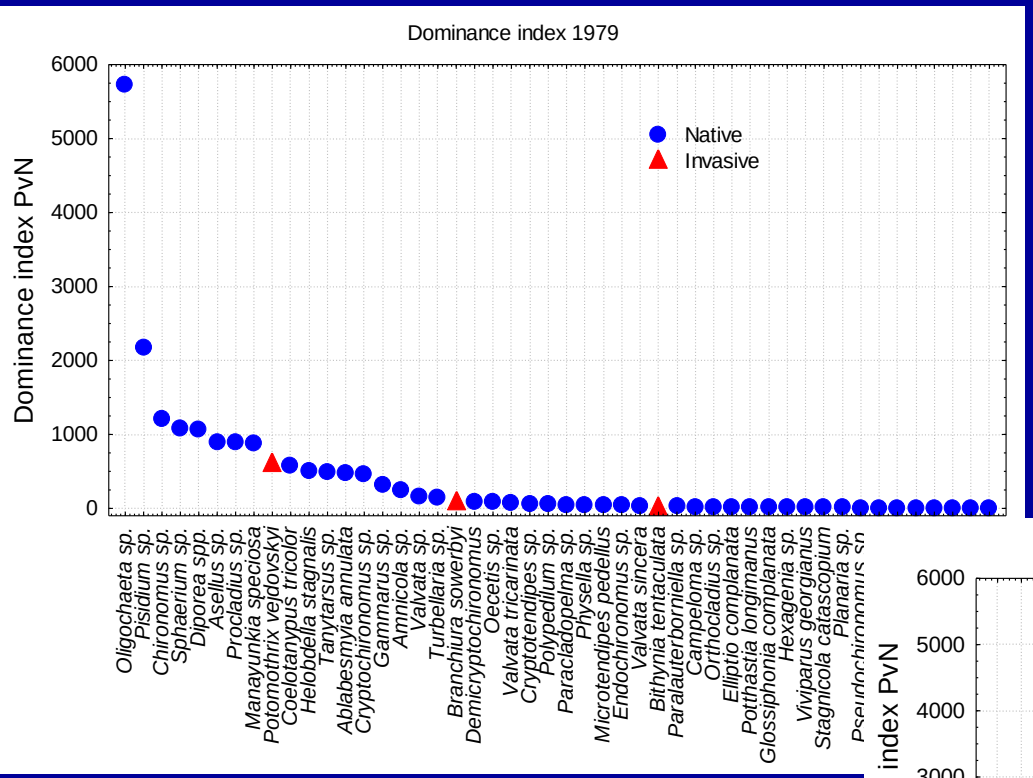
1979

Taxon richness	Total	Invaders	% Invaders
Insects	19	0	0
Molluscs	12	1	8
Crustaceans	3	0	0
Hirudinea	2	0	0
Other	6	2	33
TOTAL	42	3	7

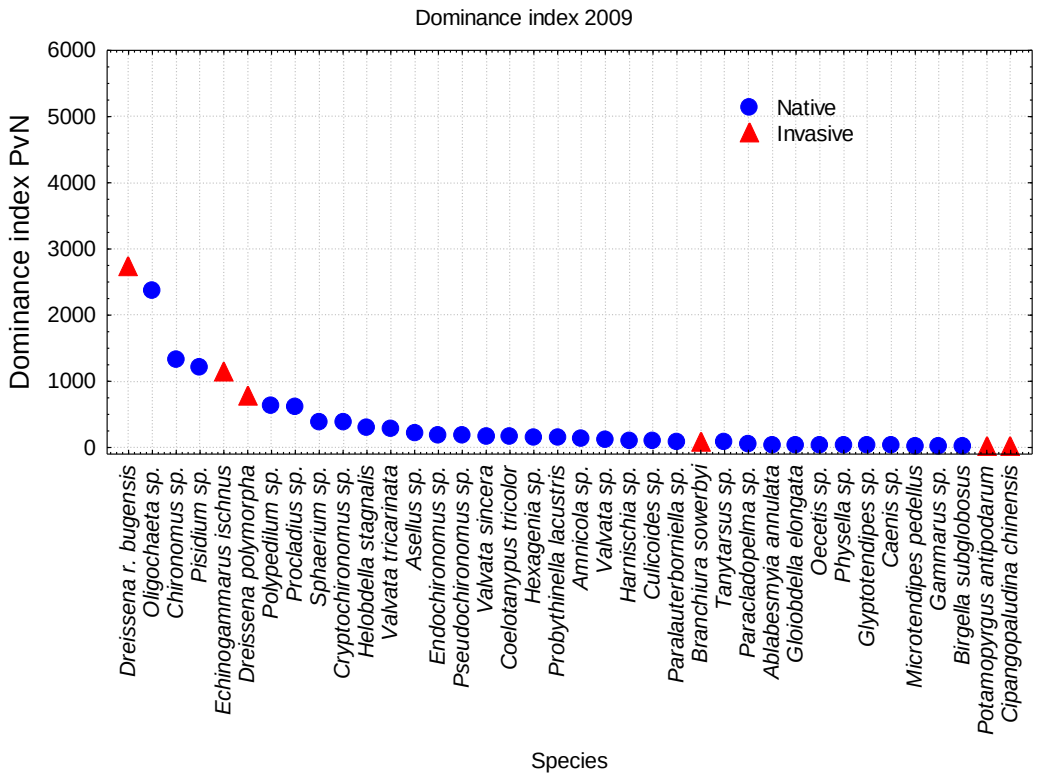
2009

Taxon richness	Total	Invaders	% Invaders
Insects	21	0	0
Molluscs	19	7	36
Crustaceans	3	1	33
Hirudinea	2	0	0
Other	3	1	33
TOTAL	48	9	19

Benthic Community Structure in 1979 and 2009:



- **Invaders became dominant species in Lake Erie benthic community**



Role of exotic species in the Lake Erie benthic community over the last 30 years has increased:

- Total benthic density lake-wide from 2.1% to 45%
- Total benthic biomass lake-wide from 2.6 to 95%
- The largest difference was found in the least studied Eastern Basin

1979

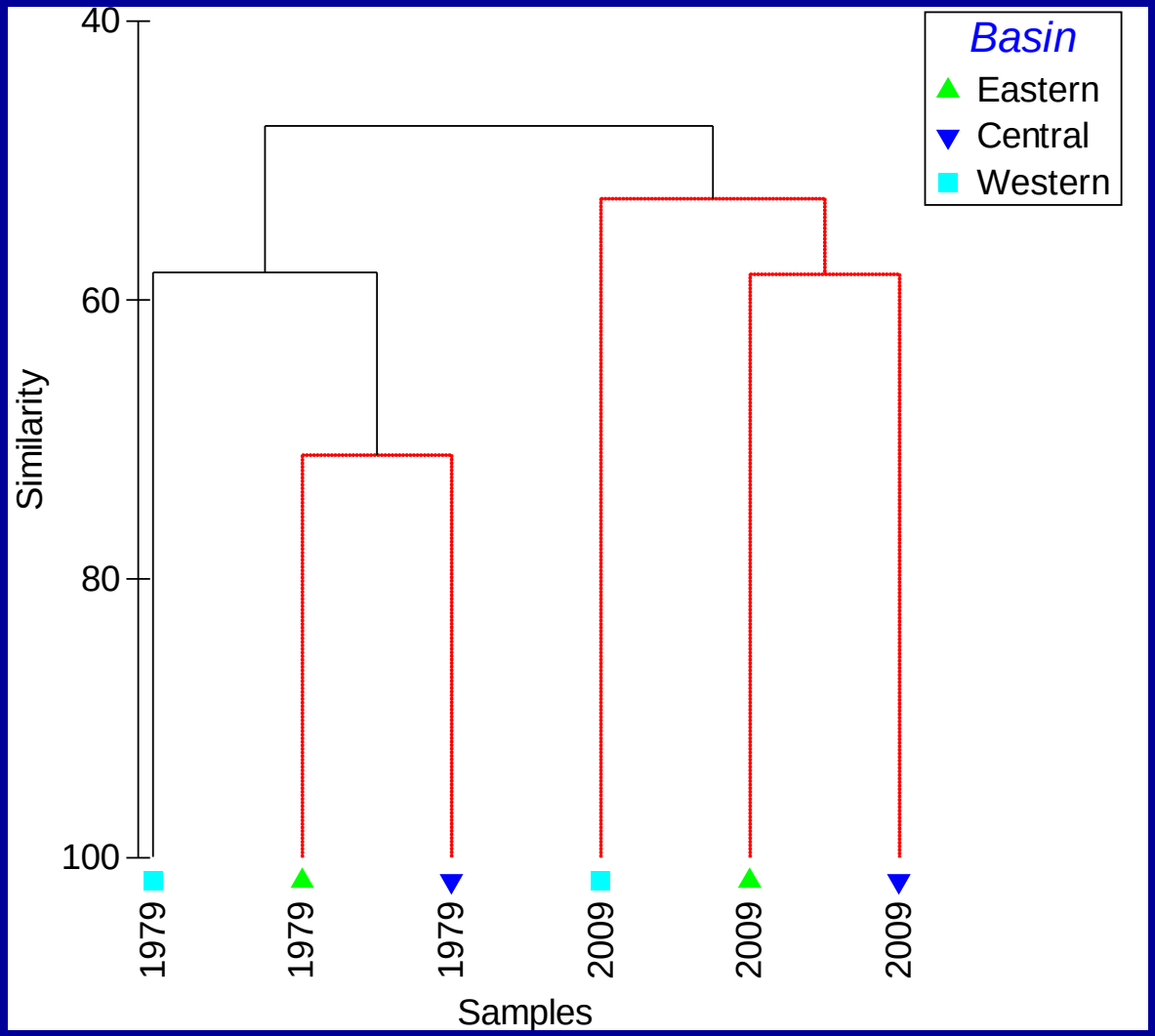
Parameters	Eastern	% invaders	Central	% invaders	Western	% invaders	**Lake wide**	**% invaders**
Density, m^{-2}	5997	4	6060	0.5	2417	1	**4825**	**2.1**
Biomass, g m^{-2}	1162	4	1334	0.1	948	5	**1148**	**2.6**

2009

Parameters	Eastern	% invaders	Central	% invaders	Western	% invaders	**Lake wide**	**% invaders**
Density, m^{-2}	1465	62	2295	10	2565	67	**2108**	**45**
Biomass, g m^{-2}	751	>99	97	86	163	79	**337**	**95**

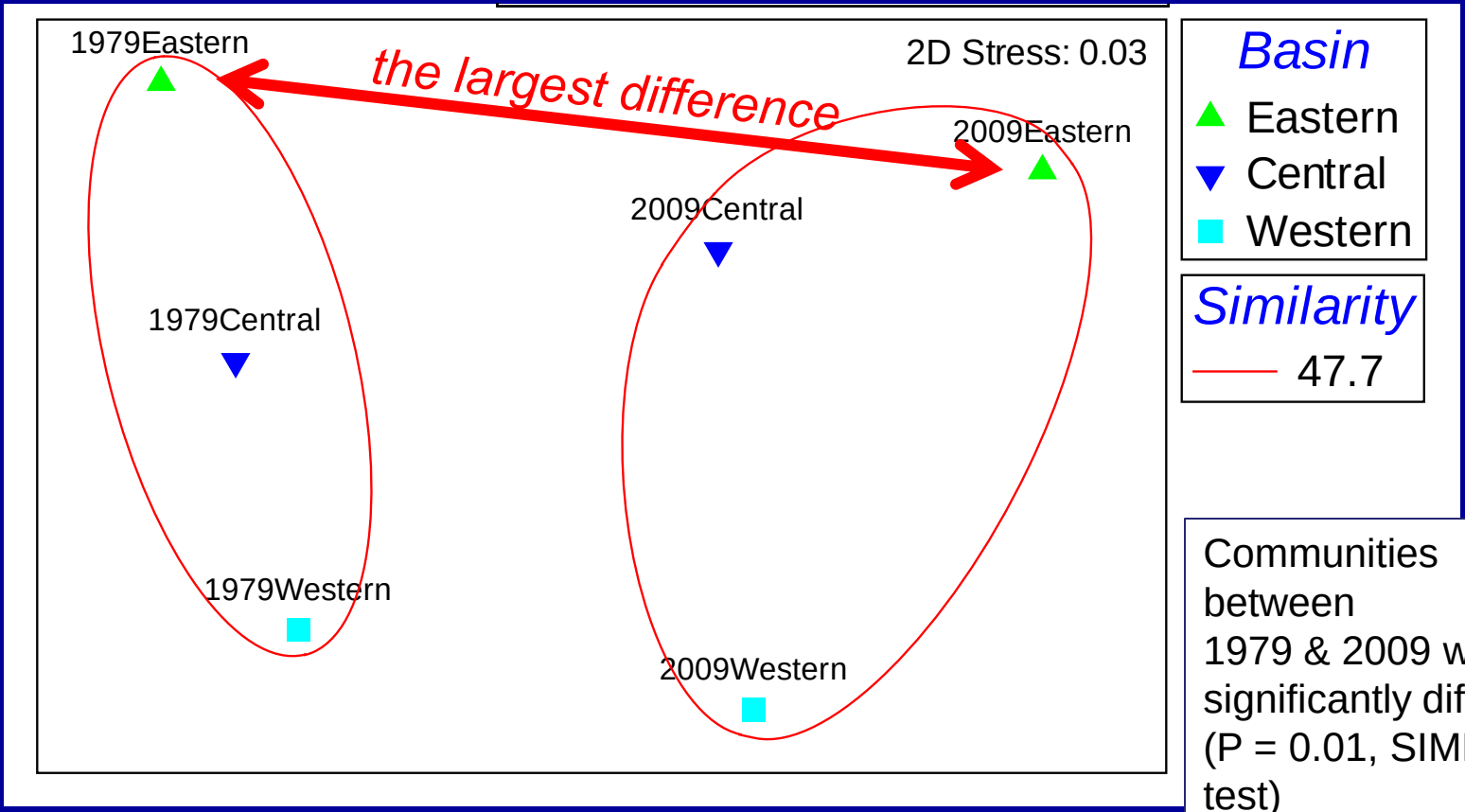
Cluster Analysis of Benthic Communities (by density):

- Benthic communities in 1979 and 2009 were significantly different (P = 0.01, SIMPROF)



MDS Plot of Differences in the Benthic Communities in Different Basins in 1979-2009 (density):

- Benthic communities have changed significantly in all lake basins
- The largest difference was found in the least studied Eastern Basin



Communities between 1979 & 2009 were significantly different (P = 0.01, SIMPROF test)

Conclusions:

- Exotic species formed 19% of the species richness, were disproportionally overrepresented by molluscs and crustaceans, and absent in insects
- Exotic species formed 45% of the total density and 95% of the total wet biomass
- Benthic communities were significantly different in all lake basins, regardless of the presence of dreissenids
- Significant difference was found between the nearshore and offshore communities in the Central Basin; in contrast, in the Eastern Basin the presence of dreissenids had stronger effect than depths
- Role of exotic species over the last 30 years has increased in:
  - benthic diversity from 7% to 19%
  - density from 2.1% to 45%
  - wet biomass from 2.6% to 95%
- Due to the introduction of exotics, benthic communities have significantly changed in all lake basins, with the largest difference found in the least studied Eastern Basin

Conclusions:

- Lake-wide dreissenid density was 532 m^{-2} and quagga mussels formed over 94%
- Average wet biomass of dreissenids was 241 g m^{-2} and quagga mussels formed 99% of total dreissenid biomass
- However, *D. polymorpha* obtained similar or larger sizes and density on examined boats – the main vectors of spread for the two species
- Therefore, despite the dominance of *D. r. bugensis* among dreissenids in Lake Erie, the introduction of *D. polymorpha* may be just as likely as that of *D. r. bugensis*

Acknowledgments

This study was funded by U.S. EPA

“The Nearshore and Offshore Lake Erie Nutrient Study”

to: C. Pennuto, A. Y. Karatayev, A. Perez-Fuentetaja, L. E. Burlakova, G. Matisoff, J. Kramer, D. Bade, J. Conroy.

Our special thanks to S. Mastitsky, Marissa Hajduk, Chris Janek, and other Buffalo State students & staff for assistance

Questions?