Diagnostic elements for North American Great Lakes fish revisited:
A deep dive into the order Perciformes

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Morone chrysops

Aplodinotus grunniens

	N sites	Total sample size	Articular	Ceratohyal	Cleithrum	Dentary	Frontal	Hyomandibular	Interoperculum	Maxilla	Operculum	Posttemporal	Premaxilla	Preoperculum	Quadrate	Suboperculum	Supracleithrum
Morone chrysops	2	210	2.8	8.8	2.0	3.3	7.3	8.8	10.3	8.5	7.8	8.8	14.8	7.5	5.8	14.3	9.8
Ambloplites rupestris	2	1342	5.5	2.5	3.0	11.5	7.5	11.0	5.8	13.0	9.0	12.0	9.8	2.5	5.0	11.0	11.0
Lepomis sp.	5	641	8.2	9.8	3.3	6.4	6.7	5.4	7.8	9.3	4.8	12.9	10.8	4.1	12.4	9.9	8.2
Micropterus sp.	4	723	7.1	12.8	7.0	5.5	10.3	8.3	7.4	5.5	8.1	12.4	5.8	5.6	6.1	12.6	5.6
Perca flavescens	15	7504	6.0	7.9	2.4	6.0	7.3	8.4	10.5	11.3	1.8	12.0	13.1	3.7	9.3	10.4	9.7
Sander sp.	11	1479	6.0	5.8	6.7	1.9	11.7	10.5	10.6	4.7	11.5	11.8	4.8	8.2	4.3	11.9	9.7
Aplodinotus grunniens	3	311	7.3	5.3	7.7	11.5	14.5	11.7	8.5	6.3	6.5	6.3	1.0	9.3	5.5	10.0	8.5

Introduction

This poster builds on our previous work on taphonomy, method, and quality assurance with respect to archaeological fish remains from North American Great Lakes watersheds.[1,2,3,4] The current research arose from the results of an experiment in which we considered identification to different taxonomic levels[4] and from Suzanne's recent experience identifying more than 3500 Perciformes bones from two adjacent sites in the Lake Erie drainage (11H). These include bones from two species (*Morone chrysops, Aplodinotus grunniens*) from two families (Moronidae, Sciaenidae) that she had previously only rarely encountered in her work on sites farther east. These species, coincidentally, have a skeletal morphology that is relatively more robust than the other local species in the order and that, in the case of *A. grunniens*, is highly distinctive in its structure and "architecture."

It was apparent during the lab work that the 14 commonly identified elements previously considered by Suzanne for use as diagnostic elements in Lower Great Lakes fish assemblages[1] were not evenly represented. Certain elements were more likely to be identified to a lower taxonomic level (genus or species) than others. Further, the relative abundance of these elements varied among species within the order. To examine this systematically, we compiled Perciformes data from a number of Late Woodland (c. 900–1650 CE) sites to evaluate the extent to which element representation varies 1) within the same order within the same site and 2) within the same genus across sites.

Taxonomy

Within the order Perciformes, the genera *Morone, Ambloplites, Perca,* and *Aplodinotus* are monospecific in late Holocene southern Ontario watersheds. The other genera contain multiple species, but we have grouped identifications at the genus level for various reasons: the species within the genus hybridize and cannot be reliably distinguished (*Sander*, 2 species); the species hybridize and the reference collections used do not contain all of the species (*Lepomis*, up to 6 species depending on the watershed); many elements are so similar that the two species cannot be reliably distinguished and by grouping at the genus level we increase our sample (*Micropterus*, 2 species). Note that the original identifications in some cases go to a lower taxonomic level or have a cf. designation.

Method

We focus here on 14 elements that have been shown in previous work to be relatively well represented across Great Lakes fish families identified from three sites near Lake Simcoe,[1] supplemented by 1 additional element (the premaxilla) that Suzanne added to the original list of 14 elements for work on the sites from the Lake Erie shore, because she soon realized that the premaxilla would likely be the top-ranked element for *A. grunniens*.
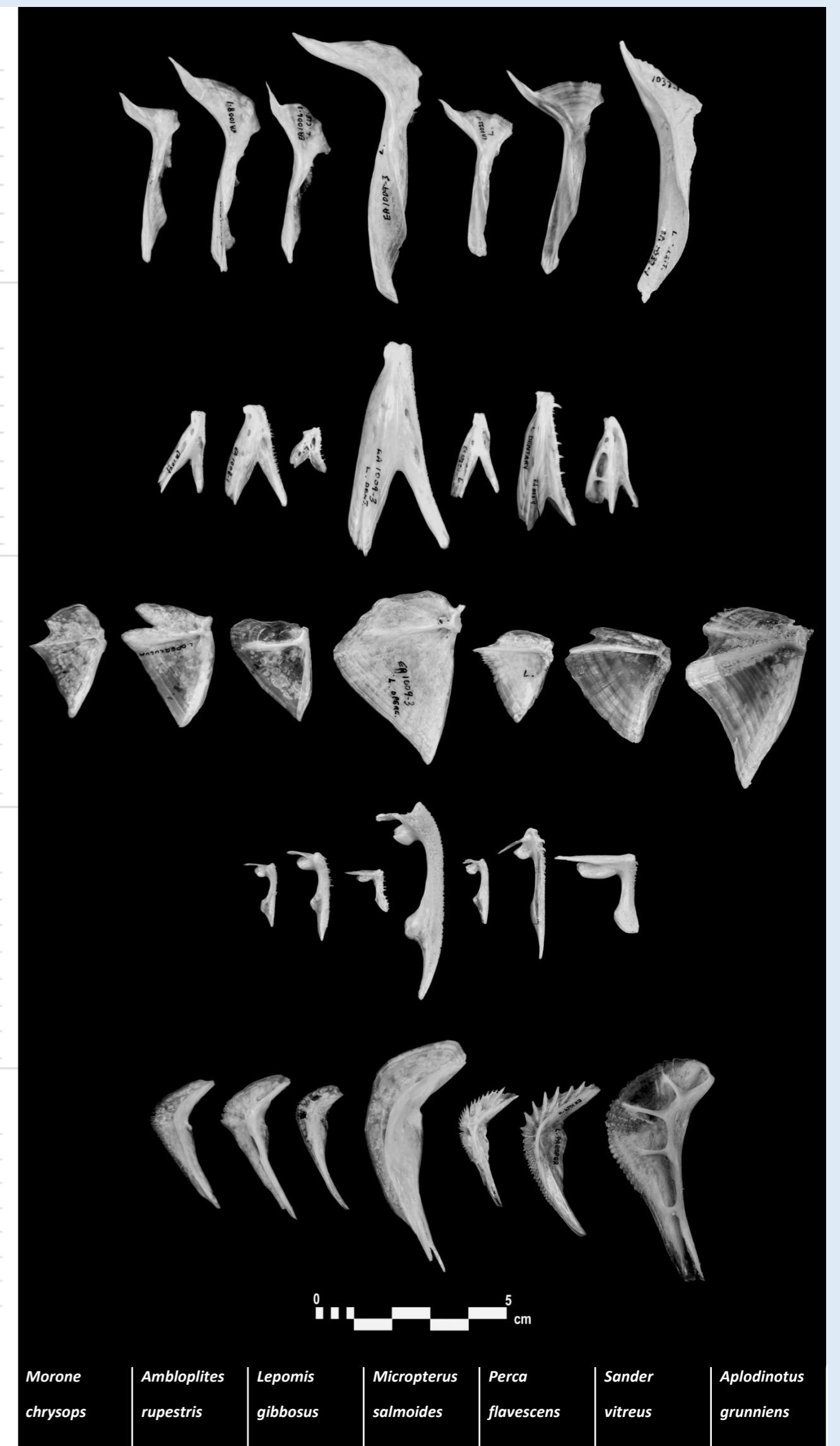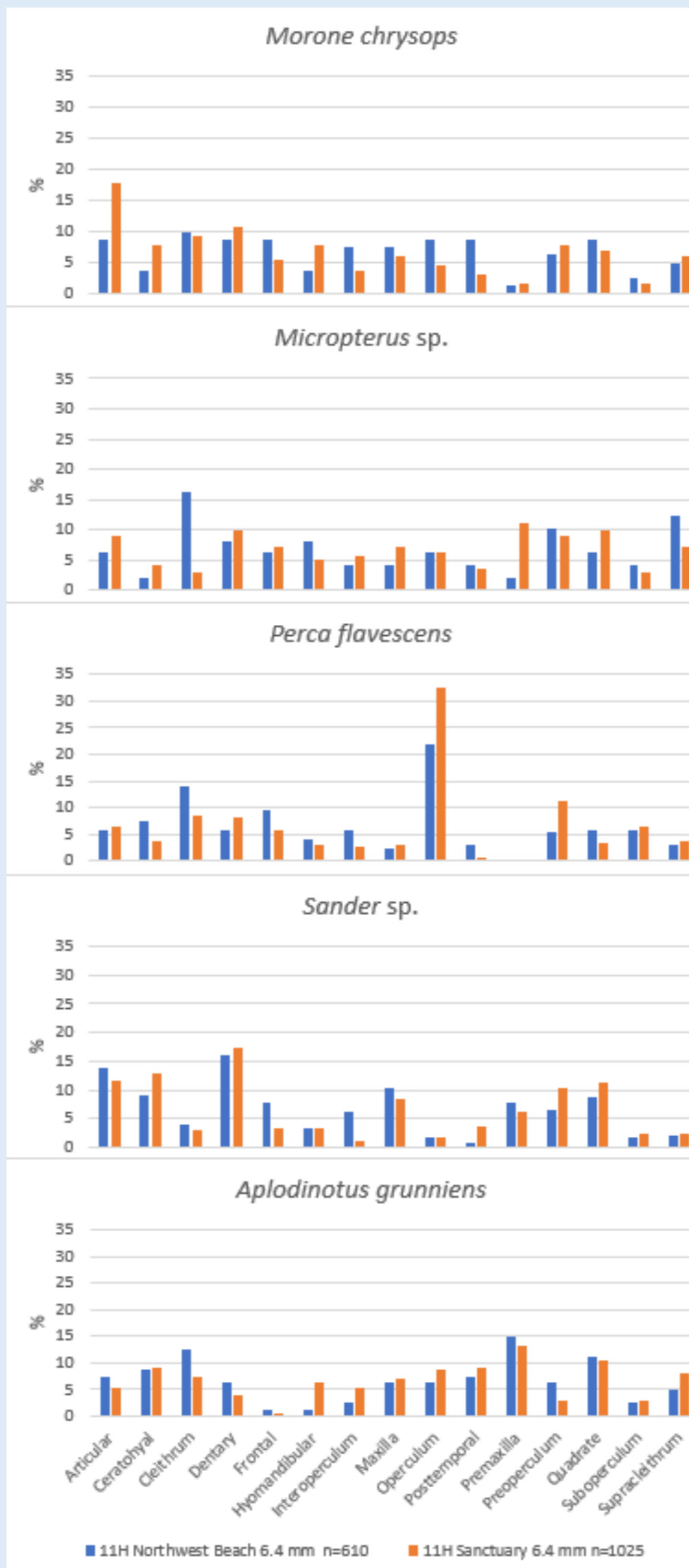
We compiled data by element for a non-random selection of Late Woodland sites that we knew had higher NISPs for one or more of the Perciformes taxa. To help ensure that we are working with statistically valid sample sizes, we adopted a cut-off of 50 (or, in one case 49) identifications per genus/species for all 15 elements combined.[5] As we had anticipated, the genus *Pomoxis* (Centrarchidae; with 2 species that, again, cannot be consistently distinguished), didn't make the cut-off for any of the sites for which we compiled data.

For each site and for each species or genus, we calculated the relative proportion represented by each element. Based on this, we determined the rank order of the individual elements, using average ranks for equally ranked elements. We then averaged the ranking values for individual sites for each species or genus. To help make sense of the ranking table (top right), we've arbitrarily divided the rank ordering into thirds, whereby green is rank order less than 5.1 and purple is rank order greater than 10.1.

Because we had not previously had an opportunity to ponder *M. chrysops* and *A. grunniens* in our own work, we also compared proportional representation for the 15 elements in the two sites from 11H, which are the only datasets discussed here with an NISP of 50+ for both species (see graphs above; note that some of the other taxa from these sites did not make the cut-off). These sites are located within 1 km of each other and were created at roughly the same time period. They were both recovered in the same way.

Results

The table at top right shows that the rankings vary by taxon. These are all paired elements, meaning that in a live population, they are all equally represented. We can observe some trends: the **cleithrum** and **preoperculum** have high or medium ranks across all species or genera. The frontal, hyomandibular, interoperculum, posttemporal, and suboperculum have medium to low ranks. We observe that for almost all taxa, the **posttemporal** and particularly the **suboperculum** are relatively poorly represented. We also note that the **premaxilla** shows the greatest extremes in rank ordering among taxa.

Morone chrysops

Micropterus sp.

Perca flavescens

Sander sp.

Aplodinotus grunniens

■ 11H Northwest Beach 6.4 mm n=610   ■ 11H Sanctuary 6.4 mm n=1025

| Morone chrysops | Ambloplites rupestris | Lepomis gibbosus | Micropterus salmoides | Perca flavescens | Sander vitreus | Aplodinotus grunniens |

Articular, Ceratohyal, Cleithrum, Dentary, Frontal, Hyomandibular, Interoperculum, Maxilla, Operculum, Posttemporal, Premaxilla, Preoperculum, Quadrate, Suboperculum, Supracleithrum

The graphs show that for 11H, element representation is clearly not equal, either within or between the species and sites. Some taxa, however, have much more even distributions than others. Notably, *M. chrysops, Micropterus,* and *A. grunniens* are relatively evenly distributed between elements for both sites (see table below). By contrast, *P. flavescens* is much more unevenly distributed compared with the other taxa for these two sites (in the live fish it would be 6.66% for each element), but the evenness values are similar to the average value of 0.55 for the other sites we examine (range: 0.86–0.23).

Discussion

Several factors will contribute to the probability of identification: recovery method(s), condition of the assemblage, robusticity of distinctive portions of the individual elements, and osteological distinctiveness are among the primary ones. For the sites included here, we have a range of recovery methods and conditions represented, which suggests that patterns may reflect osteological distinctiveness (or lack thereof). Some of the patterning in the rank ordering makes intuitive sense based on the elements' relative recognizability, even when fragmentary (the perch operculum being the most extreme example).

To return to our research questions, we note that the analysis of the material from the 11H sites demonstrates clear variability within the order Perciformes. Some species/genera have a relatively even distribution (*M. chyrsops* and *A. grunniens*), while others do not (*P. flavescens*). At 11H, we also see that the most common element differs: premaxillae are best represented for *A. grunniens*, dentaries for *Sander* sp., and opercula for *P. flavescens*.

If we consider the representation of different elements of the same genus across all of the sites, we find that there are some differences across sites, but that there is consistency.[5] As shown here, the most highly ranked elements, on average, for perch are the operculum, the cleithrum, and the preoperculum (n_{sites}=15). By contrast, the most highly ranked elements for *Sander* are the dentary, the quadrate, and the maxilla (n_{sites}=11).

Some of the unevenness may be due to a too-coarse mesh size, as we observed in the representation of quadrates of *P. flavescens* in the 6.4 mm samples compared with 3.2 mm or window screen samples from similar sites in previous research.[6]

For a given biological age, the two local species of *Sander* are larger than *P. flavescens,* meaning that above a certain size, elements that are clearly Percidae can be identified as *Sander* by default. However, some of the *Sander* in the two 11H sites were actually smaller than the *P. flavescens*. We speculate that this meant that fewer of the *Sander* could be identified on size alone. We have plans to explore whether this may have affected some of the patterning.

We anticipate that family- and order-level identifications within the Perciformes will likely tell an interesting story too, particularly for Percidae (*Perca* and *Sander* sp.).

But we also anticipate that none of our planned future research will change the take-home message from this poster, which is to avoid using an even more restricted set of elements than these 15 for North American Great Lakes fish.

Sources 1. Needs-Howarth, S. (2001) Diagnostic Elements to Facilitate Inter- and Intra-site Comparison of Pre-contact Fish Remains from the Great Lakes Area. In *Animals and Man in the Past: Essays in Honour of Dr. A.T. Clason,* edited by H. Buitenhuis and W. Prummel, pp. 400–407. Archaeological Research and Consultancy, Groningen, the Netherlands. researchgate.net/publication/274194129; **2.** Needs-Howarth, S., and A.L. Hawkins (2015) "Diagnostic Elements" for Great Lakes Taxa Revisited: Lessons from Deposits with (Mostly) Whole Fish. Poster presented at the 18th International Conference of the International Council for Archaeozoology Fish Remains Working Group, Lisbon, Portugal. researchgate.net/publication/282219864; **3.** Hawkins, A.L., and S. Needs-Howarth (2017) Diagnostic Elements and Interobserver Variation in the Identification of Fish Bones. Poster presented at the 82nd Annual Meeting of the Society for American Archaeology, Vancouver, Canada. researchgate.net/publication/315973180; **4.** Hawkins, A.L., M. Buckley, S. Needs-Howarth, and T.J. Orchard (2022) Practice Makes Perfect? Inter-analyst Variation in the Identification of Fish Remains from Archaeological Sites. *International Journal of Osteoarchaeology.* DOI: 10.1002/oa.3096; **5.** Supplementary data, researchgate.net/publication/362741689; **6.** Hawkins, A.L., and S. Needs-Howarth 2014 The Yellow Perch Fishery in Southern Ontario: Insights from Osteometrics. Poster presented at the 12th International Conference of the International Council for Archaeozoology, San Rafael, Argentina. DOI:10.13140/2.1.1718.4006

Evenness values

	11H NW beach	11H Sanctuary
M. chrysops	0.86	0.75
Micropterus sp.	0.76	0.87
P. flavescens	0.63	0.44
Sander sp.	0.70	0.66
A. grunniens	0.75	0.81