

Genetic Patterns of the Invasive Eurasian Ruffe over Time & Space



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Eurasian Ruffe

Gymnocephalus cernua

- ▶ Native range = Siberia, northern, central, & eastern Europe
- ▶ Invasive range = southern & western Europe & the Laurentian Great Lakes

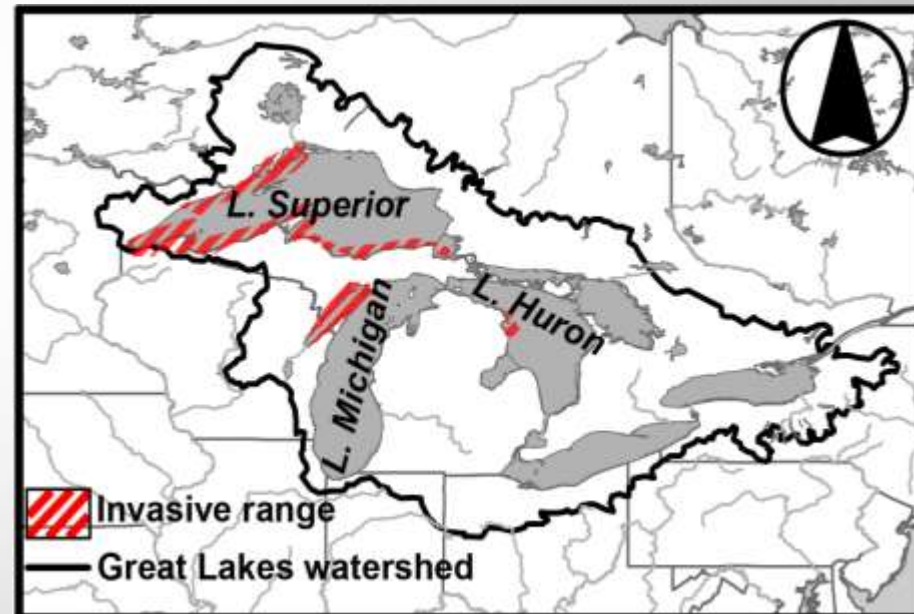


Ruffe Invasion History

- ▶ 1986 – Introduced in St. Louis Harbor via ballast water
 - ▶ Spread along L. Superior's southern shore
- ▶ 1995 – Established in northern Lake Huron
 - ▶ Ballast water discharge from intralake shipping
 - ▶ Not captured in abundance since ~2003
- ▶ 2002 – Established in northern Lake Michigan
 - ▶ Increasing population densities



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Adapted from: Stepien and Haponski 2015

Ruffe Ecology

- ▶ Adaptive and tolerant of a wide habitat range
 - ▶ Salinity (0–12ppt)
 - ▶ Temperature (4–30°C)
 - ▶ Depth & flow
 - ▶ Eutrophic or oligotrophic
- ▶ High fecundity
 - ▶ Matures at 1yr (M), 2yrs (F)
 - ▶ At small size (<10 cm TL)
 - ▶ Wide spawning range
- ▶ Consume benthic organisms
 - ▶ Fish eggs & small fishes



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Risk Analysis



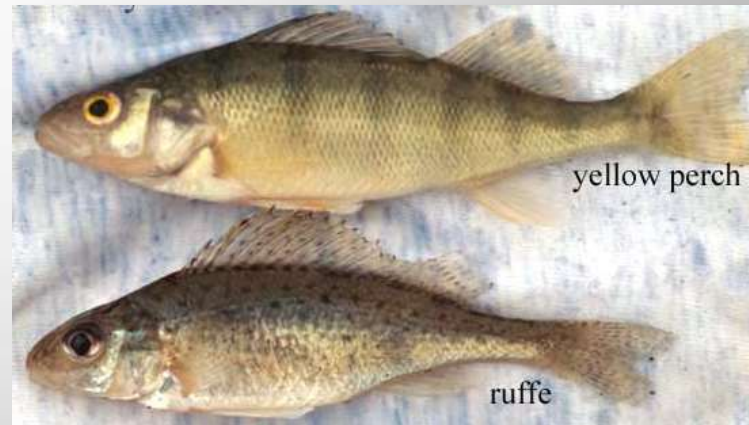
- ▶ Rapidly becomes one of the most abundant species at some sites
- ▶ Potential predator on coregonids
- ▶ Potential competitive threat to yellow perch
 - ▶ Habitat & prey overlap
 - ▶ Ruffe have feeding advantage
- ▶ Ruffe proliferate with anthropogenic disturbances



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Past Studies

- ▶ Studies in the early 90s at St. Louis Harbor revealed:
 - ▶ Ruffe quickly became most abundant species
 - ▶ As number of ruffe increased, yellow perch decreased
- ▶ Earlier studies by Stepien *et al.* have determined:
 - ▶ Elbe River, Germany likely source
 - ▶ Invasions monotypic for mtDNA control region

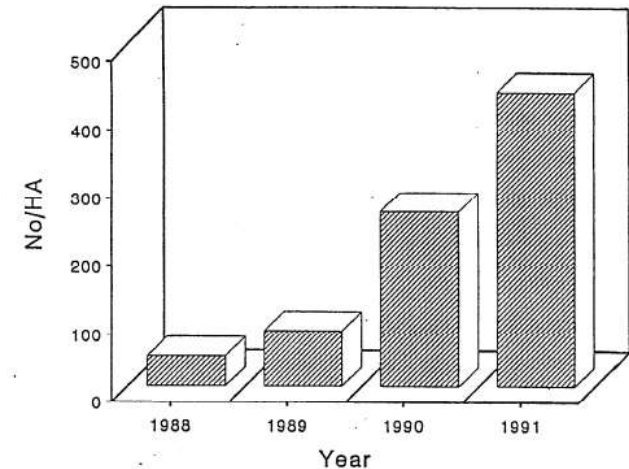


Figure 3. Abundance of ruffe (No./HA) in the St. Louis River, 1988-91.

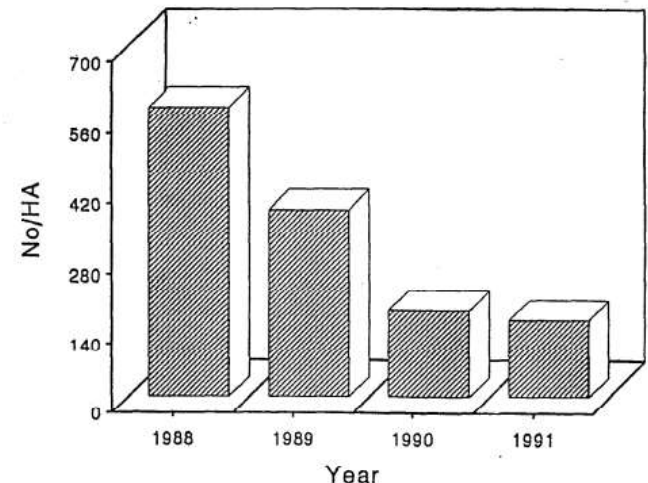


Figure 7. Abundance of yellow perch (No./HA) in the St. Louis River, 1988-91.

Project Objectives

1. Determine spatial differentiation patterns
2. Analyze whether population genetic composition changed throughout the invasion histories (~30 yrs)



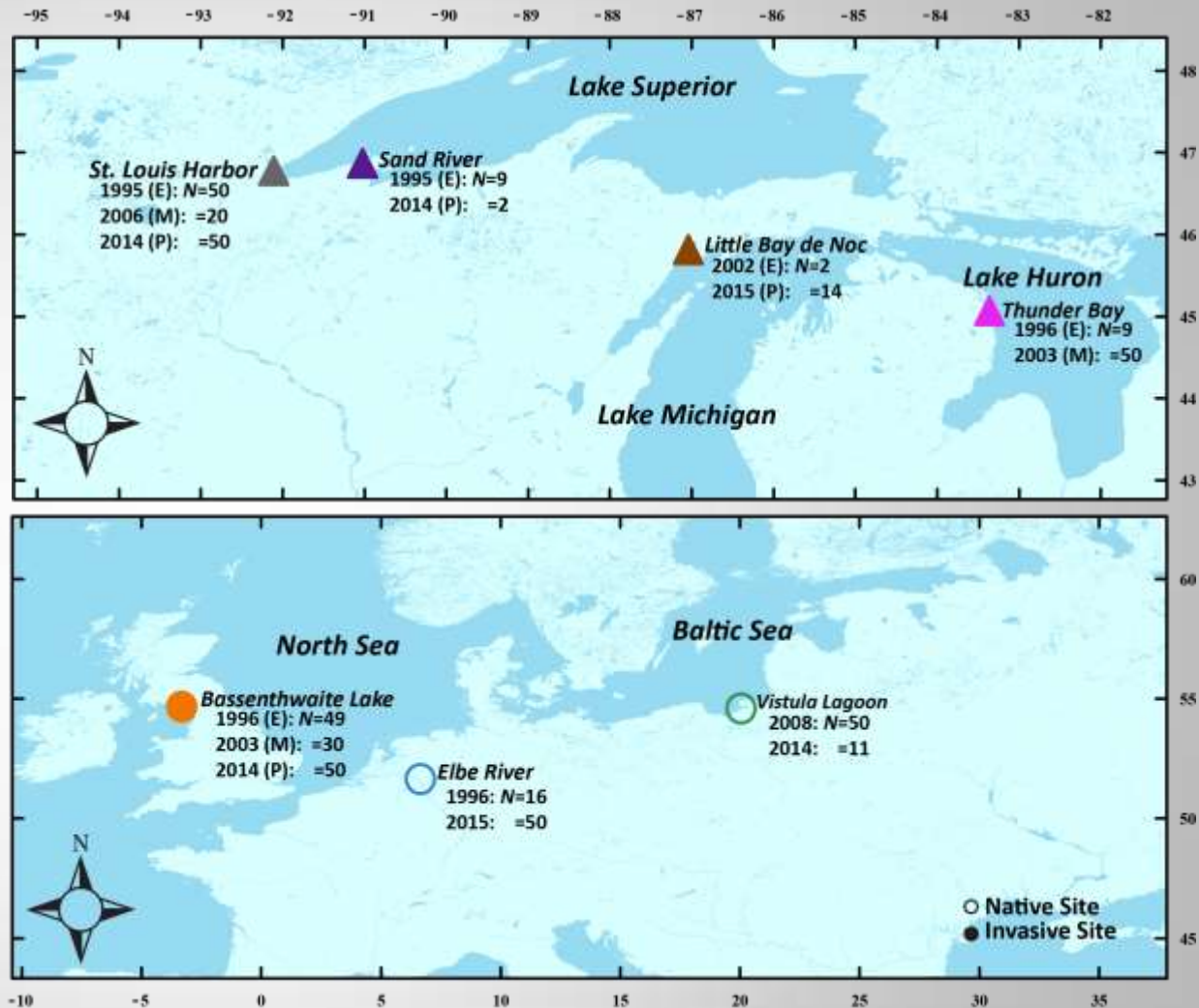
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Study Plan

- ▶ Samples representing invasive stages:
 - ▶ Early (E)
 - ▶ Middle (M)
 - ▶ Present (P)
- ▶ Compare to temporally congruent invasion in Bassenthwaite Lake
- ▶ Native samples will be used as a control
- ▶ Analyze using 10 nuclear μ sat loci



Diversity

- ▶ Greater genetic diversity in the native Baltic Sea Region than in either invasive region
- ▶ Decreases in N_A and A_R indicate slight initial founder effect

N = number of individuals
 H_O = observed heterozygosity
 N_A = number of alleles
 A_R = allelic richness



Population	Population samples	N	H_O	N_A	A_R
I Great Lakes (invasive)	I _a St. Louis Harbor	120	0.41	58	2.81
	I _b Sand River	11	0.30	28	2.61
	I _c Little Bay de Noc	16	0.42	33	2.62
	I _d Thunder Bay	59	0.39	40	2.53
	Total GL	206	0.38	70	2.68
II Northern England (invasive)	II Bassenthwaite Lake	129	0.35	57	2.42
III Baltic Sea Region (native)	III _a Elbe River	66	0.51	98	4.02
	III _b Vistula Lagoon	61	0.55	92	4.10
	Total BSR	127	0.53	126	4.05

Divergence

- ▶ Strong spatial differentiation among the 3 regions:
 - ▶ Bassenthwaite Lake is the most divergent
- ▶ Baltic Sea Region sites differ slightly
- ▶ Single pairwise difference in the Great Lakes
 - ▶ St. Louis Harbor vs Thunder Bay

Pairwise genetic divergences (note the difference between I_a and I_d)

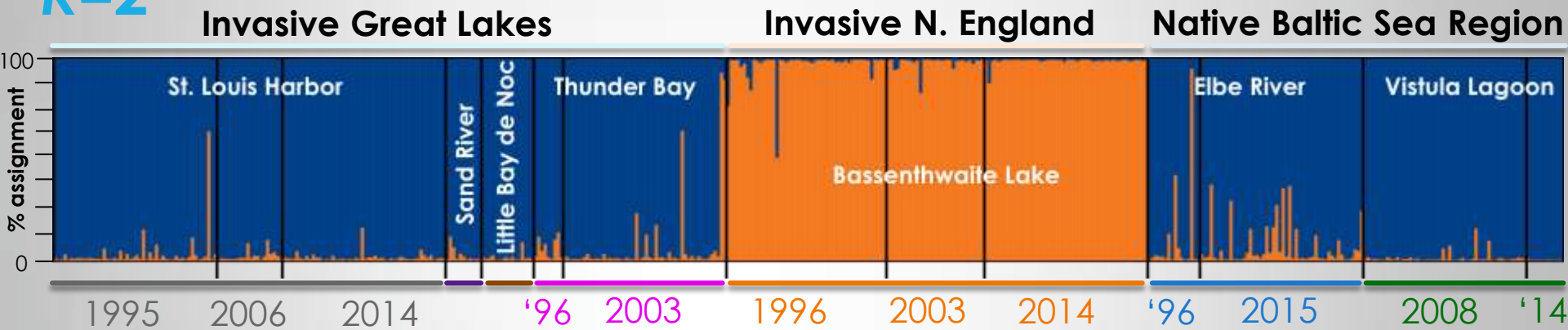
* = significant after sequential Bonferroni correction

Site	I_a	I_b	I_c	I_d	II	III _a
I_a St. Louis Harbor	-					
I_b Sand River	0.034	-				
I_c Little Bay de Noc	0.017	0.015	-			
I_d Thunder Bay	0.012*	0.043	0.030	-		
II Bassenthwaite Lake	0.177*	0.214*	0.218*	0.178*	-	
III _a Elbe River	0.080*	0.114*	0.068*	0.105*	0.170*	-
III _b Vistula Lagoon	0.110*	0.103*	0.070*	0.125*	0.247*	0.049*

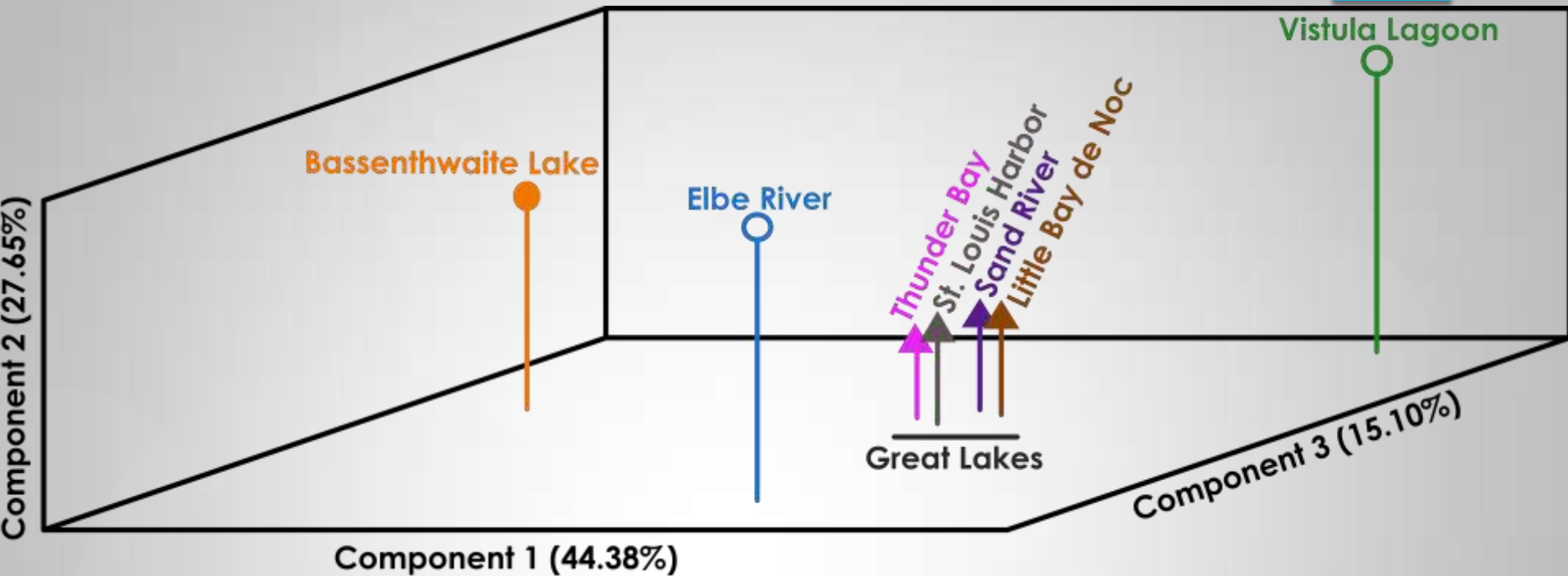
Population Structure

- ▶ Each invasion has a separate source
 - ▶ Single source of invasion with no additional introductions
- ▶ Genetic composition of invasions remained consistent over time

$K=2$

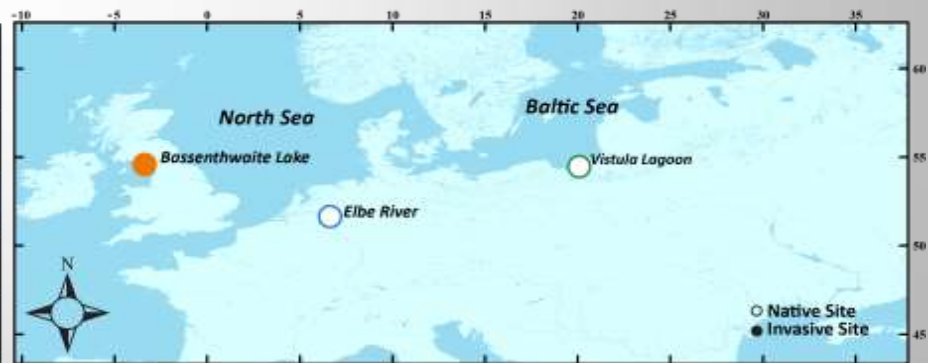
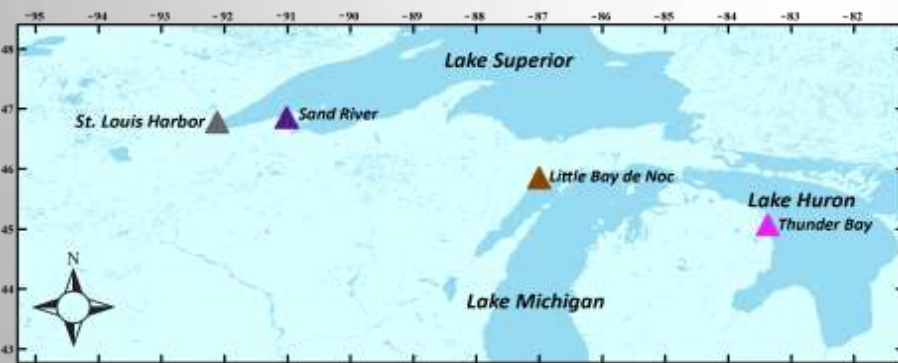


Population Structure



▶ Great Lakes sites cluster close together

▶ Elbe River closest to Great Lakes



Conclusions



- 1. Strong spatial differentiation among both invasive regions and native Baltic Sea Region**
- 2. Elbe River is genetically closest to the Great Lakes**
- 3. Slight initial founder effect in both invasions**
- 4. Range expansion of original colonists from St. Louis Harbor**
- 5. Genetic compositions of both invasions have remained stable with no additional introductions or secondary founder effects**

Thank you! Questions?

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