Assessment of Native Mussel Populations in the St. Clair Delta a Quarter-Century after the Dreissenid Invasion

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Outline

- Background information
- The decline and current status of unionid mussels in Lake St. Clair
- Population structure and genetic status of *L. siliquoidea*
- Conclusions, implications, and future research directions

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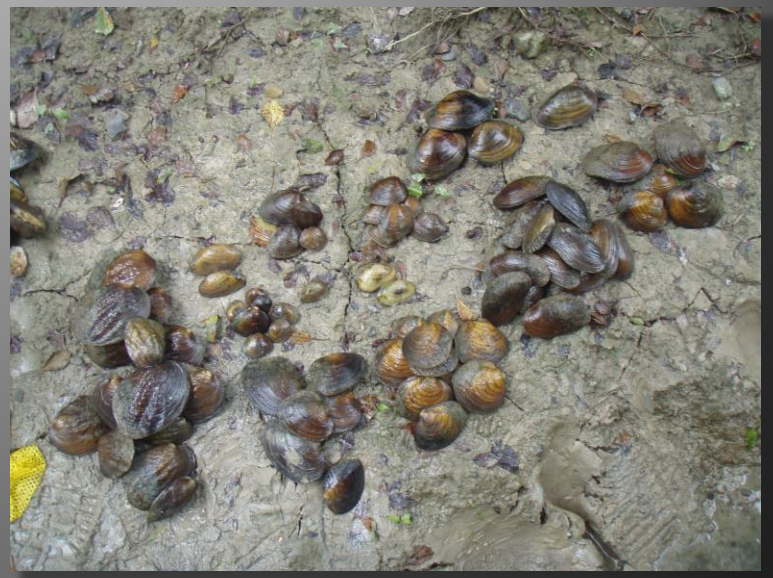
Unionid Mussels

- Native freshwater mussels (unionids) are a diverse group of bivalve mollusk
  - Largest diversity is in North America (300 species)
- 40 species known in the Lower Great Lakes
- 37 species known historically in Lake St. Clair
  - 22 species recorded in the last decade.



Strayer et al. 2004

Unique Life Cycle

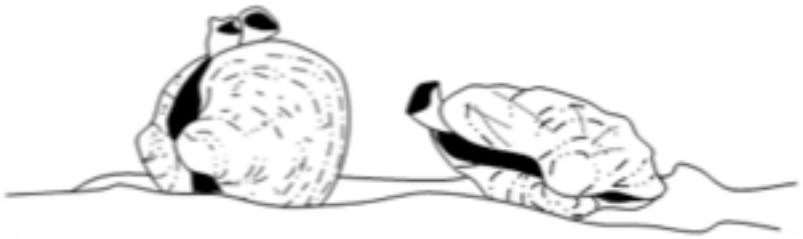


Illustration by Tammy Rodela

Unionid Functional Roles

- Filtration of the water column
- Biodeposition of nutrients
- Bioturbation of sediments
- Habitat for other species
- Resource limitation
- Food source
- Bioindicator

(Vaughn and Hakenkamp 2001)

Unionid Plight

- Most imperiled group of organisms in North America
- 70% of native species extinct of vulnerable to extinction
  - 36 species thought to be extinct
  - 165 species vulnerable to extinction
- Causes of decline include:
  - Habitat destruction
  - Pollution
  - Changes in host fish communities
  - Commercial exploitation
  - Invasive species

Strayer et al. 2004, Bogan et al. 1993, www.dnr.wi.gov

Dreissenid Mussel Biology

- Dreissenid Mussels
  - Highly invasive European bivalve mollusks
  - High reproductive potential via

r

Photo by Randy Westbrook, USGS

Dreissenid Fouling

- Fouling of unionids by dreissenids is a primary cause of mortality
  - Interfere with feeding
  - Interfere with respiration
  - Prevent closing
  - Prevent burrowing
  - Interfere with locomotion
  - Hinder reproduction

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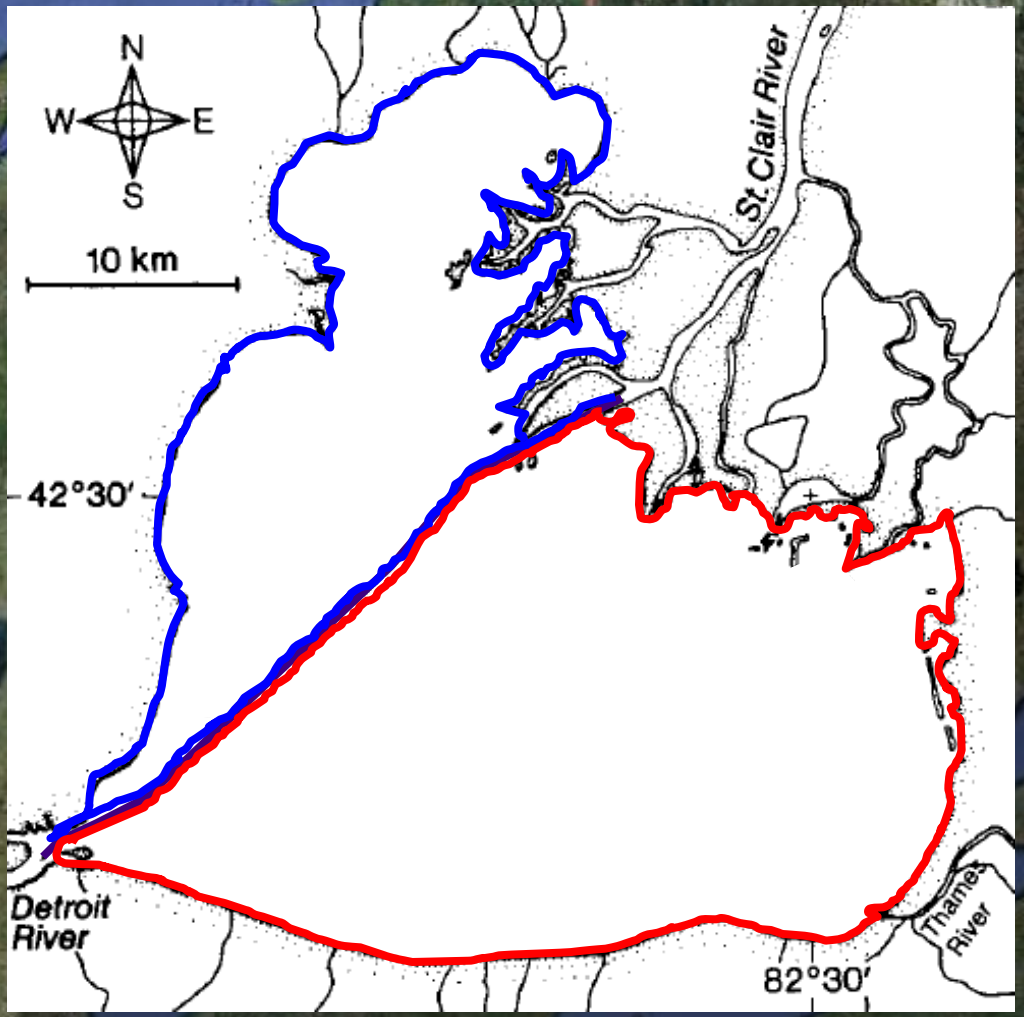
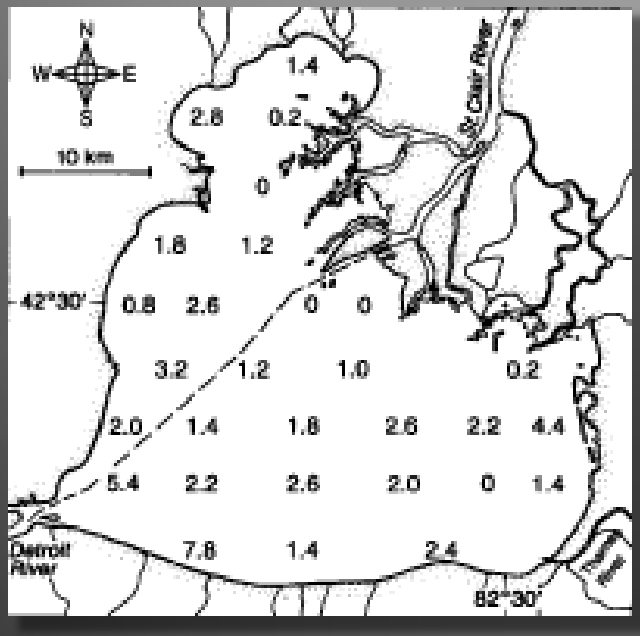
Lake St. Clair



Nalepa et al. 1994

Unionid Decline in Lake St. Clair

Unionid density (m^2)



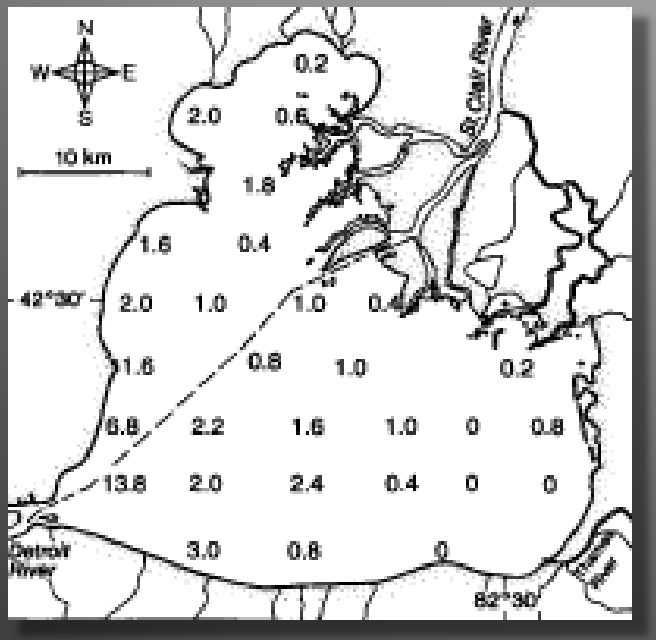
Avg. = 1.93 unionids/m^2

1986

Nalepa et al. 1996

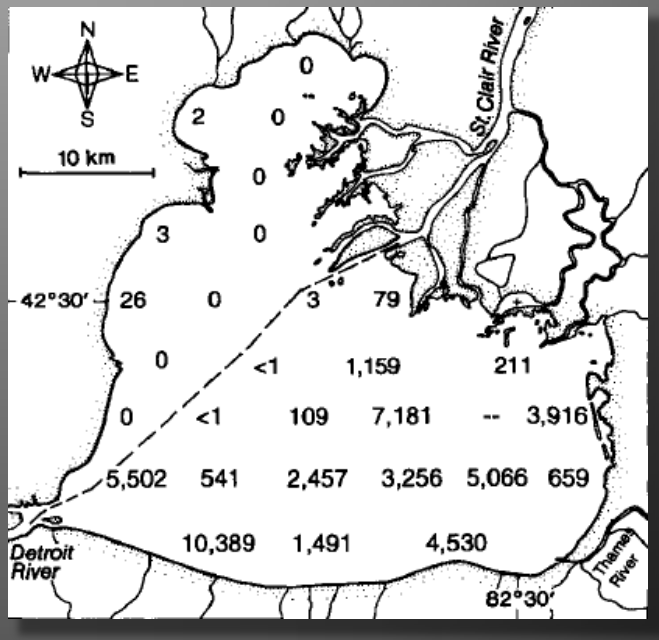
Unionid Decline in Lake St. Clair

Unionid density (m^2)



Avg. = 1.70 unionids/m^2

Dreissenid density (m^2)



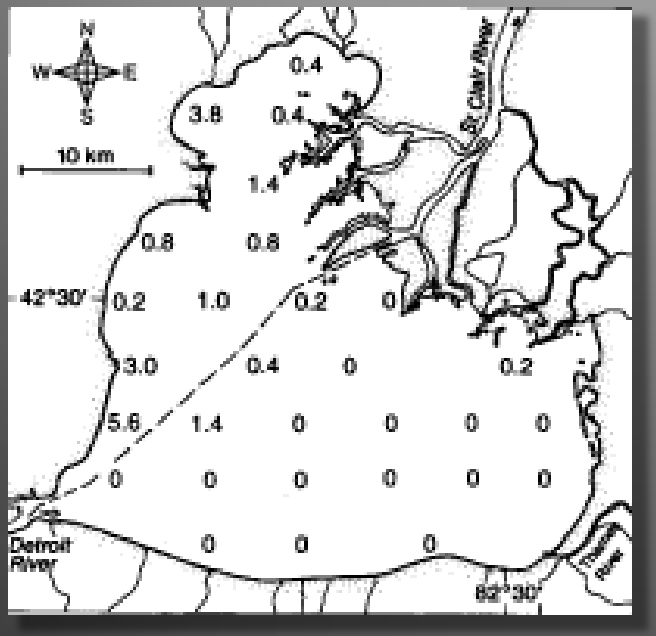
Avg. = 1610 dreissenids/m^2

1990

Nalepa et al. 1996

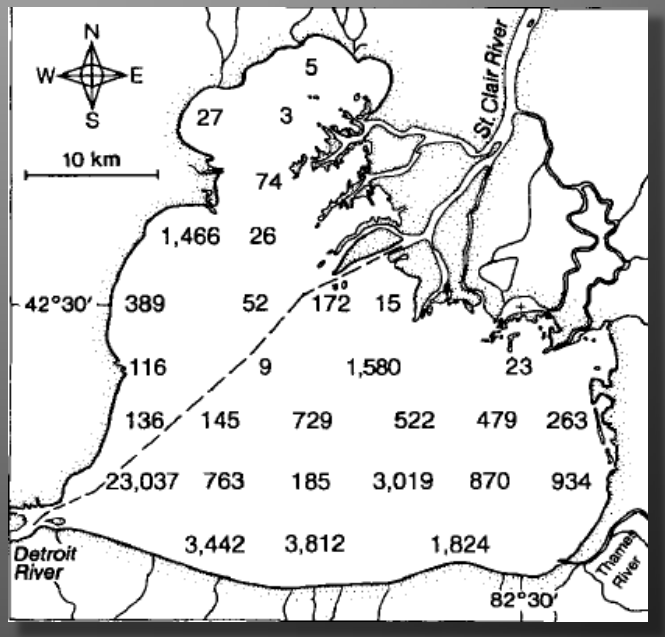
Unionid Decline in Lake St. Clair

Unionid density (m^2)



Avg. = 0.68 unionids/m^2

Dreissenid density (m^2)



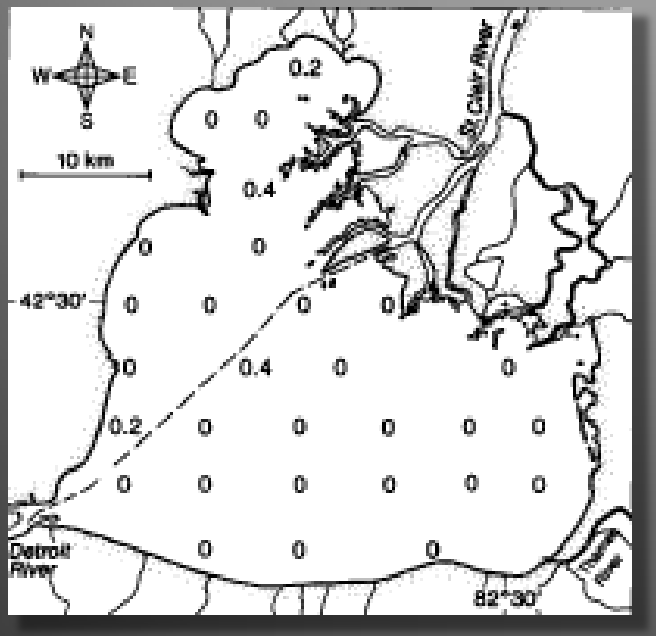
Avg. = 1521 dreissenids/m^2

1992

Nalepa et al. 1996

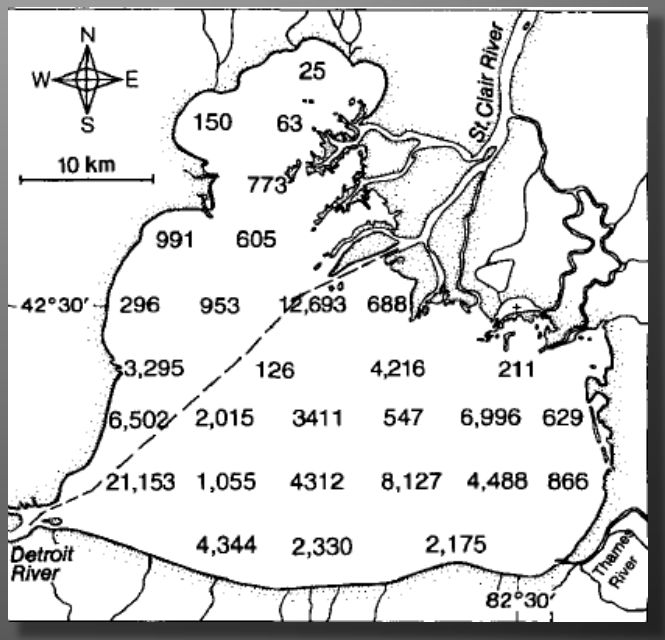
Unionid Decline in Lake St. Clair

Unionid density (m^2)



Avg. = 0.04 unionids/m^2

Dreissenid density (m^2)

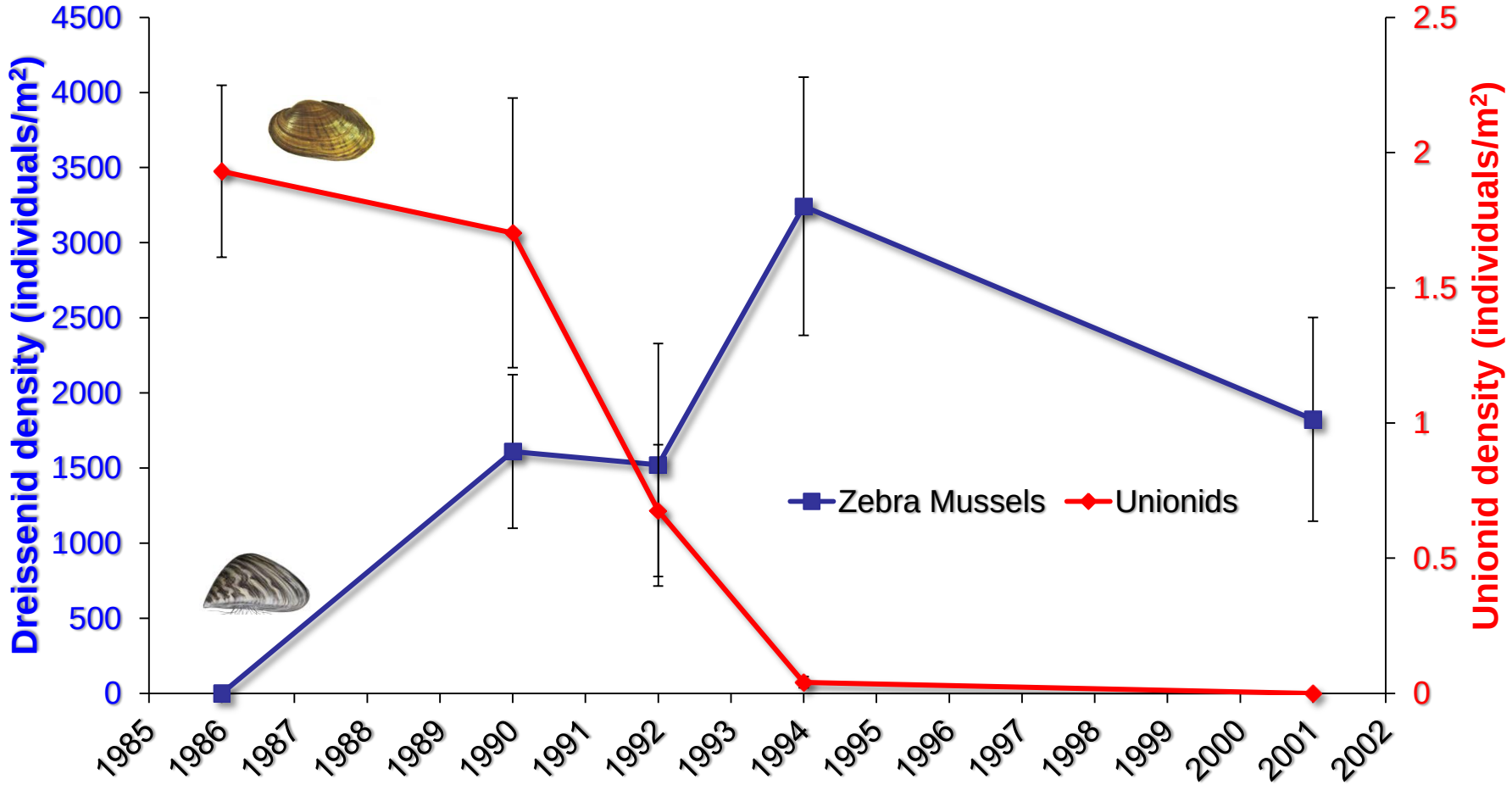


Avg. = 3242 dreissenids/m^2

1994

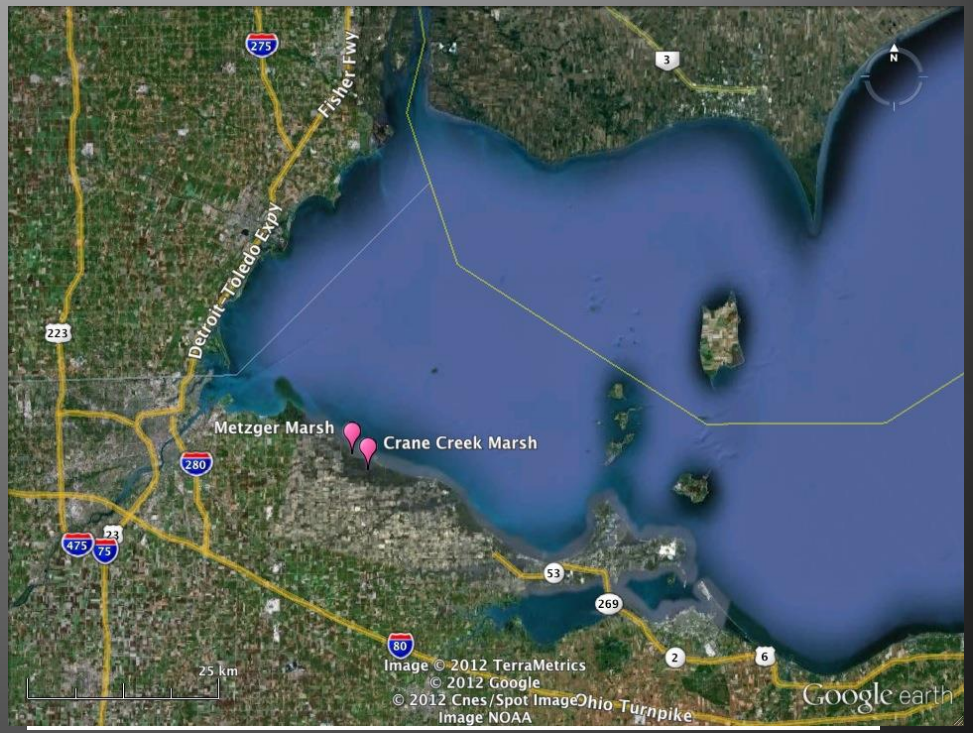
Nalepa et al. 1996

Unionid Decline in Lake St. Clair



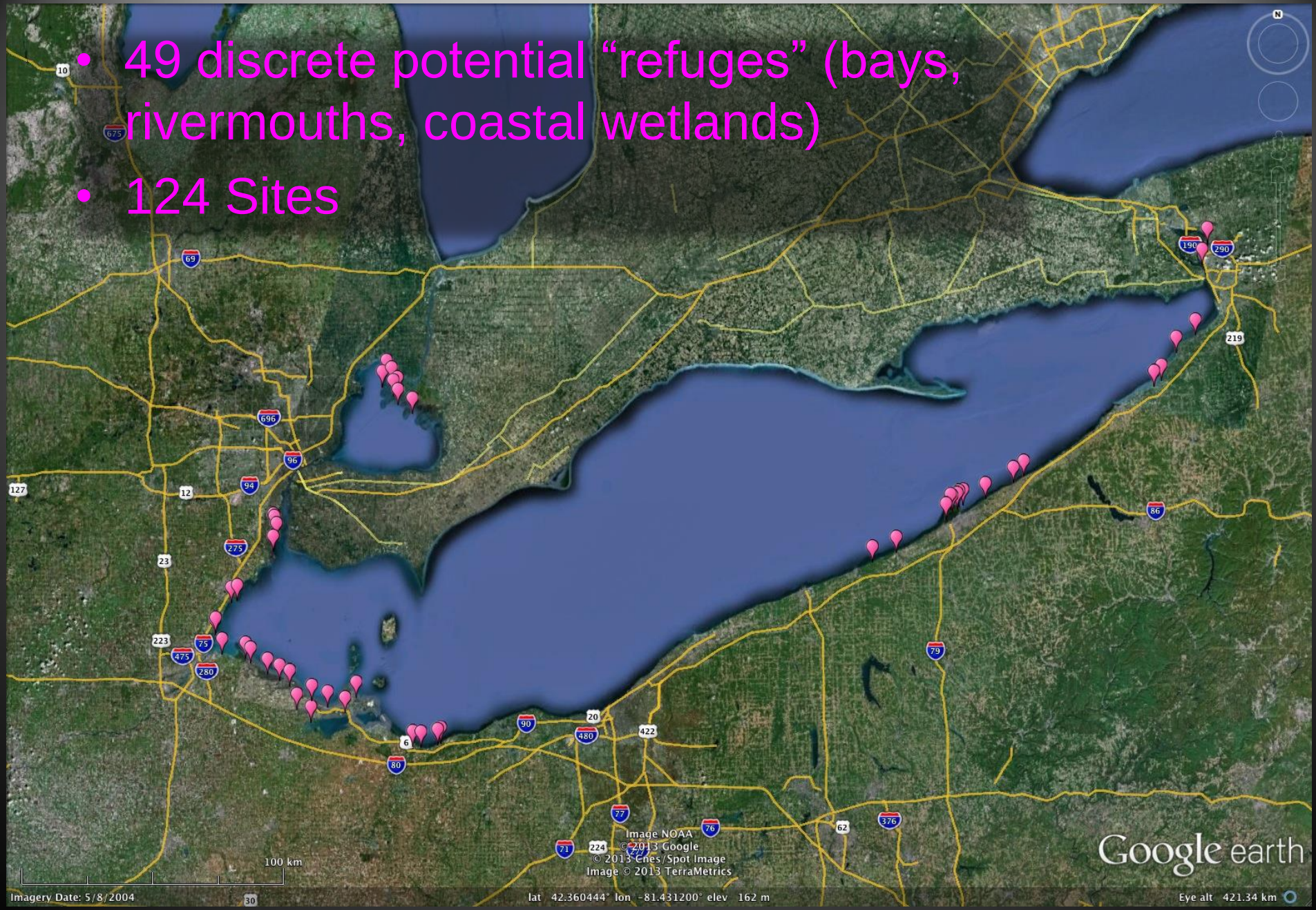
A New Hope? Unionid Refuges

- First unionid refuges found in Lake Erie coastal wetlands (Metzger Marsh, Nichols & Wilcox 1997; Crane Creek Marsh, Bowers & De Szalay 2004, 2005, 2007)
- *Dreissena* densities showed significant declines between 1994 and 2001 in St. Clair (Hunter & Simmons 2004)
- Large unionid refuge discovered and documented in the St. Clair delta 1999-2001 (Zanatta *et al.* 2002)
  - Very shallow <1 m
  - only a single live unionid found in water >2 m



- Exhaustive sampling: 1999-2001, 2003, 2010 (Zanatta *et al.* 2002, McGoldrick *et al.* 2009, Lucy *et al.* 2014)

Zanatta et al. (In Review) *NE Naturalist*



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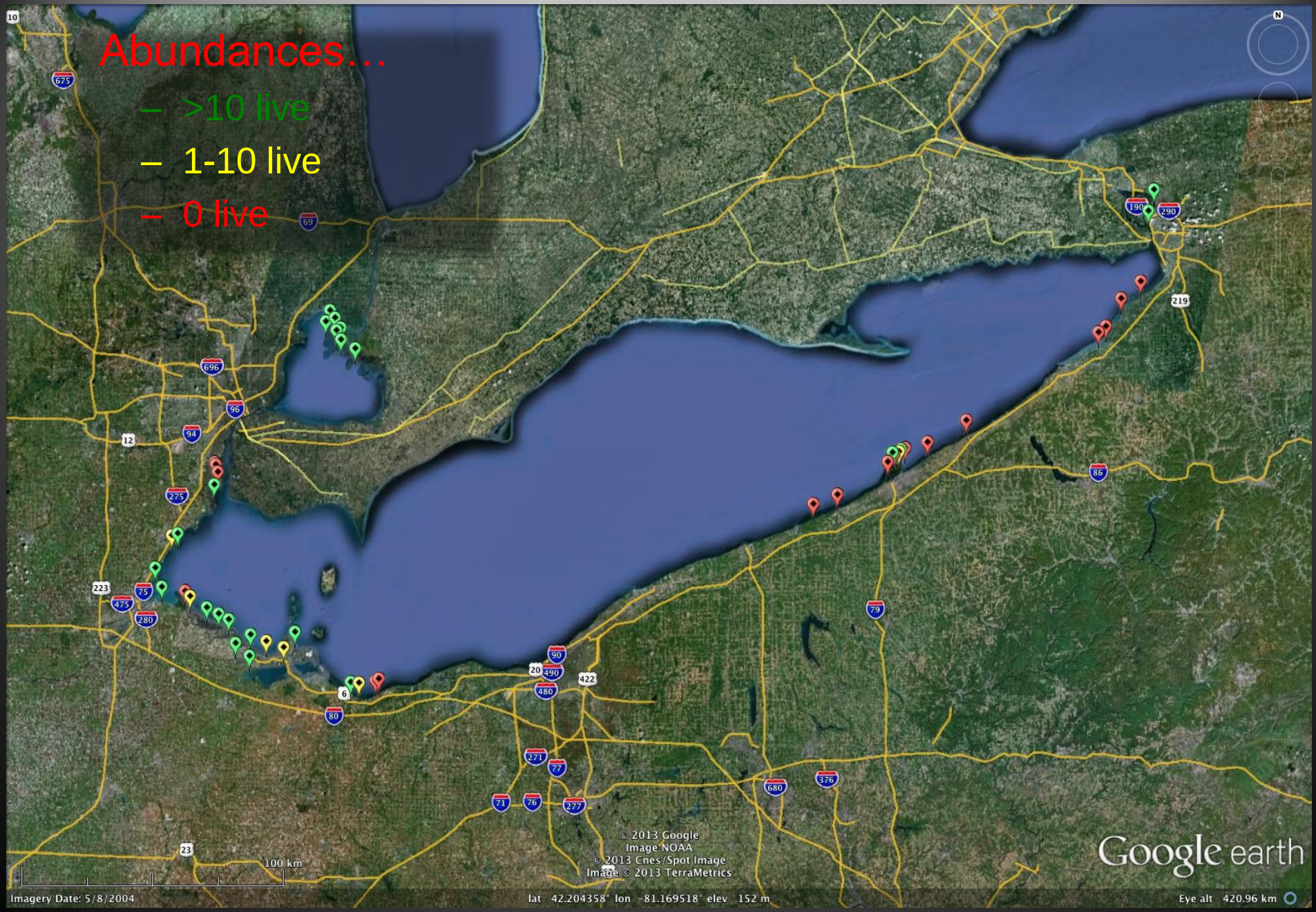

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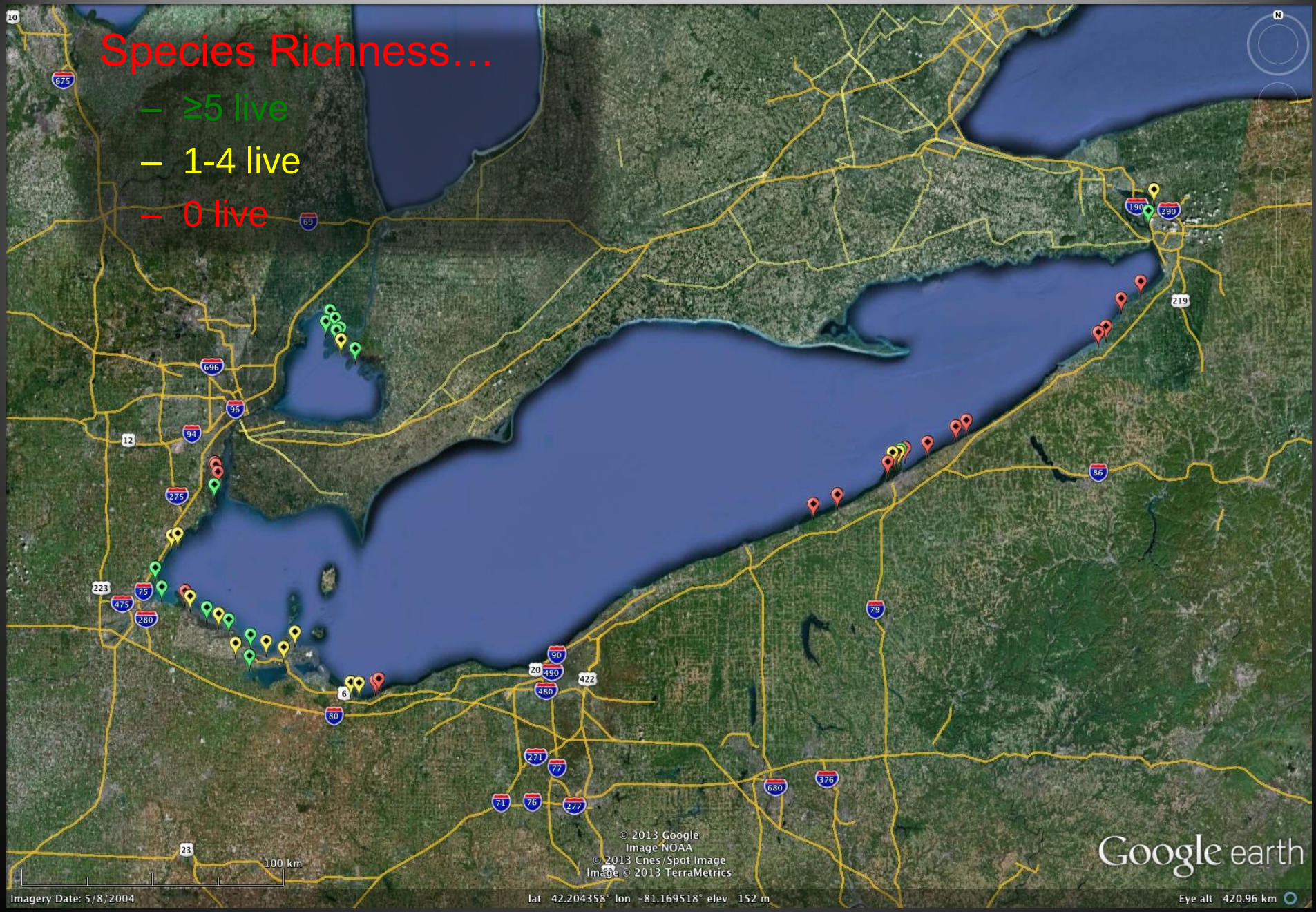

Zanatta et al. (In Review) *NE Naturalist*

Refuge Habitats

- Many factors my be contributing to unionid refuge habitats (Sherman et al. 2013)
  - Soft sediments
  - Fluctuating water levels
  - Wave action
  - Predation
  - Water flow pattern

<u>Retain remnant unionid populations</u>

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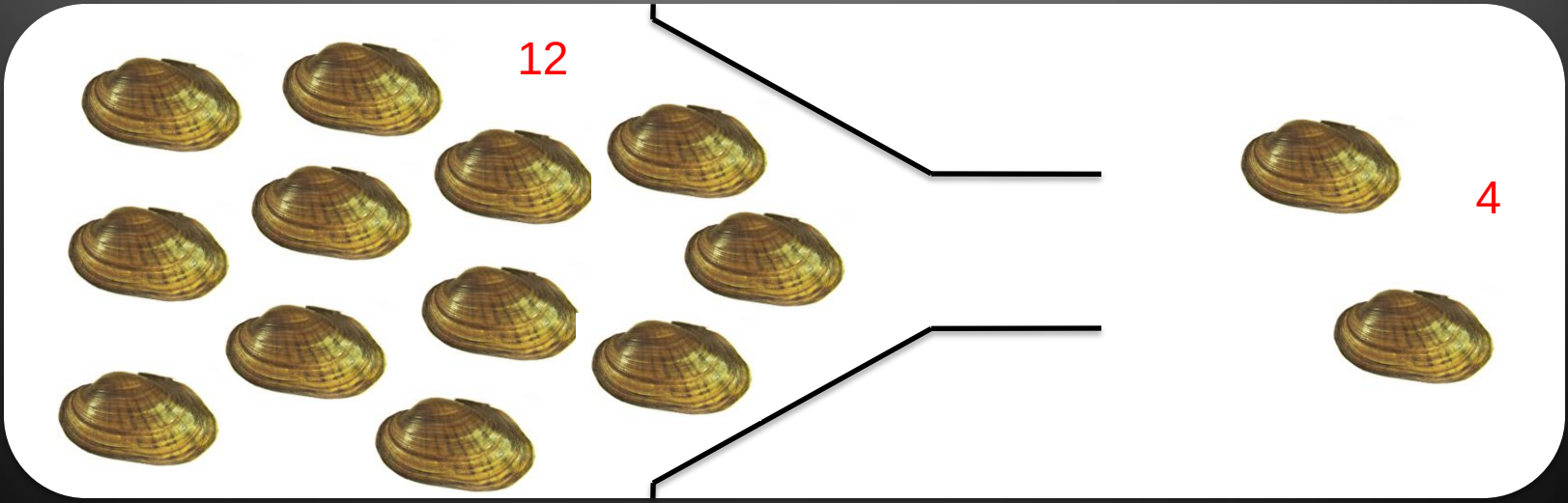
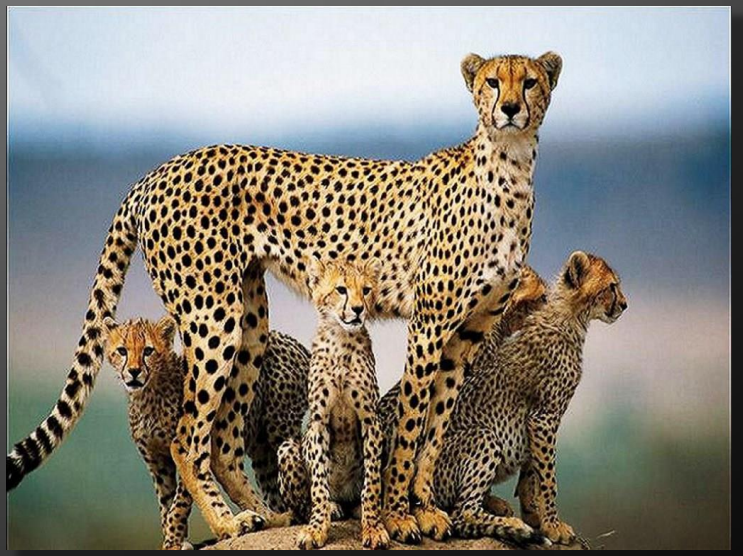
Bottlenecks

- Bottlenecks
  - Demographic: Reduction in effective population size
  - Genetic: Reduction in genetic diversity



Importance of Genetic Diversity

- Loss of adaptability
- Genetic drift
- Inbreeding
- Extinction



Objectives

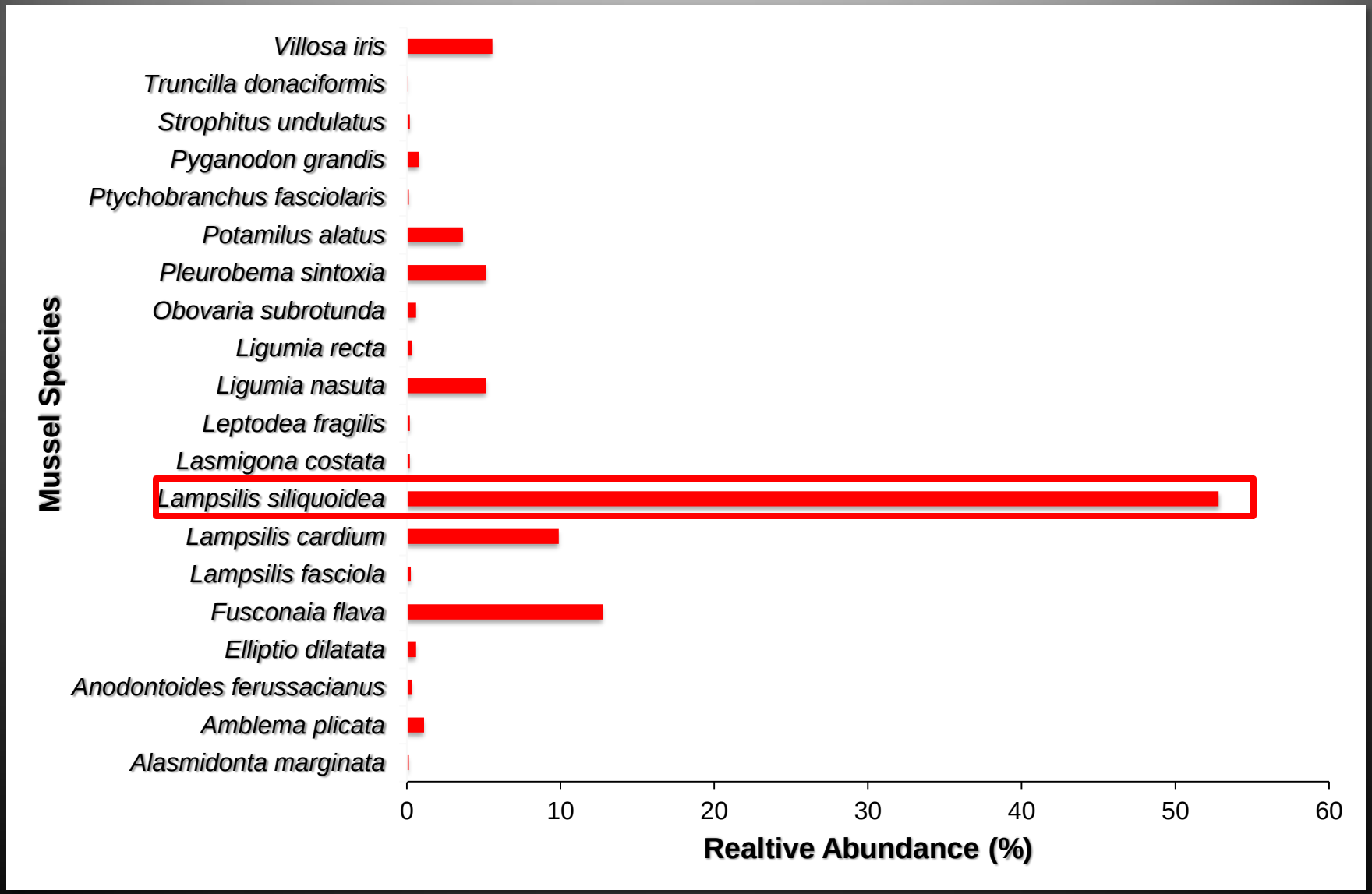
1) How much genetic diversity is present in the remnant populations of Fatmucket?

2) What is the level of gene flow occurring between sampling locations within the St. Clair delta and surrounding watersheds?

3) Is genetic differentiation related to geographic isolation at this scale?

4) Is there any evidence of a recent genetic bottleneck in the Fatmucket populations?

Species Selection



McGoldrick et al. (2009)

Fatmucket

(*Lampsilis siliquoidea*)

- Wide distribution
- Sexually dimorphic
- Muddy or sandy substrates in slow moving waters
- Lifespan >20 years
- Mantle lure
- Host species generalist

Site Selection

- Remnant St. Clair River Delta populations
  - Delta sample sites selected by visiting productive sites previously surveyed (Zanatta et al. 2002, McGoldrick et al. 2009, Lucy et al. 2014)

- Tributary populations unaffected by dreissenids
  - Selected by scouting accessible locations and investigating sites identified by museum records (Ohio State University Freshwater Bivalve Database)

Pollet Bay
(n = 30)

Goose Bay
(n = 77)

Big Muscamoot
Bay
(n = 50)

Pocket bay
(n = 17)

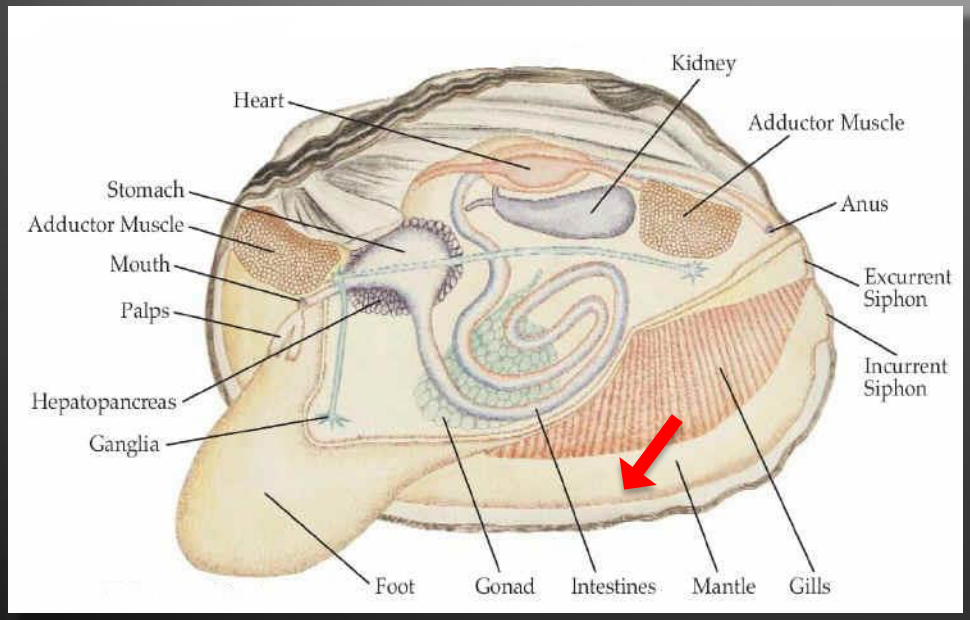
Bass Bay
(n = 29)

Clinton River
(n = 32)

0 10 20 40 60 80 km

N

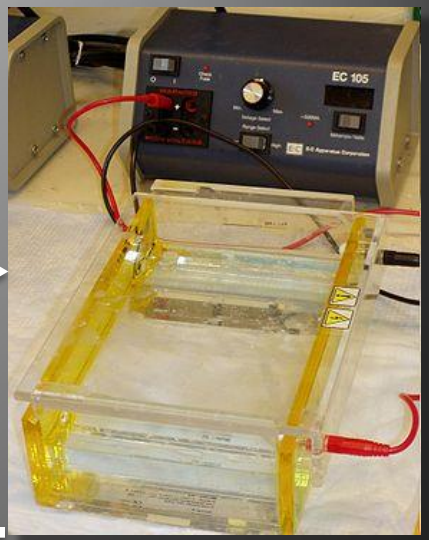
Tissue Collection



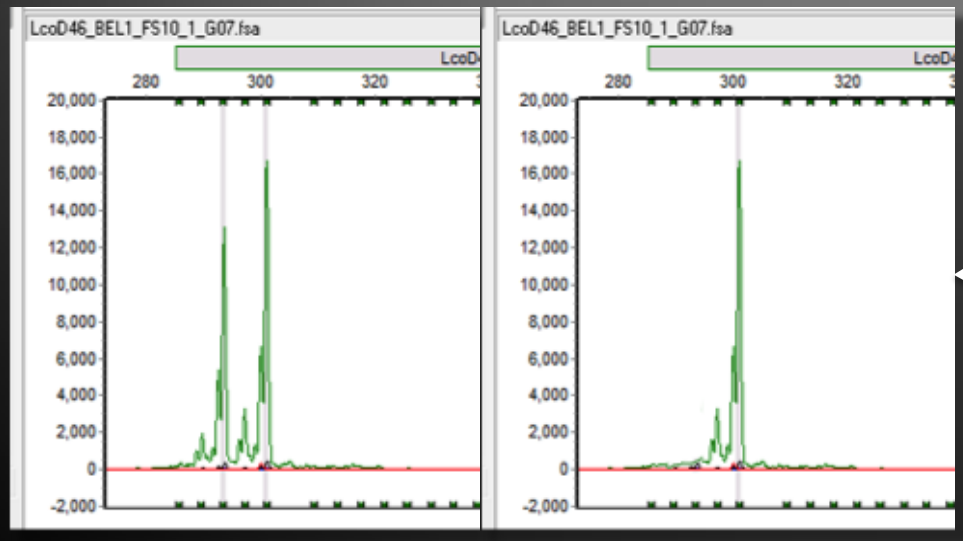
Methods: Genetics

DNA Extraction

Microsatellite PCR



Gel Electrophoresis



Electropherogram/Allele Scoring

Genotyping

Genetic Diversity

- Amplified 8 polymorphic microsatellite loci
  - Originally developed for *Lampsilis abrupta*
- 6 – 43 alleles per locus
- Average of 21 alleles per locus

Study	Common Name	Species	Avg. Polymorphism
Kelly & Rhymer 2005	Yellow Lampmussel	*Lampsilis cariosa*	21.86
Zanatta & Murphy 2007	Northern Riffleshell	*Epioblasma torulosa*	13.70
Zanatta et al. 2007	Wavy-rayed Lampmussel	*Lampsilis fasciola*	15.40
Zanatta & Murphy 2008	Snuffbox	*Epioblasma triquetra*	15.20
Current Study	Fatmucket	*Lampsilis siliquoidea*	21.63

Allelic Richness

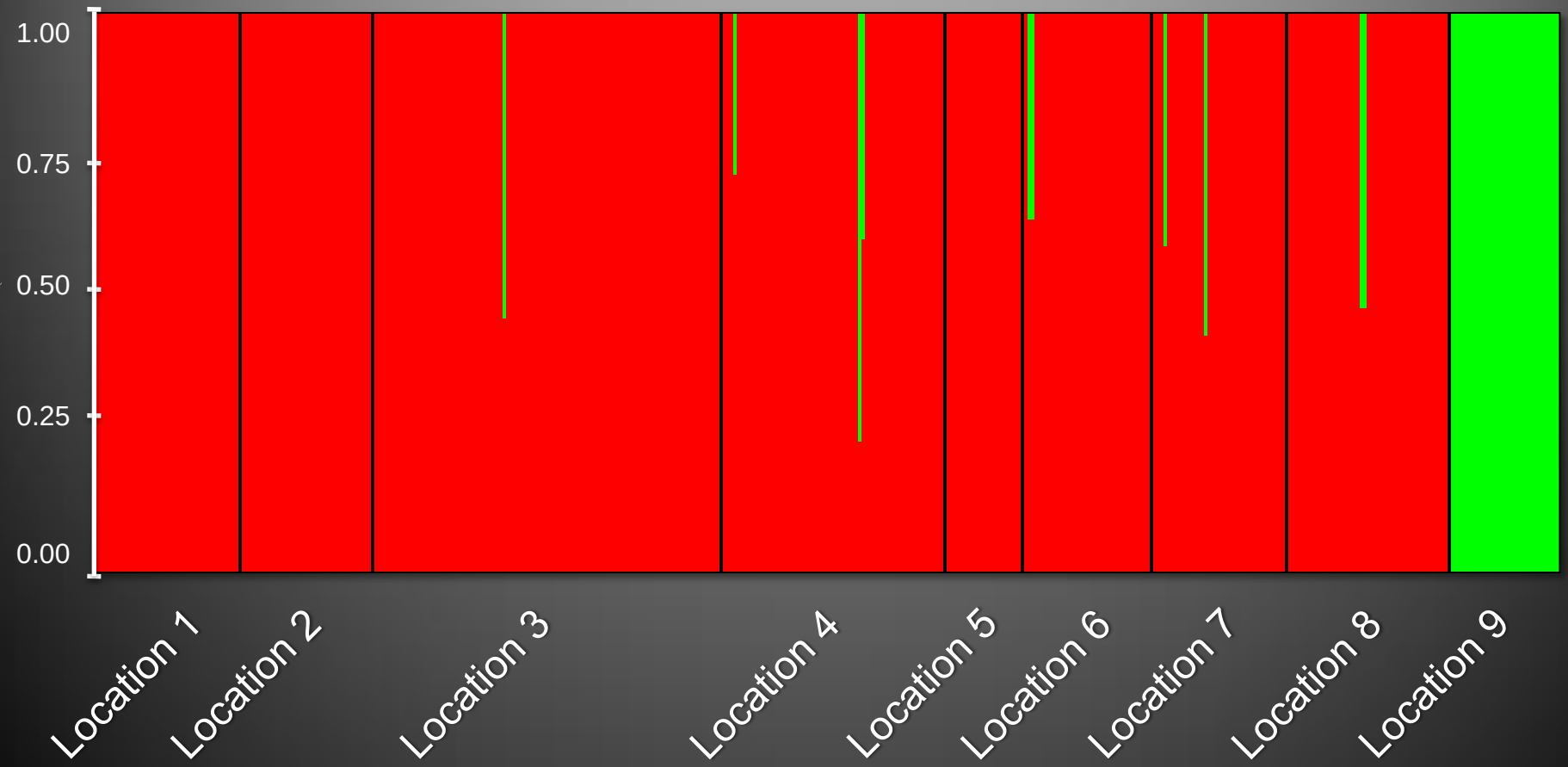
Sampling Location	Avg. Allelic Richness
Clinton River	4.03
Pollet Bay	4.08
Goose Bay	4.03
Big Musc. Bay	4.26
Pocket Bay	3.84
Bass Bay	4.15
Belle River	4.10
Pine River	3.85
Black River	3.77
Average	4.01

No statistical difference between sampling locations (p = .919)

Population Structure

- Individual based analyses using genotype data
- Predicts the most probable number of populations (K)
- Predicts the most probable population of origin for each sample
  - STRUCTURE
    - Indicated one interbreeding population

Population Structure (Example)

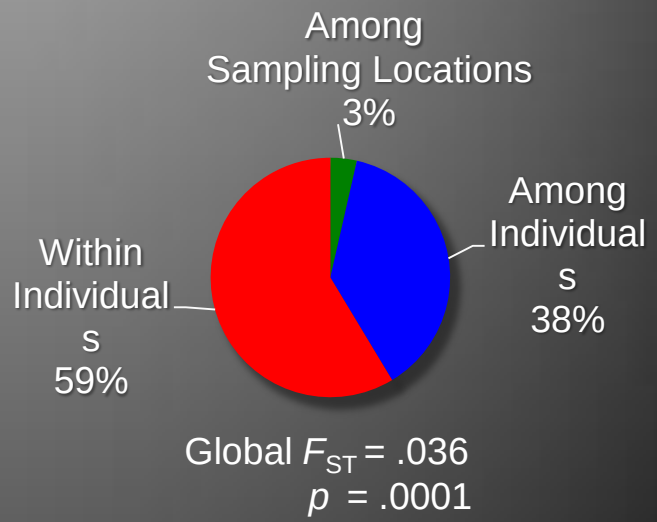


Example: K = 2

Population Structure

Genetic Differentiation: F_{ST}

	Clinton River	Pollet Bay	Goose Bay	Big Musc. Bay	Pocket Bay	Bass Bay	Pine River	Belle River	Black River
Clinton River									
Pollet bay	0.034*								
Goose Bay	0.028*	0.004*							
Big Musc. Bay	0.060*	0.022*	0.007						
Pocket Bay	0.054*	0.074*	0.069*	0.099*					
Bass Bay	0.011	0.028*	0.021*	0.052*	0.057*				
Pine River	0.030*	0.041*	0.033	0.062*	0.085*	0.024*			
Belle River	0.036*	0.024*	0.003*	0.015*	0.071*	0.020*	0.037*		
Black River	0.046*	0.044*	0.043*	0.080*	0.090*	0.022*	0.050*	0.045*	



Significant(*) = $p < 0.0014$ after Bonferroni correction

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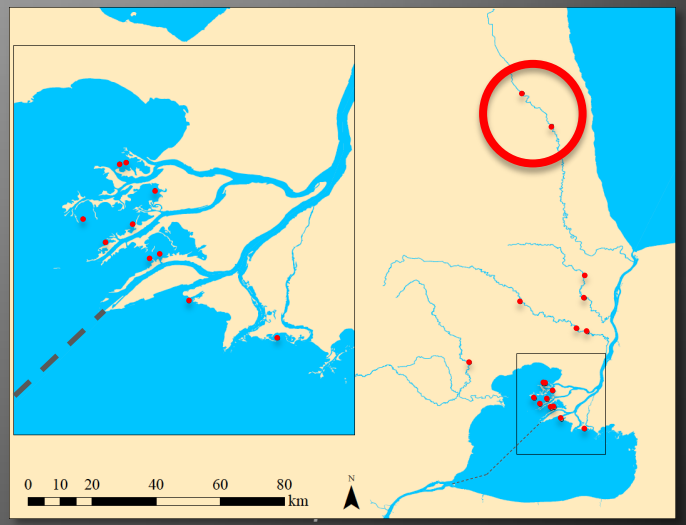
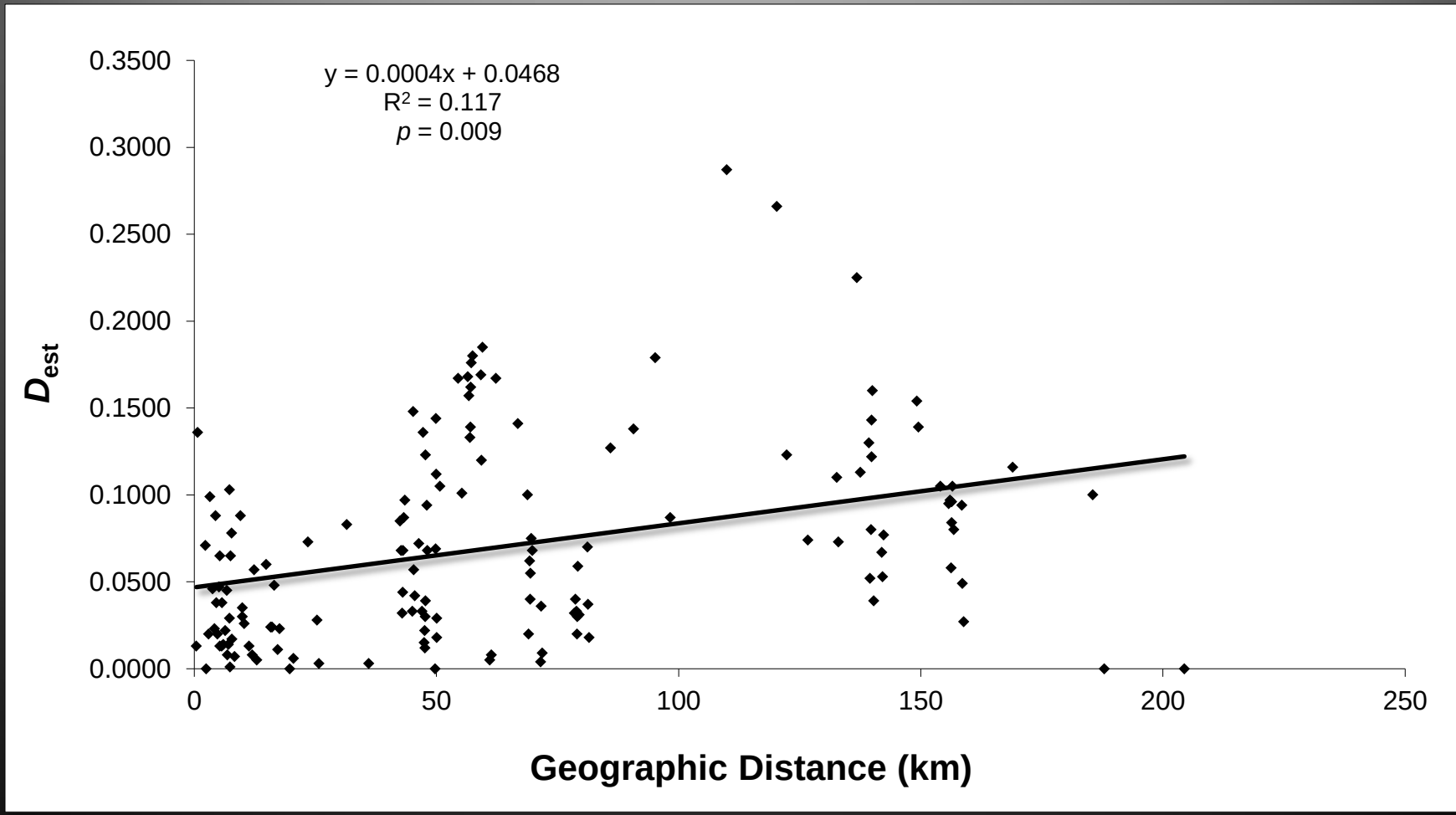


Significant(*) = $p < 0.0014$ after Bonferroni correction

Isolation by distance



Bottleneck

More ← Sensitivity → Less

Population	I.A.M	T.P.M	S.M.M	Mode Shift
Big Muscamoot Bay	0.006*	0.986	0.990	Normal L-shaped
Goose Bay	0.014*	0.986	0.996	Normal L-shaped
Pollet Bay	0.098	0.875	0.963	Normal L-shaped
Bass Bay	0.010*	0.320	0.527	Normal L-shaped
Pocket Bay	0.191	0.809	0.844	Normal L-shaped
Belle River	0.010*	0.996	0.998	Normal L-shaped
Black River	0.320	0.973	0.986	Normal L-shaped
Clinton River	0.125	0.980	0.980	Normal L-shaped
Pine River	0.006*	0.809	0.902	Normal L-shaped
All Sites	0.010*	0.994	0.996	Normal L-shaped

Significant(*) = $P < 0.05$

No tests significant after bonferroni correction ($\alpha = 0.002$) (excludes “All Sites”)

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Conclusions

1) Still diverse remnant unionid community in the St. Clair delta

   - Among highest quality refuges in the lower Great Lakes

   - Continuing declines in WIFN Territory?

   - Continued monitoring recommended

2) Genetic diversity did not appear to be compromised by recent dreissenid invasion

3) Sampling locations appear to comprise a single interbreeding population

4) Genetic differentiation was significantly correlated with geographic distance

5) Little evidence was found supporting a recent genetic bottleneck

   - Insufficient time since dreissenid invasion?

   - Insufficient demographic bottleneck to produce genetic bottleneck?

Rowe and Zanatta (2014) *Biological Invasions*

Future Directions

- The results for Fatmucket mussels represent a “best case scenario”
- Further studies should be conducted with less common and more sensitive species
- Monitoring of unionids in Lake St. Clair and St. Clair River should continue in order to protect the Great Lakes’ fragile mussel assemblages and populations

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  - Coastal Zone Management Program
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- Central Michigan University

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Ken Koster
Roy Beasley
David Dortman

DTE dive team


Questions?
Papers and more info:
http://people.cst.cmich.edu/zanat1d/