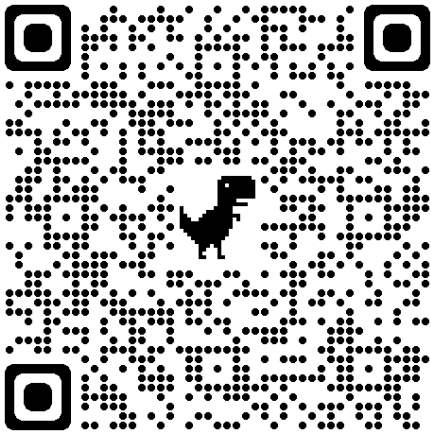


Restoration Opportunities for Muskellunge in a Great Lakes Area of Concern Based on Movement and Trophic Ecology

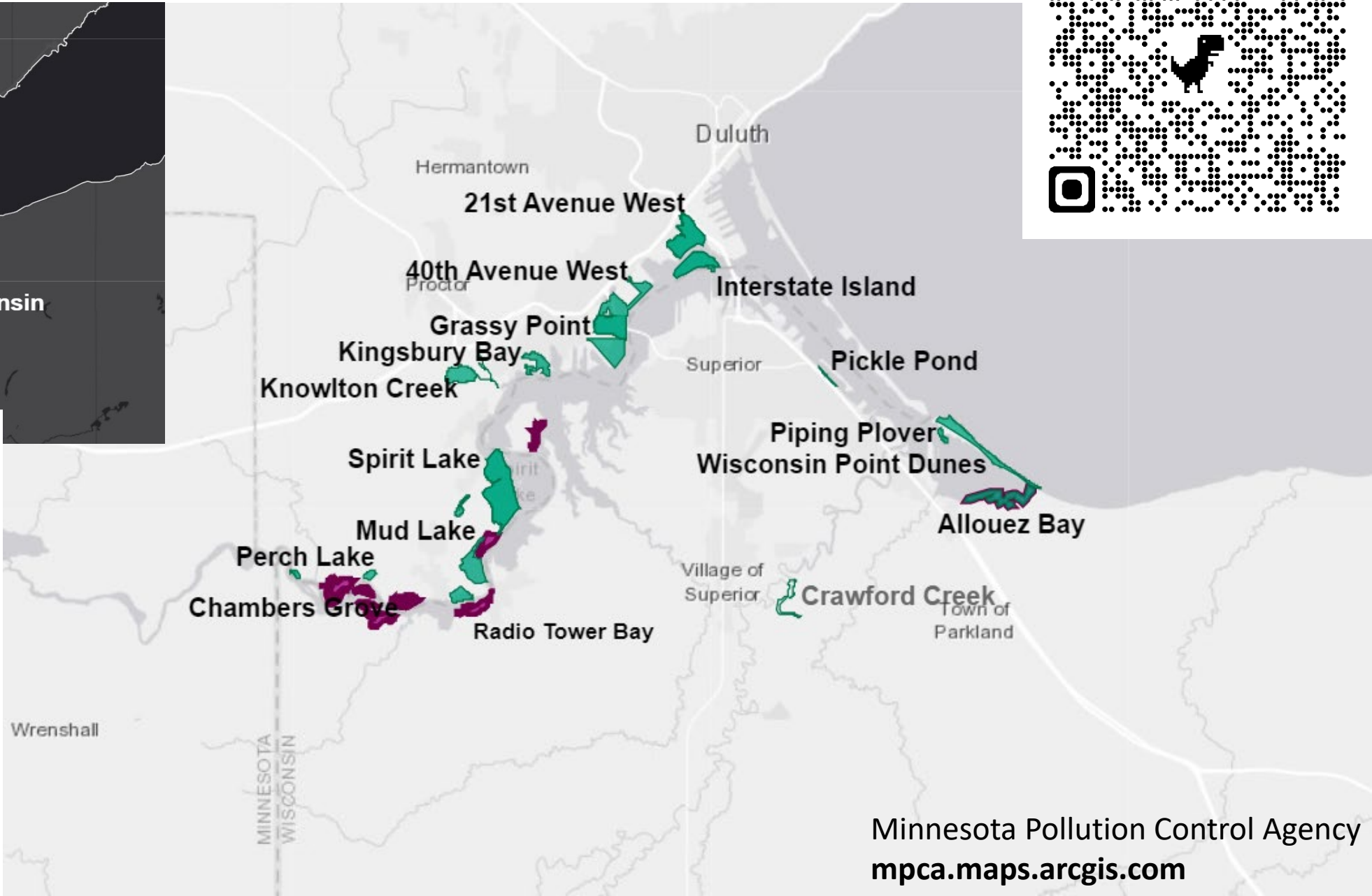
D. Sullivan, J. Pinkerton, D. Wilfond, L. Miller, and J. Hoffman



St. Louis River AOC Restoration Projects



Habitat Restoration Progress
as of 3/31/22



Muskellunge in the St. Louis River



— MN & WI DNR stocked

- 1983 to 2005
- 2 genetic strains (MN/WI)

— Natural reproduction

- 2005 +
- Hybridization

— Ongoing studies

- Acoustic tagging
- Isotope tracing

Research Goals

Characterize movement

- Behavioral changes
 - By season
 - By reproductive period
- Emigration to L. Superior

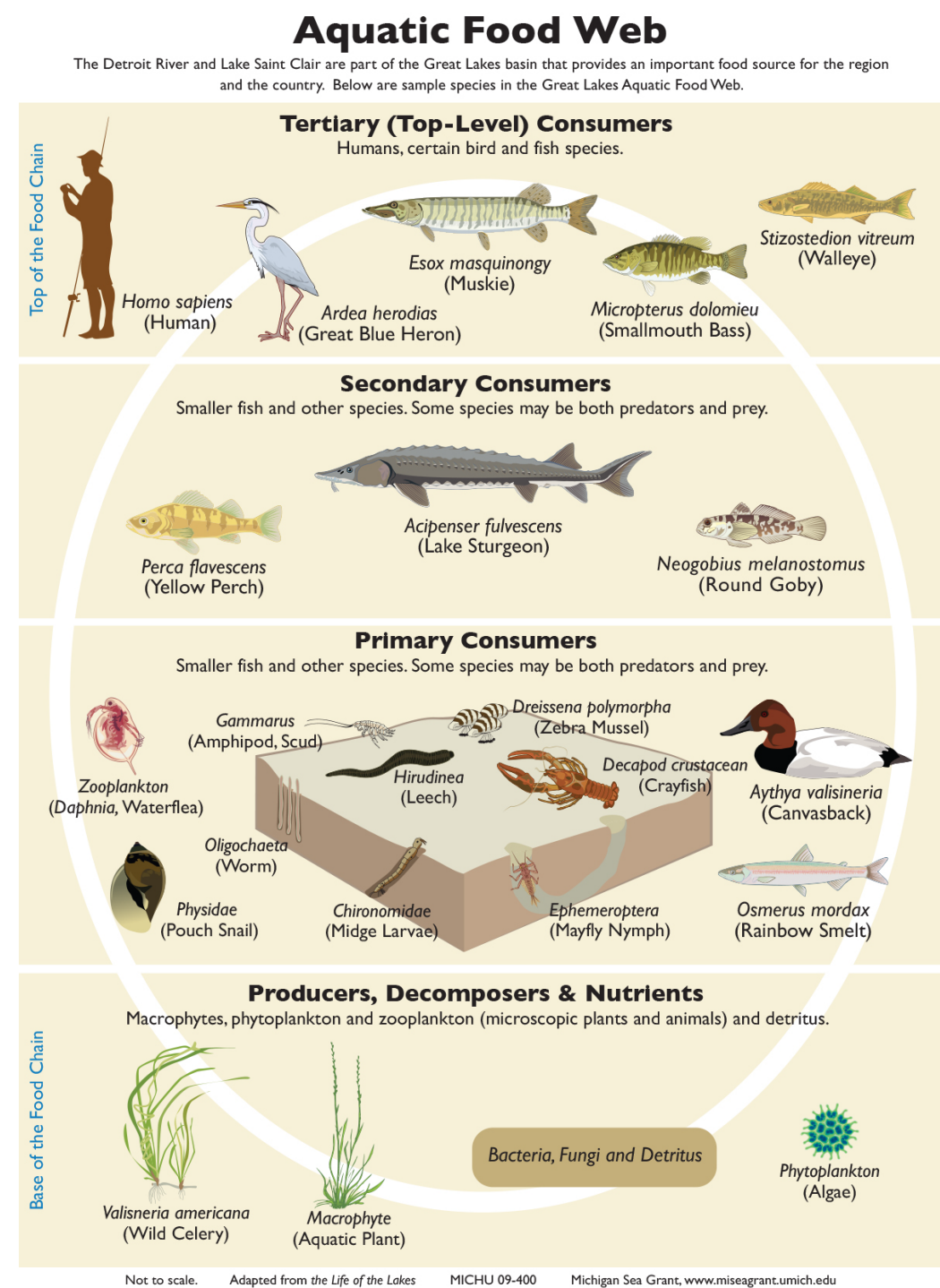
Characterize habitat use

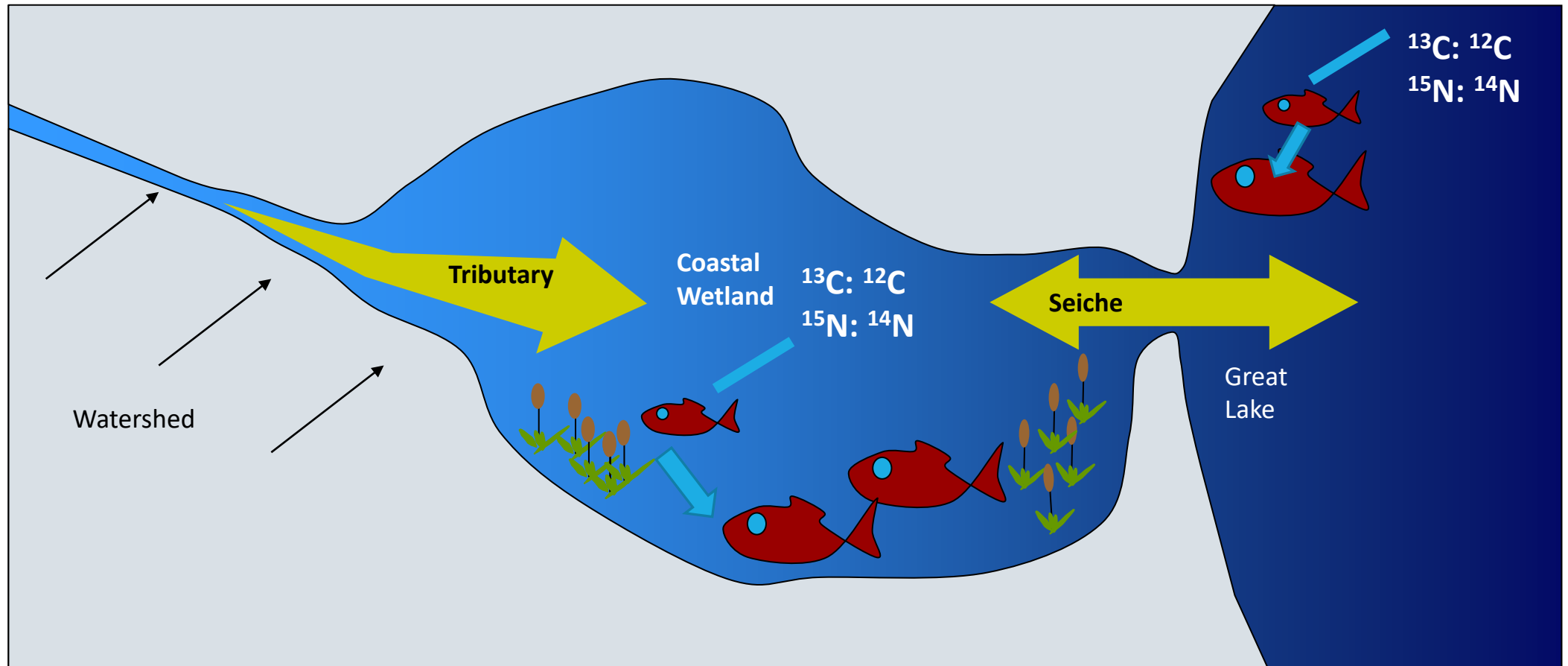
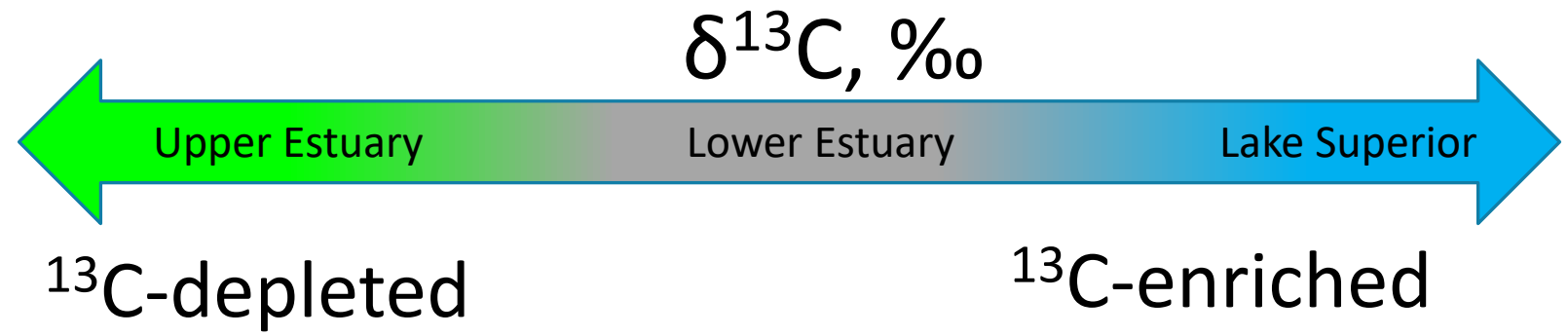
- SLRE vs. Lake Superior
 - By strain
 - By sex
 - By size



Stable Isotope Ratios

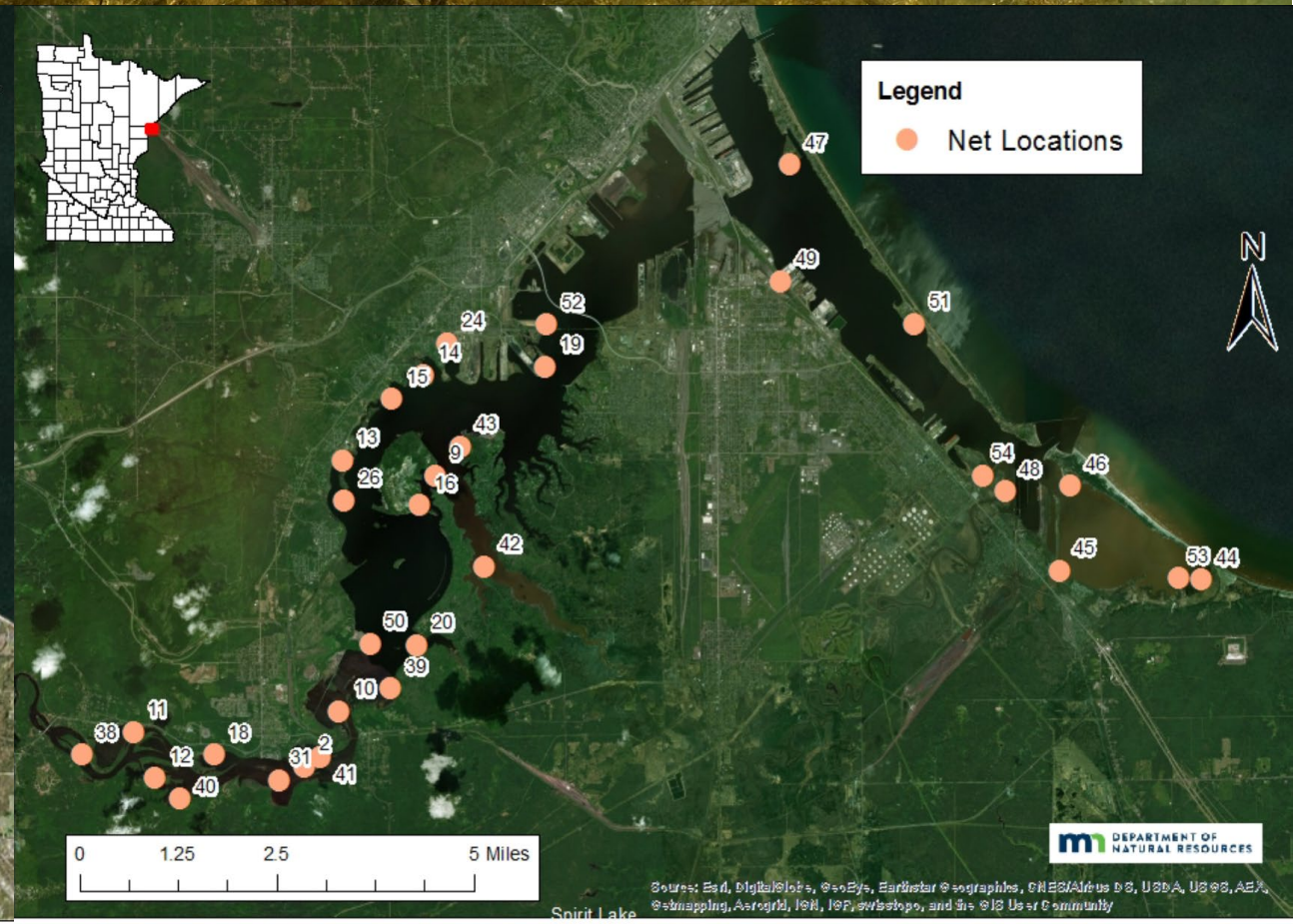
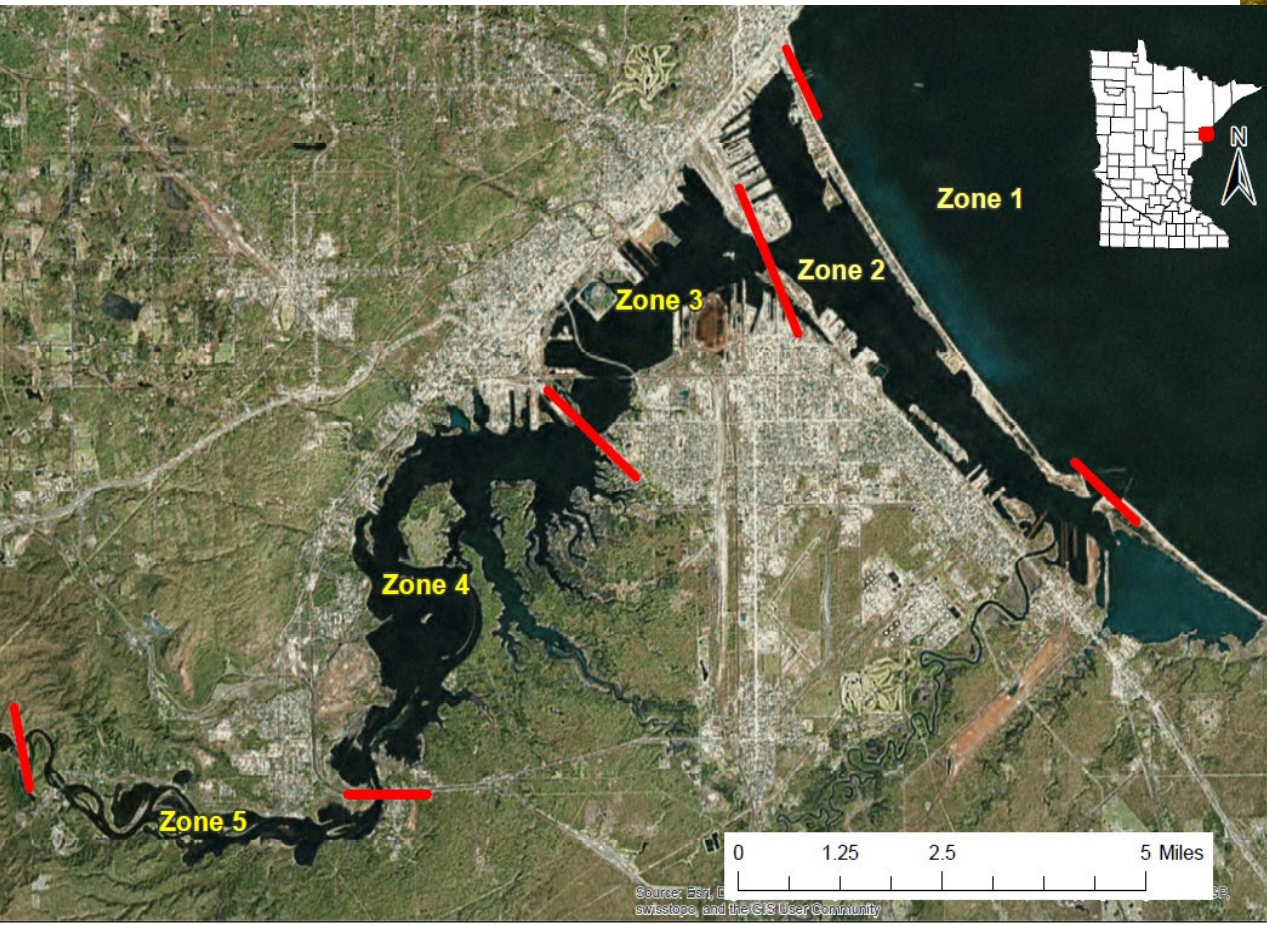
- Isotopes: Atoms of the same element with different masses (measure $^{13}\text{C}:^{12}\text{C}$)
- Diet marker passed up through food webs—
“You are what you eat”
- Time integrated signal - $\delta^{13}\text{C}$ value reflects diet over a 1-2 year period for large fish
- Habitat-specific signatures
 - $\delta^{13}\text{C}$ value differs between habitats with difference in biogeochemistry and/or food web structure
- Known values for the SLRE and L. Superior





Study Area/Capture

— Angled & Trapped
— 2015 to 2017



Methods

- Fin clip for SI analysis ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$)
- Clean, grind, weigh
- Mass spectrometer/UC Davis SI Lab
- Analysis of Covariance (ANCOVA)
- Tukey HSD Post-Hoc Test



By Survey

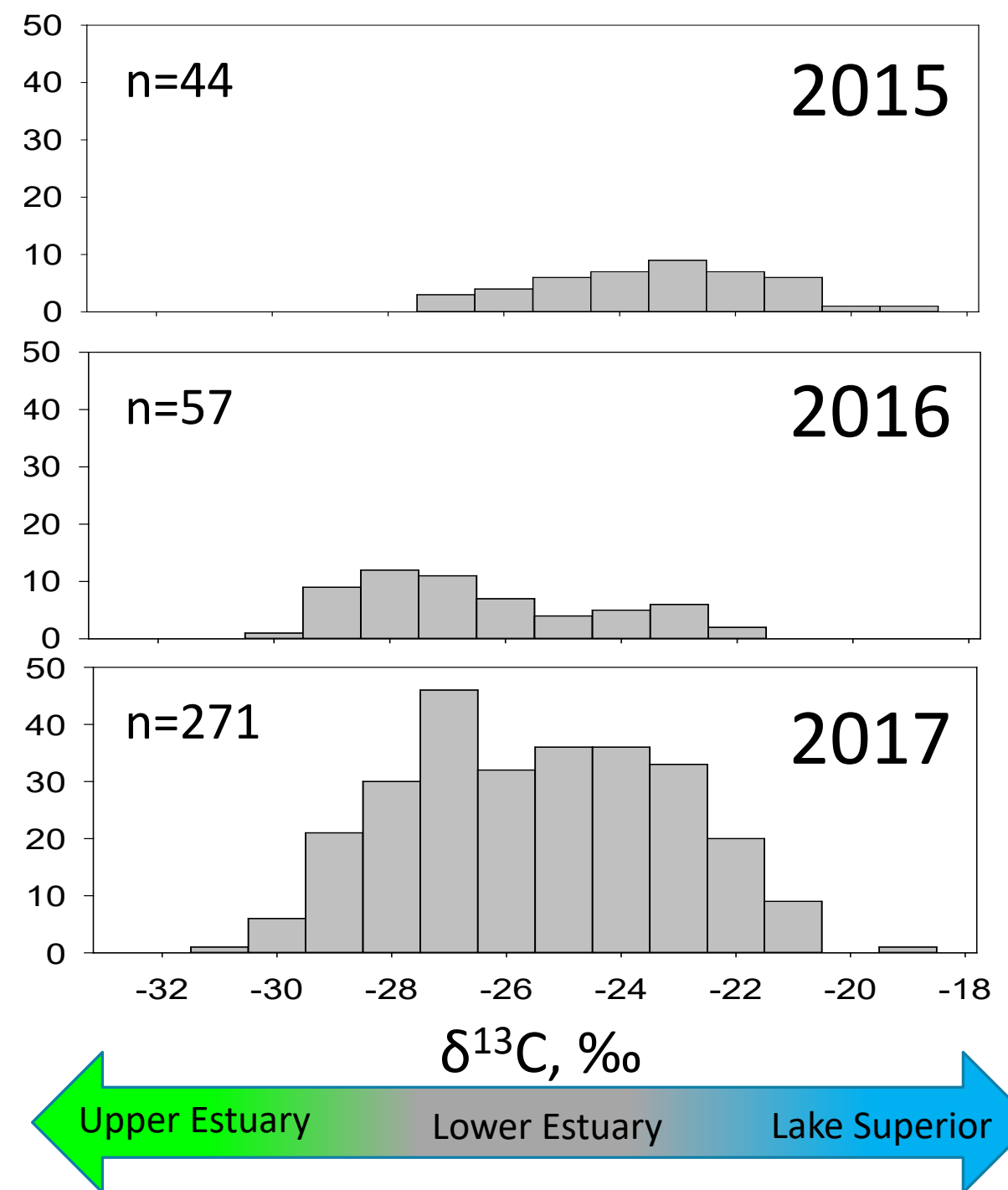
2015: Angler only

2016: Angler and MN-WI DNR spawning survey (fishery independent)

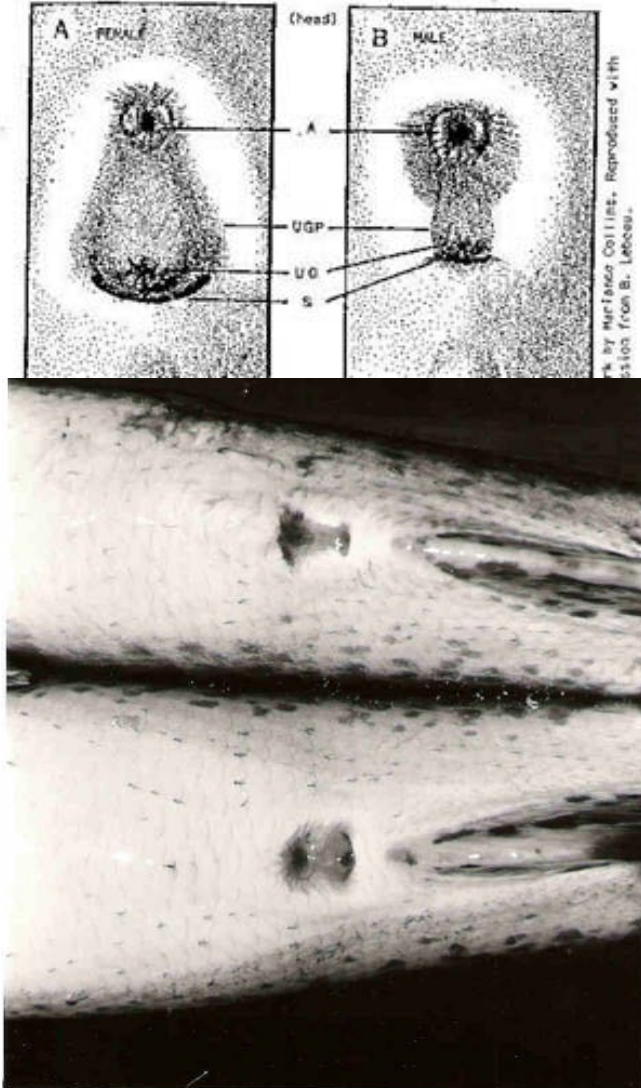
2017: MN-WI DNR survey only



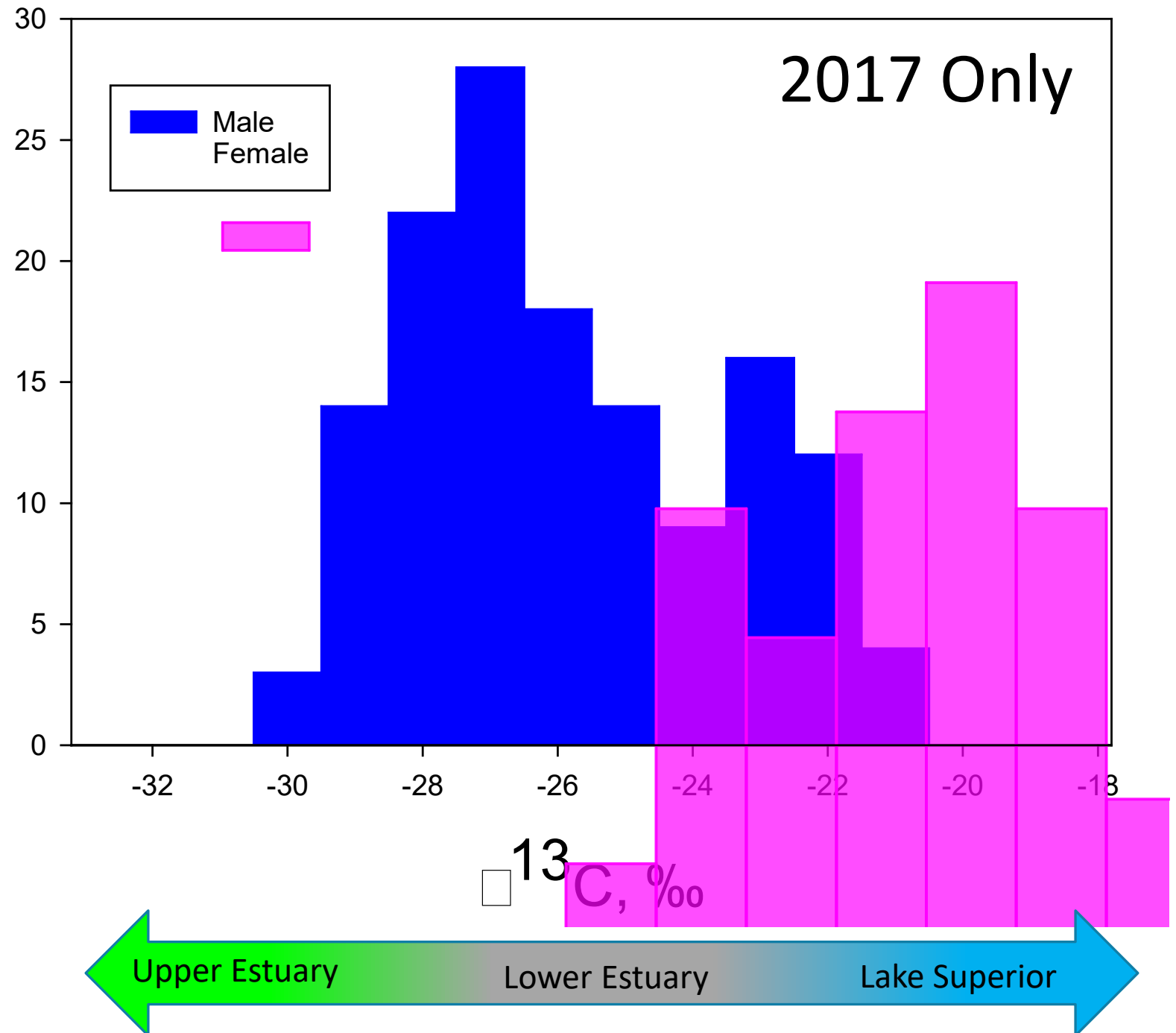
Frequency



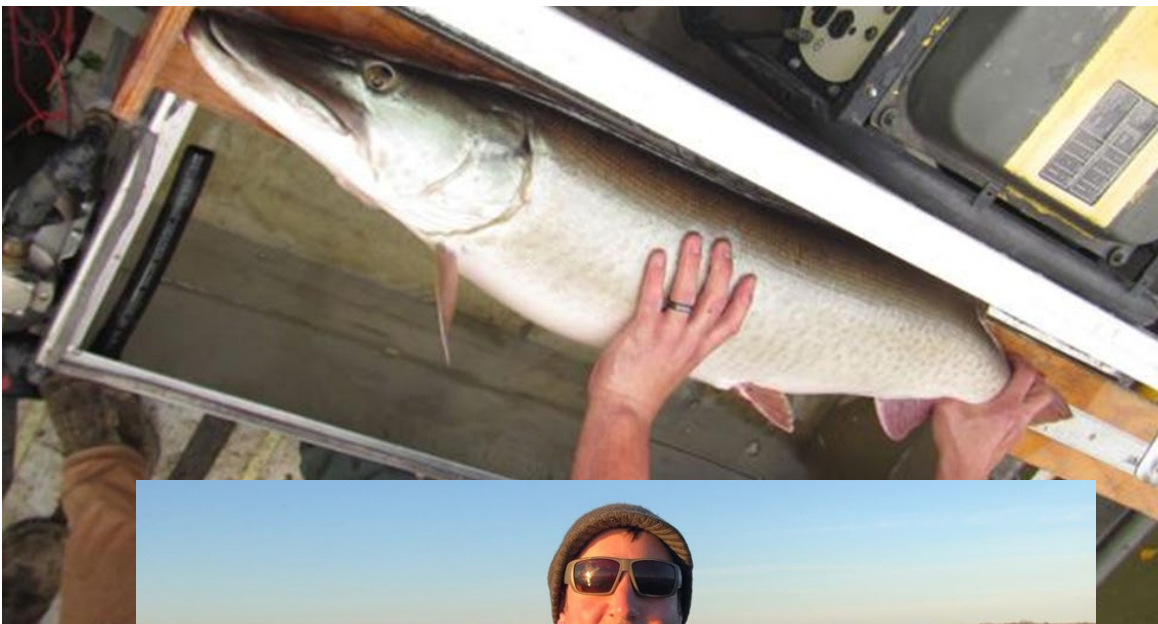
By Sex



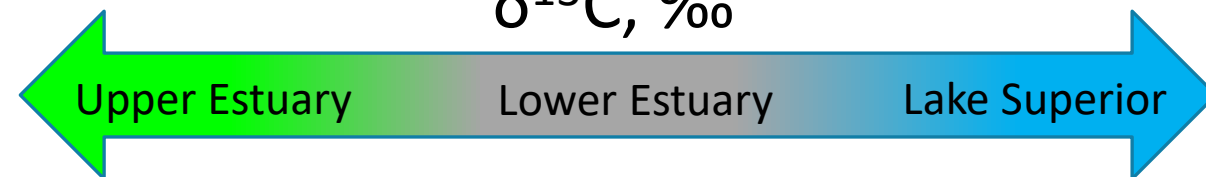
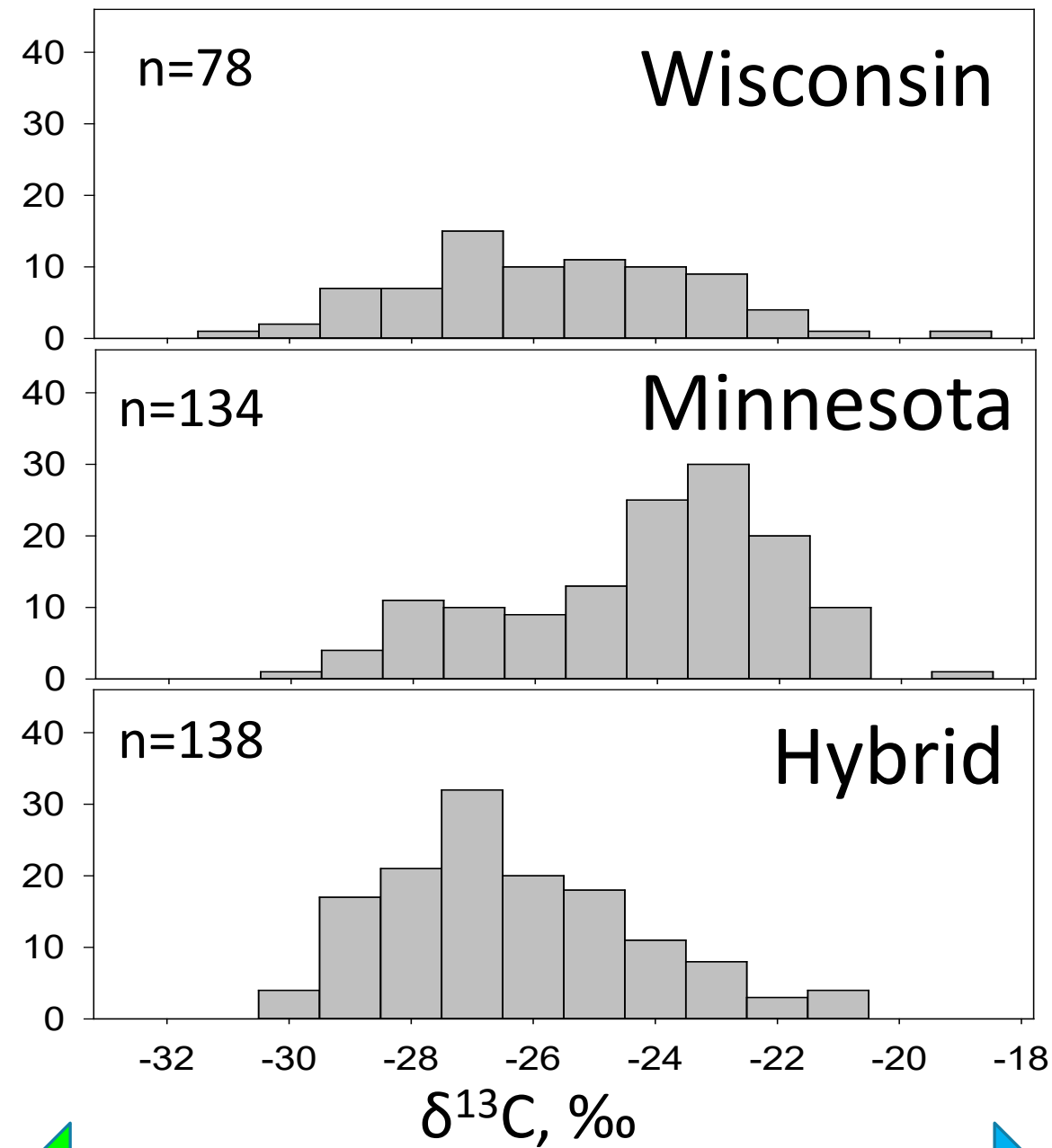
Frequency



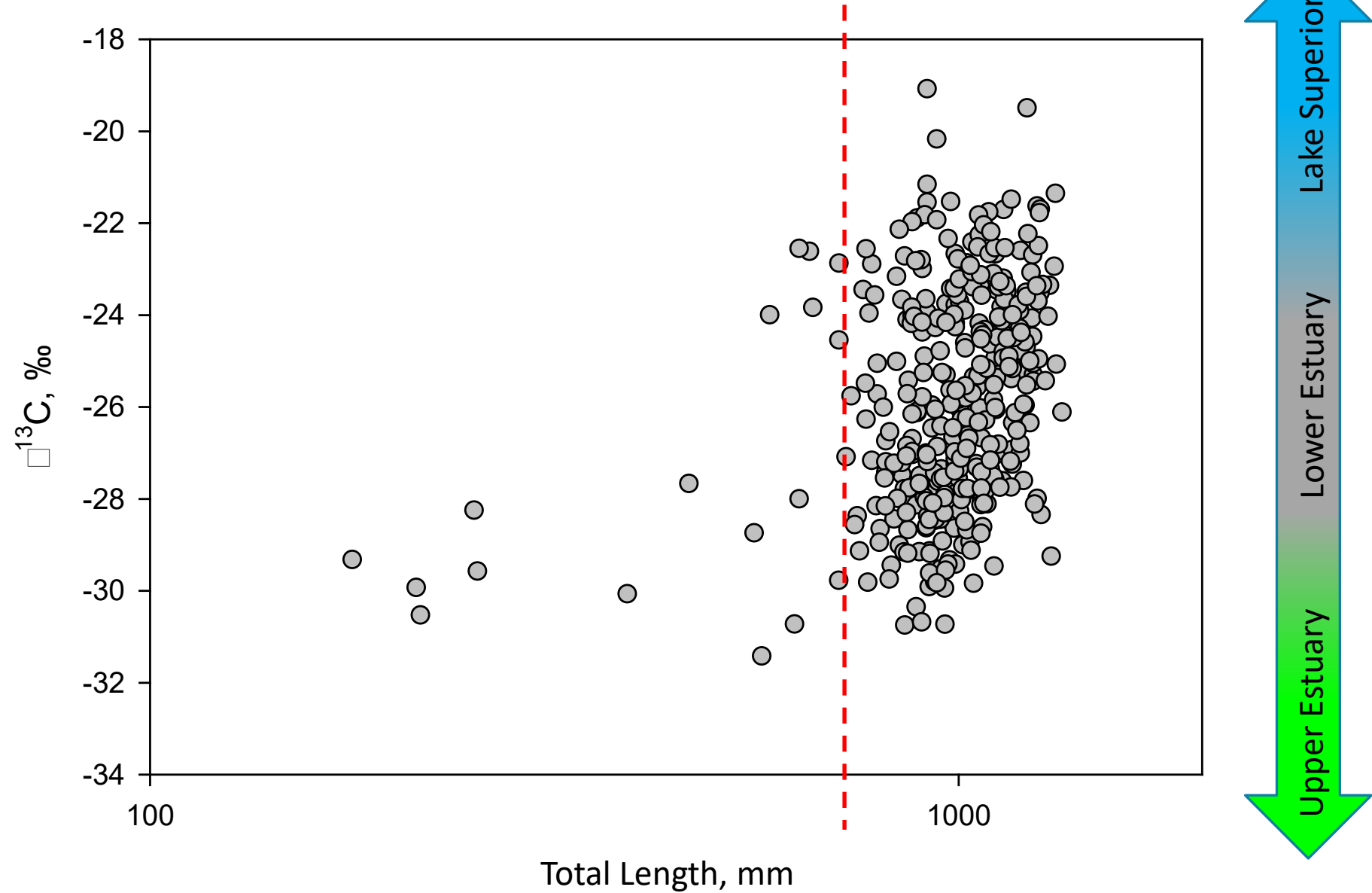
By Strain



Frequency



By Size



d¹³C ANCOVA - 2017 data only

Analysis of Variance					
Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Strain	84.444	2	42.222	12.554	≤0.001
Sex	10.124	2	5.062	1.505	0.224
Strain*Sex	26.028	4	6.507	1.935	0.105
Length	74.759	1	74.759	22.228	≤0.001
Error	823.994	245	3.363		

Response: δ¹³C
Factors: Strain, Sex
Covariate: Length (mm)



Strain Differences?

Wisconsin Strain (Chippewa Flowage)
Minnesota Strain (Leech Lake)

Tukey HSD Post-Hoc Test				
Strain Comparison	Difference	p-Value	95% Confidence Interval	
			Lower	Upper
Wisconsin vs. Minnesota	-1.772	≤0.001	-2.372	-1.172
Wisconsin vs. Hybrid	-0.541	0.167	-1.242	0.160
Hybrid vs. Minnesota	1.231	≤0.001	0.527	1.936



Summary

- 1. Muskellunge in lower SLR use Lake Superior habitat**
- 2. Minnesota strain fish are using Lake Superior more than Wisconsin or hybrid strain fish**
- 3. Among strains, larger fish use Lake Superior more than smaller fish**
 - Potential life stage-specific habitat use of SLR Estuary ($\geq 762\text{mm}$, 30")



Next Steps

—Mixing model and diet estimates

- Quantify diet proportion in SLRE vs. L. Superior

—Direct comparisons with acoustic tagged fish

- Proportion of diet vs. proportion of time spent in SLRE & L. Superior

—Isotopic analysis of 2018 survey year fish

- All recaptures, n= 44 fish



Questions?



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