# 3.0 Diet Analysis of Western Basin Age-2-and-Older Yellow and White Perch

**Abstract**

*Native yellow perch**and invasive white perch are abundant omnivores in western Lake Erie. We evaluated diets of age-2-and older yellow perch and white perch collected in Lake Erie’s western basin during spring and autumn. Evaluation metrics included frequency of occurrence and contributions of prey to predator diets by weight. Benthic macroinvertebrates contributed most to yellow perch and white perch diets during spring and autumn. Bythotrephes sp. occurrence in yellow perch and white perch diets was low in spring and considerably increased frequency in autumn. Compiling results from 2014 with data dating back to 2005 suggested decreased utilization of zooplankton for both yellow and white perch during spring and autumn and increased utilization of fish prey during autumn for both species.*

**Introduction**

A fish’s diet is the integrated response of multiple ecological interactions including habitat use, foraging behavior, prey community characteristics, and inter-specific interactions. Fish diet samples have quantified how the invasion of white perch into Lake Erie in the early 1950s has influenced interactions with native yellow perch which are similar in morphology and habitat use. Early research largely concluded that given the high foraging efficiency of white perch there is both high potential for inter-specific competition and that yellow perch have been negatively affected by the invasion of white perch (Parrish and Margraf 1990). More recent analyses using stable isotopes and diet contents suggest a low to moderate degree of overlap (Guzzo et al. 2013). Analysis of yellow perch diets has been proposed as a useful indicator of Lake Erie’s benthic community relative to direct sampling of benthos (Tyson and Knight 2001). As part of the LEBS Western Basin Forage Fish Assessment, we annually evaluate diet composition of age-2-and-older yellow perch and white perch.

**Methods**

Yellow perch and white perch were collected using a bottom trawl during the USGS Western Basin Forage Assessment surveys in June (Spring) and September (Autumn), 2014 (See Section 1.0). A maximum of five age-2-and-older yellow perch and white perch that showed no signs of regurgitation (exposed stomach or visible food content in the mouth cavity) at each bottom trawl site were retained for diet analysis. Total length, weight, sex, site location, and date were recorded for each collection. The digestive tract from each retained fish was removed, individually frozen in tap water, and returned to the laboratory for diet analysis. Otoliths were removed and processed in the laboratory to verify that our analyses were restricted to age-2-and-older fish.

In the laboratory, each fish sample was slowly thawed by immersing in cold tap water. The stomach was isolated from the digestive tract at the esophagus and pyloric caeca. The stomach was placed in a 0.25 mm sieve and cut lengthwise. Stomach contents were placed into a petri dish with soapy tap water to remove the surface tension of the water, thus allowing prey items to sink to the bottom of the dish where they were more easily identified. Once in the petri dish, stomach contents were quantified using a dissecting microscope and zooplankton, macroinvertebrates, and fish were counted and identified by taxon. A subsample was taken when ≥200 individuals of a particular prey item occurred in a given sample. To subsample, a petri dish was divided into eight equal sections and a count of each prey item was taken until 200 was reached. The area that contained n=200 was recorded and then extrapolated for the entire sample. Prey items from each stomach (when applicable) were dried at 60o C for 72 hrs to enumerate dry weights by prey taxon. For diet items that could not be dried and weighed, length measurements were taken and later used to estimate dry weight using length-weight and wet-weight:dry-weight conversion equations (equations and sources available upon request).

Diet analyses included percent occurrence by number and percent composition by dry weight. Diet data from non-empty stomachs were used to calculate diet contribution metrics by predator type (i.e., yellow perch and white perch) and season for zooplankton, benthic macroinvertebrates, and fish prey. Percent occurrence was estimated as the number of fish examined that contained each prey item relative to the number of total fish with diet contents times 100. Percent composition by weight was calculated as the contribution of each prey type by dry weight to the total diet dry weight for each individual and then averaged across all fish for each species and season. Percent occurrence from 2014 sampling was compared to results from 2005-2013. For the historical comparison, we only used data from 2014 sampling that occurred in Michigan and Ontario waters, thus providing continuity in the time series.

**Results**

*Frequency of occurrence*

Fish that contained diet items were representative of the total range of length groups collected for both species and seasons (Figure 3.1). Lengths of fish with diet contents were also similar between species, however a few extra large yellow perch and white perch (i.e., total length exceeding 300mm) were caught during autumn sampling (Figure 3.1). The proportion of empty stomachs, relative to the number retained, was relatively low in the autumn and spring, and thus, we subsampled the number of sites used for diet analysis in both spring and autumn. Subsampling was intended to allow diet description across the spatial extent of the survey (Figure 3.2).

Spring sampling provided 85 age-2-and-older yellow perch stomachs from fish ranging between 160-280 mm in length. A total of 72 (84.7%) of the yellow perch stomachs contained prey. In spring 2014, benthic macroinvertebrates were present in almost all yellow perch stomachs (75.6%) and Chironomidae, *Dreissena* spp. and *Hexagenia* spp. were the most common benthic macroinvertebrates (Table 3.1). Zooplankton occurred in 20.5% of spring yellow perch diets with *Leptodora kindtii and Daphnia* spp. occurring most at 5.5% and 5.0%, respectively. Fish prey had a 4.2% occurrence in yellow perch diets during spring sampling with unidentified fish remains being the most common at 1.8% (Table 3.1). During autumn sampling, 76 age-2-and-older yellow perch stomachs were collected from fish ranging from 170-320 mm in length with 53 (69.7%) of the stomachs containing prey. A decline in occurrence for benthic macroinvertebrates (46.8%) and an increase for zooplankton (33.3%) was observed in autumn yellow perch diets relative to the spring. However, occurrence of fish prey increased dramatically from spring to autumn for yellow perch. Fish occurred in 20.0% of yellow perch and unidentified fish remains was the most common fish prey occurring in 14.7% of stomachs. *Bythotrephes* sp. was detected at low occurrence in spring (3.6%) and increased frequency in autumn (20.0%).

Spring sampling provided 71 stomachs from age-2-and-older white perch ranging from 170-300 mm in length A total of 63 (88.7%) of the white perch stomachs contained prey items. In spring, zooplankton was present in 44.5% of samples with *Daphnia retrocurva* occurring most frequently (14.4 %).

**Figure 3.1**. Length distributions of yellow perch (top row) and white perch (bottom row) sampled for diet analysis during the 2013 Western Basin Forage Fish Assessment in the spring (left column) and autumn (right column).

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**Figure 3.2**. Percentage of stomachs with diet contents by site for yellow perch (top row) and white perch (bottom row) during spring (left column) and autumn (right column).

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| **Table 3.1**  Percent occurrence of prey items found in the diets of age-2-and-older yellow perch and white perch collected during spring and autumn 2014 in Ontario, Michigan, and Ohio waters of Lake Erie's western basin. Abbreviation: n=number of stomachs containing prey items. | | | | | | | | | | | | | | | | |
|  |  | | **Yellow** | | **Perch** | | |  | | **White** | | **Perch** | |  |
| Prey Type | Prey taxa | | 2014 Spring n=72 | | 2014 Autumn n=53 | | | | 2014 Spring n=63 | | | 2014 Autumn n=52 | |  |
| **Zooplankton** |  | | **20.5** | **33.3** | | |  | | | **44.5** | **34.5** | |  | | |
|  | *Bosmina* sp. | | 0.9 | 0.0 | | |  | | | 2.0 | 0.0 | |  | | |
|  | *Bythotrephes* sp. | | 3.6 | 20.0 | | |  | | | 5.2 | 22.6 | |  | | |
|  | *Calanoida* sp. | | 1.8 | 1.3 | | |  | | | 3.9 | 1.2 | |  | | |
|  | *Cyclopoida* spp. | | 0.9 | 0.0 | | |  | | | 4.6 | 0.0 | |  | | |
|  | *Daphnia retrocurva* | | 2.3 | 0.0 | | |  | | | 7.2 | 0.0 | |  | | |
|  | *Daphnia* spp. | | 5.0 | 12.0 | | |  | | | 14.4 | 7.1 | |  | | |
|  | *Diaphonosoma* sp. | | 0.5 | 0.0 | | |  | | | 1.3 | 0.0 | |  | | |
|  | *Leptodora kindtii* | | 5.5 | 0.0 | | |  | | | 5.9 | 3.6 | |  | | |
|  |  | |  |  | | |  | | |  |  | |  | | |
| **Benthic Macroinvertebrates** | |  | **75.6** |  | | **46.8** | **53.6** | | | | **35.7** | |  | | |
|  | Amphipoda | | 6.4 | 2.7 | | |  | | | 6.5 | 7.1 | |  | | |
|  | Chironomidae | | 23.2 | 6.7 | | |  | | | 16.3 | 9.5 | |  | | |
|  | *Dreissena* spp. | | 10.9 | 2.7 | | |  | | | 1.3 | 1.2 | |  | | |
|  | Gastropoda | | 2.7 | 10.7 | | |  | | | 0.0 | 0.0 | |  | | |
|  | *Hemimysis anomala* | | 0.5 | 0.0 | | |  | | | 0.0 | 0.0 | |  | | |
|  | *Hexagenia* spp. | | 15.5 | 22.7 | | |  | | | 24.2 | 10.7 | |  | | |
|  | Hirudinea | | 0.0 | 1.3 | | |  | | | 0.0 | 0.0 | |  | | |
|  | Nematoda | | 2.7 | 0.0 | | |  | | | 1.3 | 1.2 | |  | | |
|  | Oligochaeta | | 0.5 | 0.0 | | |  | | | 0.0 | 0.0 | |  | | |
|  | Ostracoda | | 0.5 | 0.0 | | |  | | | 0.7 | 0.0 | |  | | |
|  | Sphaeriidae | | 2.7 | 0.0 | | |  | | | 0.0 | 4.8 | |  | | |
|  | *Trichoptera* spp. | | 10.0 | 0.0 | | |  | | | 3.3 | 1.2 | |  | | |
|  |  | |  |  | | |  | | |  |  | |  | | |
| **Fishes** |  | | **4.2** | **20.0** | | |  | | | **2.0** | **29.8** | |  | | |
|  | Emerald Shiner | | 1.4 | 1.3 | | |  | | | 0.7 | 11.9 | |  | | |
|  | Fish eggs | | 0.5 | 0.0 | | |  | | | 0.0 | 0.0 | |  | | |
|  | Round Goby | | 0.5 | 0.0 | | |  | | | 0.0 | 0.0 | |  | | |
|  | Rainbow Smelt | | 0.0 | 1.3 | | |  | | | 0.0 | 2.4 | |  | | |
|  | Yellow Perch | | 0.0 | 2.7 | | |  | | | 0.0 | 0.0 | |  | | |
|  | Unidentified fish | | 1.8 | 14.7 | | |  | | | 1.3 | 15.5 | |  | | |

Benthic macroinvertebrates occurred in 53.6% of spring stomach samples with *Hexagenia* spp.being most common (24.2%). Fish were present in 2.0% of white perch stomachs with unidentified fish remains occurring most frequently during spring. During autumn sampling, 78 age-2-and-older white perch were collected from fish ranging from 170-310 mm in length with 52 (66.7%) containing prey items. Benthic macroinvertebrates were the most commonly occurring prey type in autumn (35.7%), which was mostly comprised of Chironomidae and *Hexagenia* spp. (Table 3.1). A decline in occurrence for zooplankton (34.5%) and an increase for fish prey (29.8%) was observed in autumn white perch diets relative to the spring. *Bythotrephes* sp. was detected at low occurrence in spring (5.2%) and increased in autumn (22.6%) (Table 3.1).

Frequency of occurrence of zooplankton and benthic macroinvertebrates was higher for both white perch and yellow perch in 2014 than in 2013 during both seasons (Figure 3.3). Zooplankton occurrence has shown a declining trend over the past few years across both species in both seasons. Occurrence of zooplankton was up in spring and autumn 2014 compared to 2013. Occurrence of fish in yellow perch spring diets remained low (7.8%) and increased in the autumn (33.3% of diets). Historically, zooplankton was found in at least half of white perch sampled in spring (maximum 100% in 2005), but they were only found in 37% of spring diets in 2014. Benthic macroinvertebrates were found about twice as often as in 2013 across both seasons and species (Figure 3.3). Occurrence of fish prey in diets has not shown unfamiliar change over recent years (Figure 3.3).

**Figure 3.3.** Historical percent occurrence in yellow (solid line and filled circles) and white perch diets (dashed line and unfilled circles) of zooplankton (top row), benthic macroinvertebrates (middle row) and fish (bottom row) during spring (left column) and autumn (right column). Included 2013 sites were restricted to those near historical trawl sites in Michigan and Ontario.

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*Percent composition by weight*

Benthic macroinvertebrates contributed most to age-2-and-older yellow perch diets in spring (81.1%), followed by zooplankton (13.7%) and fish prey (5.2%, Figure 3.4). *Dreissena* spp., *Hexagenia* spp. and Chironomidae were the predominant benthic macroinvertebrate contributors by weight in the spring (Figure 3.5). *Daphnia retrocurva and Daphnia* spp.were the dominant zooplankton taxa, while emerald shiners were the most prominent identifiable fish prey in spring yellow perch diets (Figure 3.5). In autumn, benthic macroinvertebrate taxa continued to show the highest contribution to diet weights in autumn (50.9%), followed by zooplankton (26.8%) and fish prey (22.3%) (Figure 3.4). The major benthic macroinvertebrate taxa contributors in autumn were *Hexagenia* spp. and Gastropoda (27.4%, and 15.1%, respectively). Bythotrephes sp.accounted for almost 100% of total zooplankton observed in diets. Fish prey significantly contributed (22.3%) to autumn yellow perch diets. The major fish prey taxa contributors in autumn was unidentified fish remains (16.2%) (Figure 3.5).

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**Figure 3.4**. Age-2-and-older yellow perch and white perch mean diet composition (% dry weight) by prey type and season.

Spring white perch diets were predominantly composed of benthic macroinvertebrates (64.0%), followed by zooplankton (34.0%) and fish (2.0%). (Figure 3.4). *Hexagenia* spp.was the dominant benthic macroinvertebrate taxa contributing 48.6% to diet weight on average in spring (Figure 3.4). *Daphnia* spp.and emerald shiner were the dominant contributors for their prey groups, and White perch showed a shift towards increased piscivory in the autumn, while zooplankton (33.8%) and benthic macroinvertebrates (26.7%) made lower contributions to their diet weights (Figure 3.4). Emerald shiner and unidentified fish remains were the major fish prey taxa (19.2% and 17.0%) during autumn. *Hexagenia* spp. was the predominant benthic macroinvertebrate taxa and *Bythotrephes* sp. was the predominant zooplankton taxa during autumn (Figure 3.5).

In summary, yellow perch and white perch diets in spring were distributed across our western basin sampling area. In fall, the north shore near the Detroit River was under-represented due to a high number of empty stomachs (Figure 3.2). Yellow perch and white perch showed a higher occurrence of zooplankton and benthic invertebrates in diets in both the spring and the autumn. In contrast, both species exhibited increased occurrence of fish in diets in the autumn relative to the spring and this autumn frequency has increased in the past few years relative to historical data. Hexagenia spp. occurred frequently in diets in 2014 and contributed 39.7% to diet composition by weight in the spring. The timing of our spring sampling in 2014 coincided with a *Hexagenia* spp. hatch and we found multiple fish with full stomachs that were comprised completely of *Hexagenia* spp. We continued to detect high occurrence of Dreissena spp. in yellow perch diets, but importance of Dreissena spp. to diets may be overestimated in diet content studies due to digestion and evacuation differences relative to softer prey (Brush et al. 2012). In 2014, *Bythotrephes* sp. was frequently observed in diets (maximum 22.6% of diets in white perch in autumn). We observed only one *Hemimysis* sp. and no *Cercopagis* sp. in any fish diets.

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**Figure 3.5**. Age-2-and-older yellow perch (top panel) and white perch (bottom panel) mean diet composition (% dry weight) by prey species in spring (black bars) and autumn (gray bars).