



Introduction

- Yellow perch (*Perca flavescens*) is an integral species of the benthic food web of Lake Erie and supports the most valuable commercial fishery in the lake.
- Lake Erie has experienced a large annual hypoxic zone (DO < 2 mg/L) in its central basin since the mid 1990s, which is increasing in duration and extent.¹
- Hypoxia occurs locally in the shallow, wind-mixed western portion of the lake.
- Individual hypoxia exposure histories of yellow perch can be provided by otolith microchemistry analyses using the redox-sensitive element manganese (Mn).²



Objective

Determine differences in: 1) magnitude and 2) duration of hypoxia exposure between yellow perch from the western basin and yellow perch from the central basin of Lake Erie using otolith chemistry.

Sampling sites & Chemical analyses

- Yellow perch collected in September and October 2014 (**Fig. 1**).
 - Western basin:
 - Individuals analyzed: Age 0: **36** - Age 1: **51** - Age 2+: **9**
 - Central basin:
 - Individuals analyzed: Age 0: **18** - Age 1: **8** - Age 2+: **8**

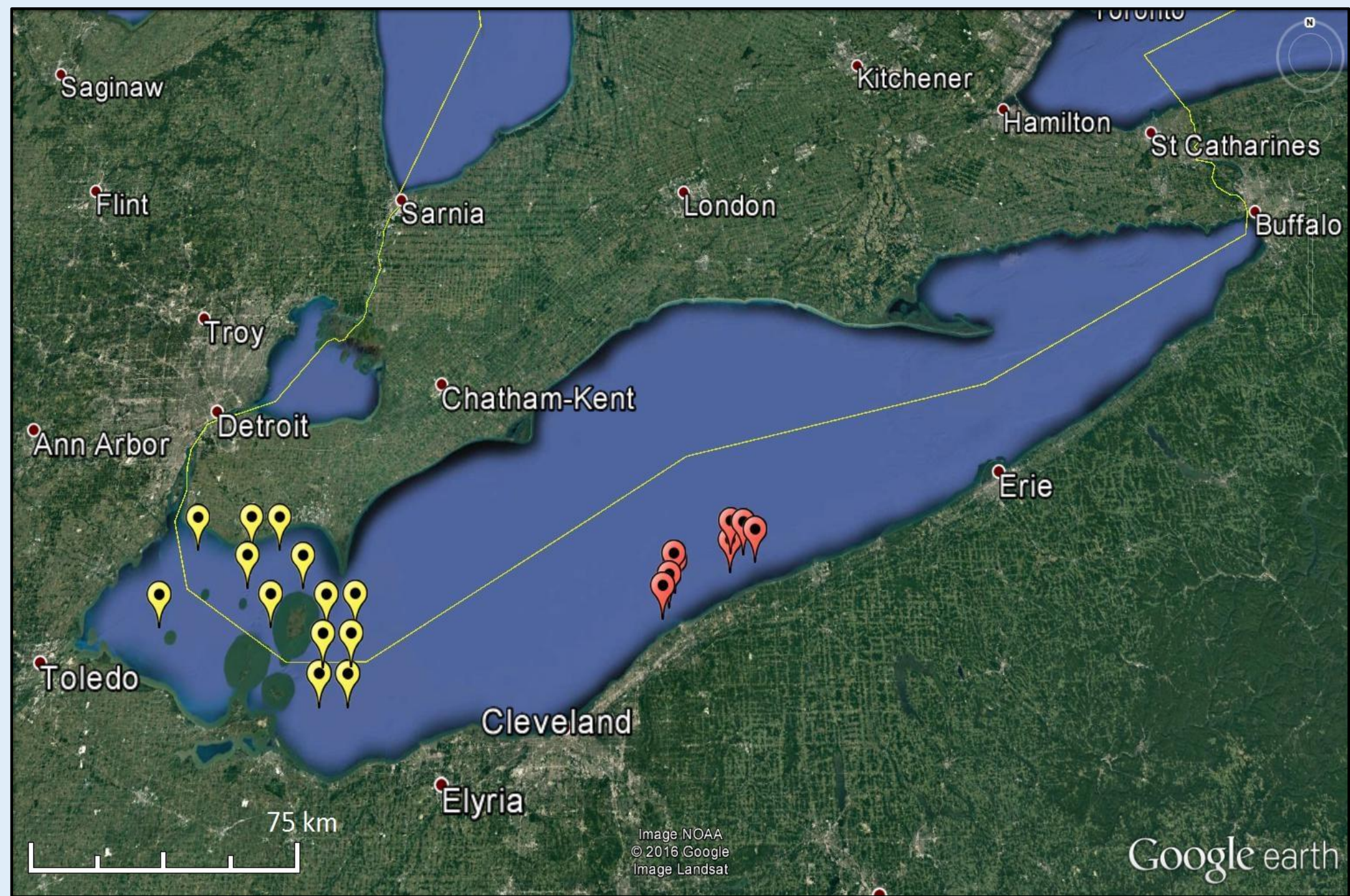


Figure 1: Stations sampled with trawls in the western basin (yellow pin) and central basin (red pin) of Lake Erie.

- Otoliths extracted, cleaned and polished down to core.
- Otoliths analyzed via laser ablation inductively coupled mass spectrometry (LA-ICPMS) for calcium (Ca) and manganese (Mn).
- Otolith ablated along transect drawn from edge to edge through core (**Fig. 2**).

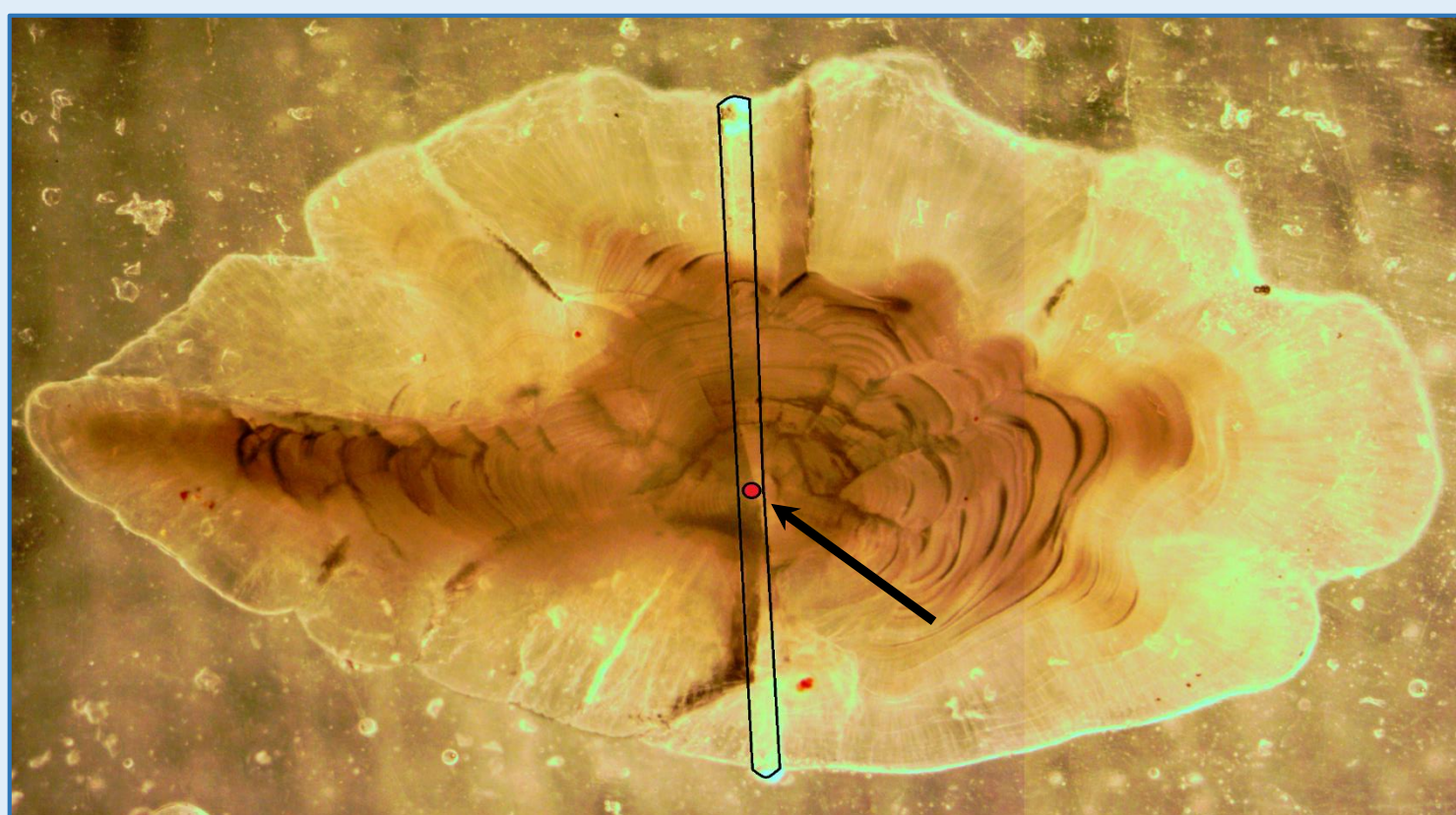


Figure 2: Polished and analyzed otolith with transect outlined and core (red dot) indicated by black arrow.

Statistical analyses

- Mn:Ca ratios (x 1000) from core to edge.
- Two metrics (**Fig. 3**):
 - Magnitude of hypoxia exposure = max. Mn:Ca ratio (**black arrow**).
 - Duration of hypoxia exposure = % of transect occupied by threshold exceedances (summed distance of **red brackets**).
- Threshold of hypoxia exposure at 0.01.

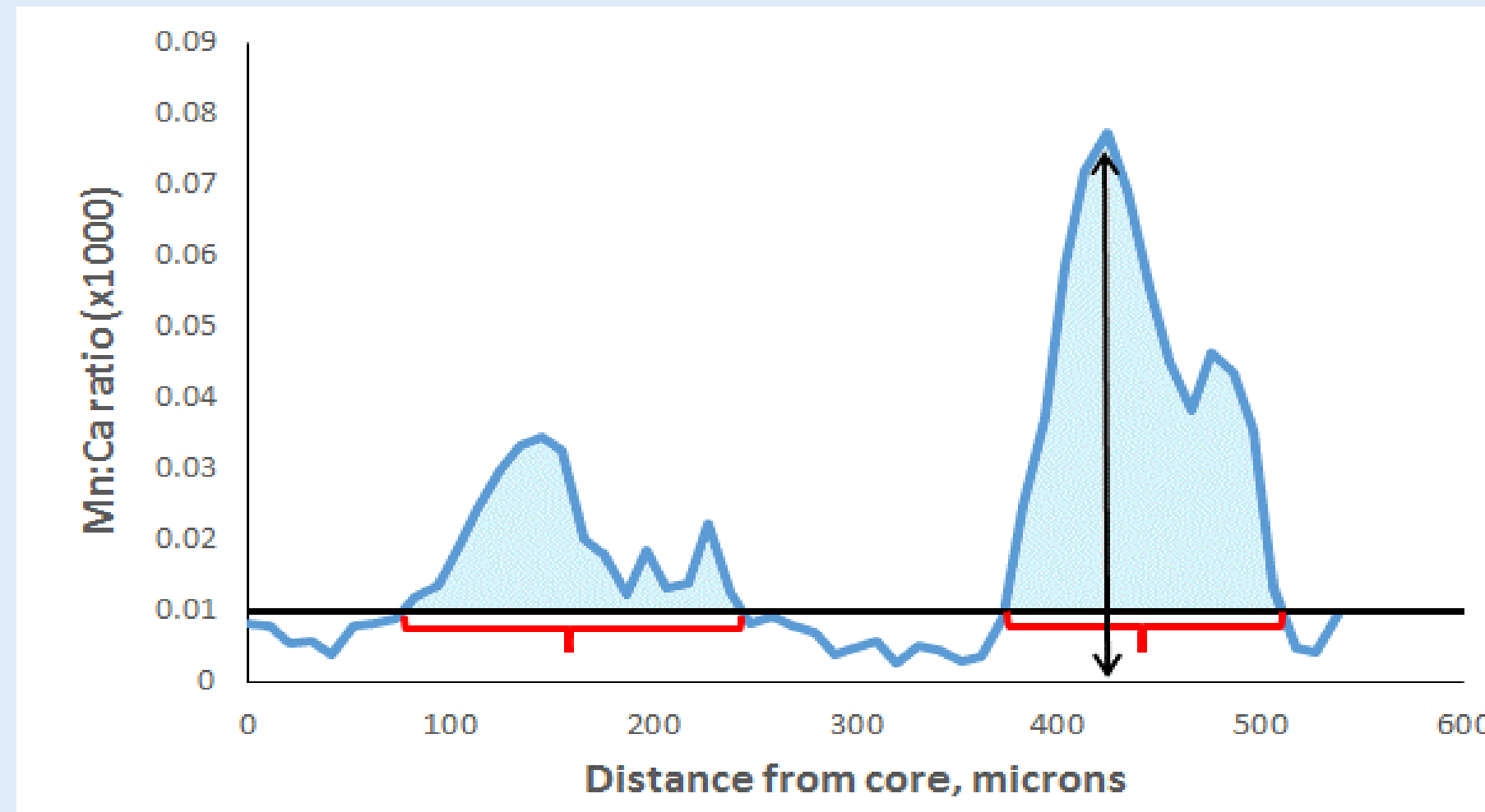


Figure 3: Illustration of quantification of metrics of hypoxia exposure as indicated by Mn:Ca ratios.

- Hierarchical cluster analysis:
 - Can individuals be clustered out in 2 distinct basin groups?
 - Both metrics used in analysis.

Results

- Central basin vs. Western basin: differences in Mn:Ca ratio and duration of hypoxia exposure given by Mann-Whitney U tests in **Fig. 4**

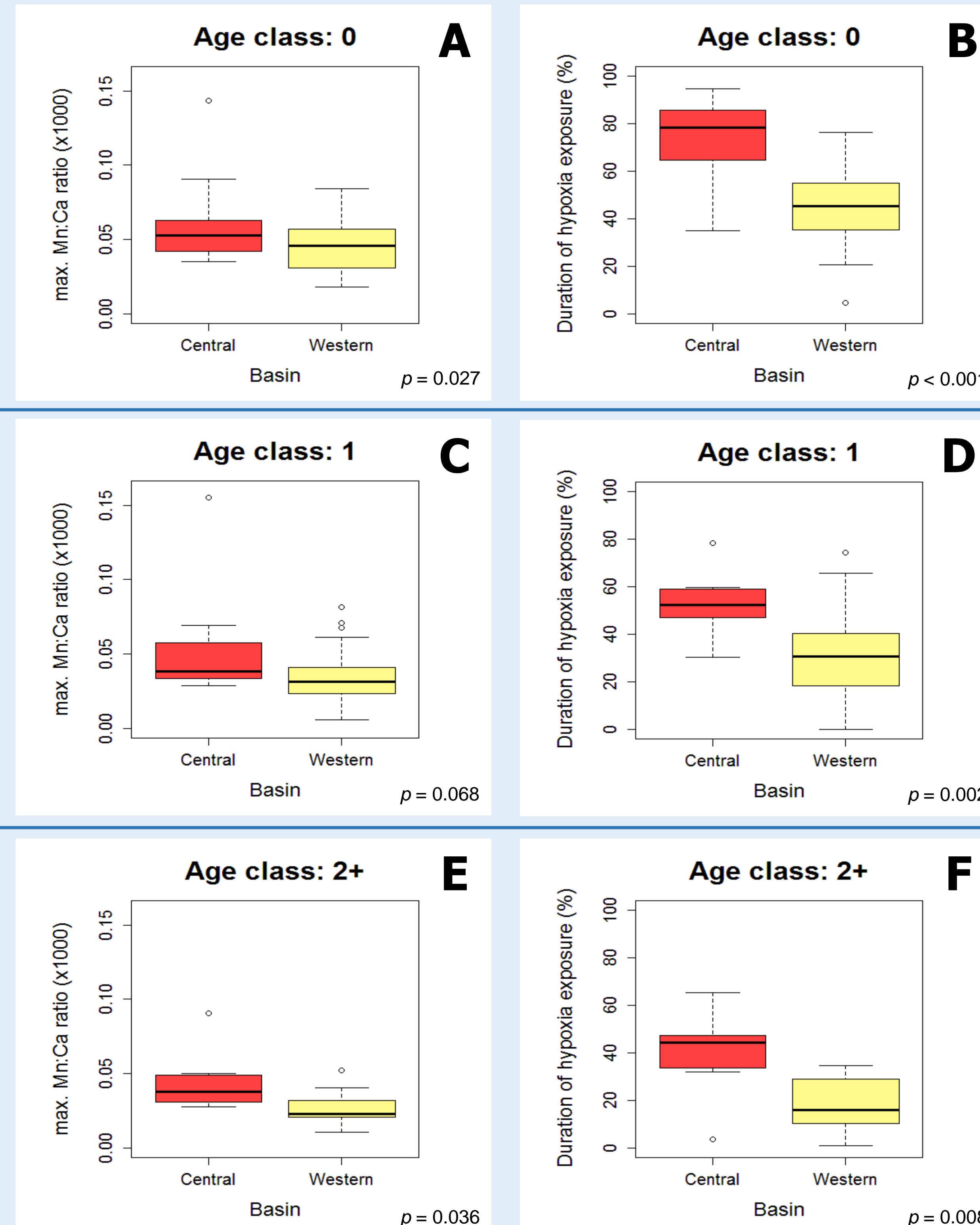


Figure 4: Comparisons of magnitude of hypoxia exposure (A, C and E) and duration of hypoxia exposure (B, D and F) between individuals of the central (red) and western basin (yellow) for each age class (0, 1 and 2+).

Results - continued

- Hierarchical cluster analysis:
 - Dendrogram for age 2+ class in **Fig. 5**
 - Results for all age classes in **Table 1**.

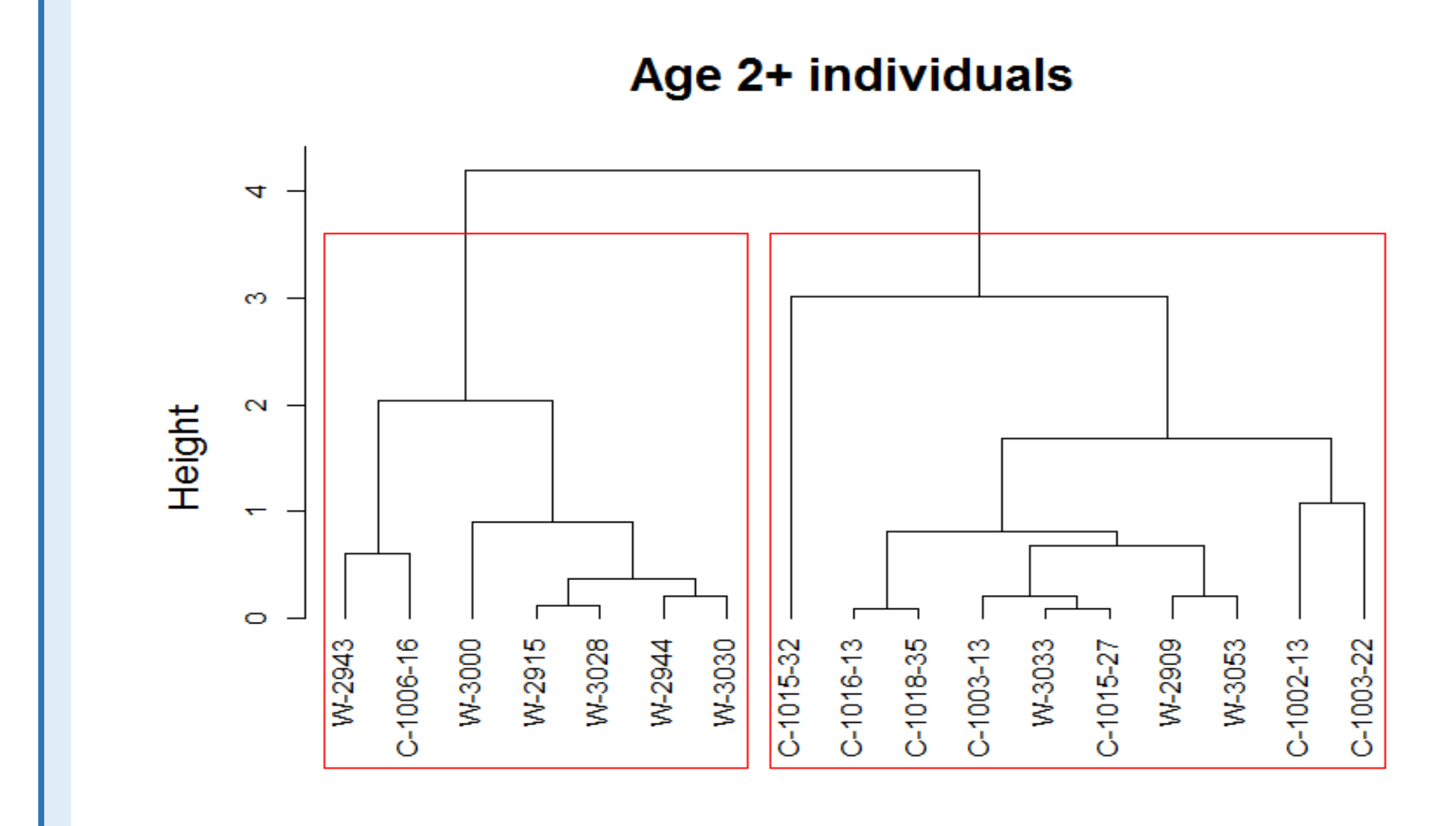


Figure 5: Dendrogram of relationships between age 2+ individuals. Two clusters are highlighted by red rectangles. Individuals of the central basin have name tags starting with C, while those from the western basin have name tags starting with W.

Table 1: Overview of individuals from each basin assigned to each cluster for each age class (0, 1 and 2+). Age 0 and 1 both have a 3rd cluster with 1 individual each. These 2 individuals have much higher maximum Mn:Ca ratios than the other individuals in the entire analysis (see outliers in Figure 4A and 4C).

	Age 0			Age 1			Age 2+	
	Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2
Central basin	2	15	1	0	7	1	1	7
Western basin	29	7	-	22	29	-	6	3

Conclusions

- Individuals from the central basin have been exposed longer to hypoxia than individuals from the western basin.
- Magnitude of hypoxia exposure is on average higher for central basin individuals.
- Central basin individuals can mostly be assigned to one cluster.

Future work

- Relate differences in hypoxia exposure to DO data measured during catch surveys and from online databases.
- Inclusion of otoliths from individuals of Eastern basin of Lake Erie in the analysis.
- Multiple cohort analysis of patterns of hypoxia exposure (2011-2016).
- Study if sub-lethal hypoxia exposure results in differential growth and survival patterns compared to non-exposed fish.
- Comparison of consequences of hypoxia exposure from multiple large anthropogenic hypoxic regions in **Project Hypoxolith**:
 - Yellow perch from Lake Erie.
 - Atlantic croaker (*Micropogonias undulatus*) from Gulf of Mexico.
 - European flounder (*Platichthys flesus*) and Atlantic cod (*Gadus morhua*) from Baltic Sea.

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¹ Rucinski, D. K. et al. (2010). A simple 1-dimensional, climate based dissolved oxygen model for the central basin of Lake Erie. *Journal of Great Lakes Research*, 36(3), 465–476.
² Limburg, K. E. et al. (2015). In search of the dead zone: Use of otoliths for tracking fish exposure to hypoxia. *Journal of Marine Systems*, 141(S1), 167–178.