Diet Study of Walleye in Black Lake Using Isotope Analysis of d15N and d13C

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Abstract

Walleye have been declining in Black Lake over the past years. Not much is known about the community of Black Lake. Our study aimed to do a diet analysis of walleye diets to provide information for future studies on the population. We sampled four sites and ran isotope analysis tests on the potential prey items we caught. Our data was inconclusive as we only found that minnows were prey of walleye. However, hypothetical data was found that pointed to yellow perch as another prey item.

Introduction

Walleye are a dominant fish in many North American temperate lakes (Rose 1999). These fish often take the position of top predator in the aquatic food web. These piscivorous fish start out their lives as zooplanktivores, competing for resources with other fishes that will become their prey when they are recruited into a higher trophic level as adults (Ward 2008).

In many inland lakes walleye are important game fish (Rose 1999). One such lake is Black Lake. Black Lake is a Northern Michigan inland temperate lake. Over the past twenty years data on this lakes makeup has been studied. But not much is known about the biota or the nutrient sources of the lake.

Over the past years walleye populations in Black Lake have been reported as falling. Potential reasons for this fall have been suggested including influence from zebra mussels (*Dreissena polymorpha)*, pathogens, and over fishing. Over fishing could be the result of the lake being a noted game lake that has fishing on it year round. The zebra mussel populations could also be affecting the walleye population (Stoermer 2007). Zebra mussels are well known filter feeders that eat phytoplankton. It is possible that zebra mussels are causing a community shift in the phytoplankton. This could be causing a shift in zooplankton populations that walleye fry eat before their gape becomes large enough for them to become piscivores (Ward 2008). This could be resulting in intracompetiton and could be reducing the size of fry and the number that are recruited into the adult class (Browne 2009).

An ultimate goal would be to discover why walleye populations are falling. However, with our limited knowledge of the lake biota we have decided to perform a diet analysis that can be the basis for further study on why walleye populations may be falling. We performed this diet analysis by using isotope analysis of d15N and d13C of walleye and forage fish and macroinvertebrates we caught on Black Lake to see if we could find a diet for the walleye in the lake.

Materials and Methods

Sampling of Black Lake consisted of two trips to the lake. We sampled at four different sites around the lake. The four sites were the state park at the end of highway 211 heading North of Onaway, the state forest on Dorvian Beach road, a boat launch on the township line between N. Allis and Bearinger road, and another boat launch on Corbat road. We sampled for forage fish by seining using ten-foot seines. Fish caught were collected into buckets, identified and most were released. Sample fish that were taken back to the lab were taken in ratio to the sample community caught. For example if the majority of fish were minnow and a small percent were log perch we would take three minnow and one perch back to the lab for a rough representation of the community. Fish taken as samples were put in plastic bags and labeled with the location and date they were caught. We hit the fish over the head with a rock to kill them before putting them on ice. We put fish samples in a cooler of ice immediately after they were caught, identified, and killed. Crayfish were also caught seining. We took three crayfish from each site. Crayfish were put in plastic bags labeled with date and site then put in the cooler of ice immediately after catching them. For sampling macroinvertebrates we used dip nets and sieves. Samples of sediment were taken with dip nets and then sieved through to look for macroinvertebrates. When we found macroinvertebrates we recorded the number and took samples for lab analysis. Macroinvertebrate samples were placed in plastic bags labeled with date and location and put immediately on ice in the cooler.

After returning to the lab we froze all samples at -80°C for 24 hours. After this we freeze-dried all samples. This took about 24 hours as well. After freeze-drying, samples were kept in a dedicator to prevent absorption of moisture while we waited to perform our isotope analysis on them. Samples were then crushed into powder in a mill. The powdered samples were then sent for isotope analysis in the mass spectrometer. Graphs of d15N v d13C data obtained from isotope analysis were made with standard deviations to observe overlap in isotope ratios to see if the prey items we caught were a part of walleye diets.

Hypothetical data was taken from a perch study on Canadian Shield lakes (Johnson et al 2004) as a potential prey species. The isotope data from this was incorporated into the second half of our results. A mixing model was performed with this data to make a potential diet percentage for walleye.

Results

Data from the University of Michigan Biological station Limnology class 2010 was used to analysis the abiotic factors of the lake. Dissolved oxygen v. depth and temp v. depth were recorded (figure 1 and 2).

Walleye samples of 16, 18 and 20.5 inches were obtained. Samples of Mayfly larvae (*ephemeroptera),* dragon fly larvae (*odonate),* and crayfish (*decapoda)* were sampled for macroinvertebrates (table 1). Minnow (*Notropis),* log perch (*percidae*) were the samples of forage fish obtained (table 2). Log perch was obtained at only 2 sites, the township line between N. Allis and Bearinger Township and at the boat launch on Corbat road. Minnow were the most abundant at all sites (table 2).

Walleye's isotope analysis reported an average d15N of 8.2 after a subtraction of 3 was made to account for nitrogen enrichment. Minnow d15N was 7.4; log perch, 6.7, mayfly, 4.3, crayfish, 5.4 and odonate, 5.7. (table 2) For d13C, 1 was subtracted from each walleye isotope ratio. The average d13C value of walleye was -31.27. Minnow average d13C value was -30.32, mayfly, -30.33, logs perch, -30.68, crayfish, -28.14 and odonate, -30.30 (table 3). Standard deviation was recorded for each species (table3).

From the isotope analysis and graph of isotope ratios only minnow was found to over lap walleye in both d15N and d13C ratios (figure 3). All other species were too low in nitrogen or their carbon was too heavy to be considered prey species. Walleye was also heavier in nitrogen then any of our sampled forage fish and macroinvertebrates.

A second analysis used yellow perch isotope analysis from a study on Canadian Shield lakes (Johnson et al 2004). Yellow perch had an average d15 N of 12.17 and a d13C of -32.07 (table 4). Yellow perch had a higher nitrogen ratio then walleye and lighter carbon then all other sampled species (Figure 4)

Using the data that incorporated yellow perch, a mixing model was performed using minnow and yellow perch. Yellow perch was source 1, minnow was source 2 and walleye was sample 1. The results were a diet analysis that reported 84% of walleye diet as minnow and 16% of the diet as yellow perch (table5)

Discussion

Our data shows that minnow were the only sampled potential prey item significantly close enough to walleye isotope ratios to be considered a prey item. However, minnow have a lower d15N ratio then walleye, which means that walleye must also be eating something else we did not find. In the graph of our walleye data, walleye is more enriched in 15N then our potential prey items (figure 3). The graph we want is where the walleye is in the middle of a triangle of prey items. The subtraction of 3 from walleye d15N values was to account for bioaccumulation, which falls between 1.3-5.3% as one moves up trophic levels (Adams et al 2000). This missing prey species would have to be or at least have a d15N ratio of a higher trophic level prey. Possibilities for this were researched to be piscivorous fish like yellow perch or organisms that have similar d15N values like leeches (Venturelli 2006)

What we found when we did the analysis for walleye diet with yellow perch inserted from the Canadian Shield lakes data (Johnson et al. 2004) was that yellow perch accounted for the high ratio of d15N in walleye. The yellow perch d15N ratio was above that of walleye, which explains why walleye d15N values were higher than the prey item we did find, minnow (Browne 2009).

With this finding we ran the mixing model to show what the diet of the walleye potentially is. With the results it appears that walleye are mainly eating minnow with a small proportion of yellow perch. However, this analysis is inconclusive. The yellow perch data is not our own or even from Black Lake and there are possibilities for there to be other prey items in the lake or other piscivorous fish accounting for the heavy reading of 15N in walleye. Further support for the hypothesis that yellow perch maybe a missing prey item is that other piscivorous fish from similar environments like pike often have a diet dominated by yellow perch and minnows, minnow being one of the prey items we caught and found to be in fact apart of walleye diet (Paradis 2007). Also, the lakes are similar in carbon levels which suggests that they have similar nutrient input most likely allochthonous which accounts for a light d13C ratio (Keogh 1996). The most concrete support we found for are results was that in other studies, walleye and yellow perch are a common predator and prey respectively in north American inland lakes. (Rose 1999)

To further our research a more comprehensive study of walleye ought to be performed. A population study to confirm a decline in the walleye population could be conducted with the DNRs tagging program. Also sampling of piscivorous fish to compare isotopes to get at definite read on what walleye are eating.

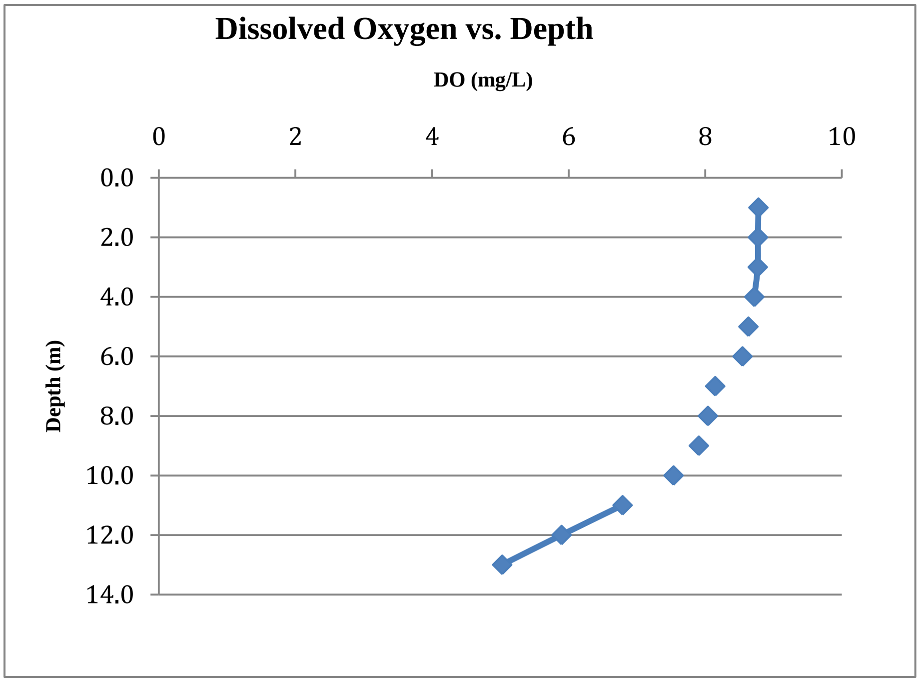

Figure 1: a graph of the dissolved oxygen (DO) vs. Depth. As depth increases there is a general trend that DO decreases.

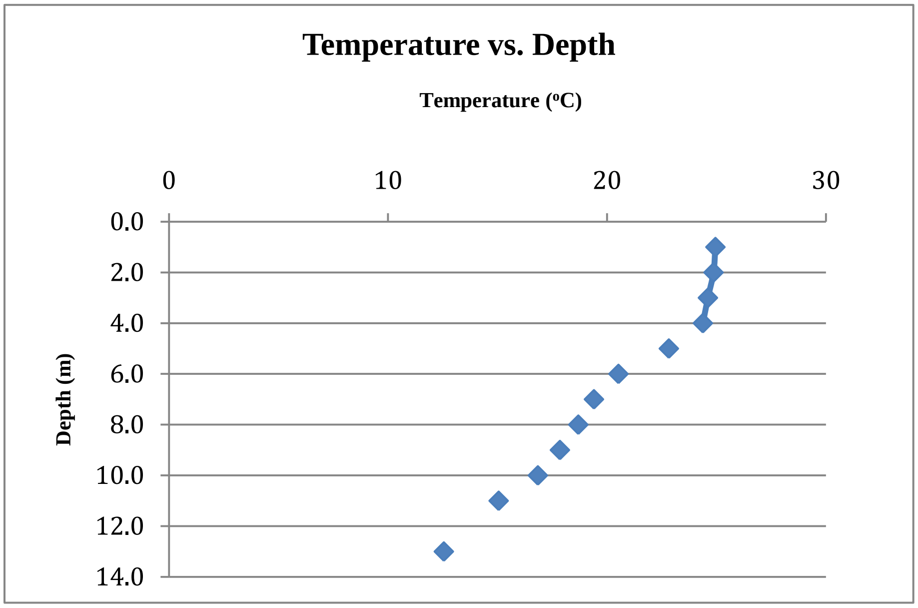

Figure 2: a graph of the temperature vs depth of Black Lake. As depth increases temperature generally decreases.

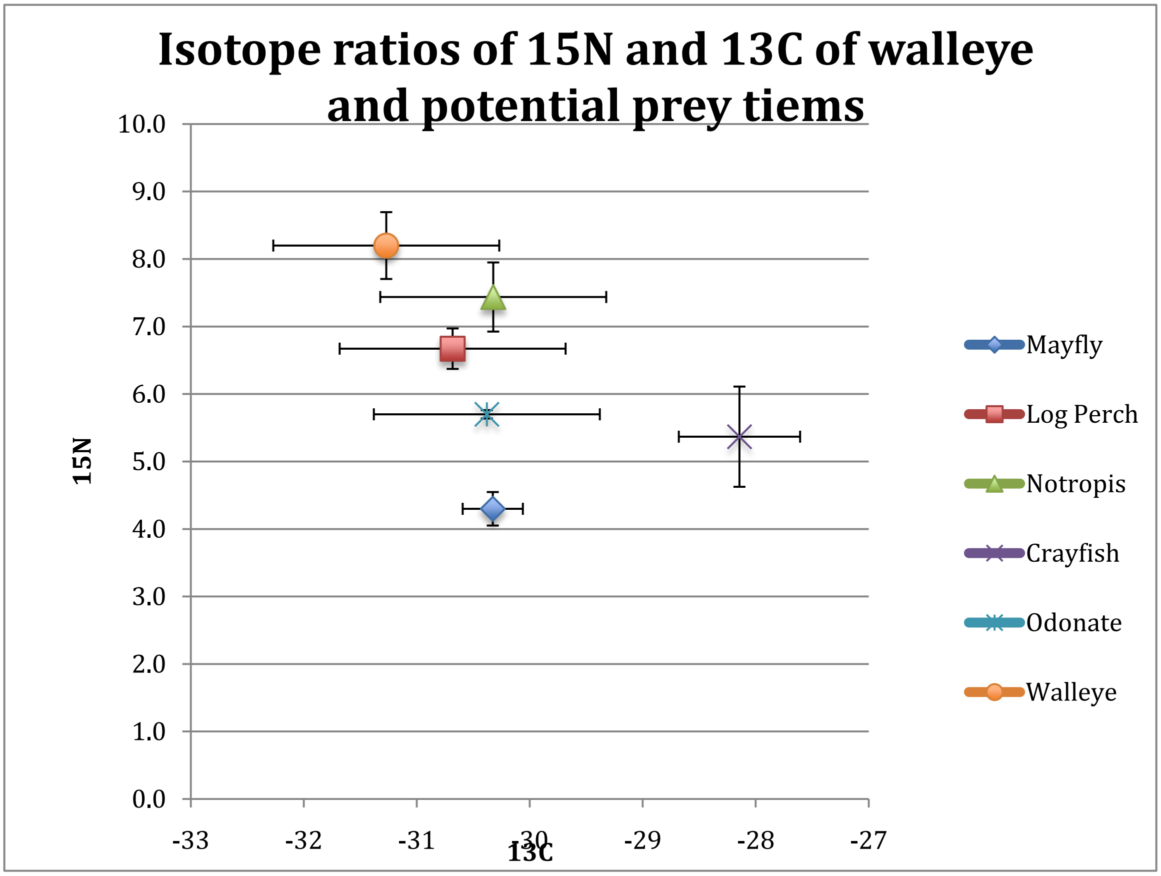

Figure 3: A graph of the d15N and d13C ratios. as seen on the graph, walleye has the lightest C and heaviest N. The only other species close to the walleye and intersecting when looking at the standard error bars is *Notropis* (minnow).

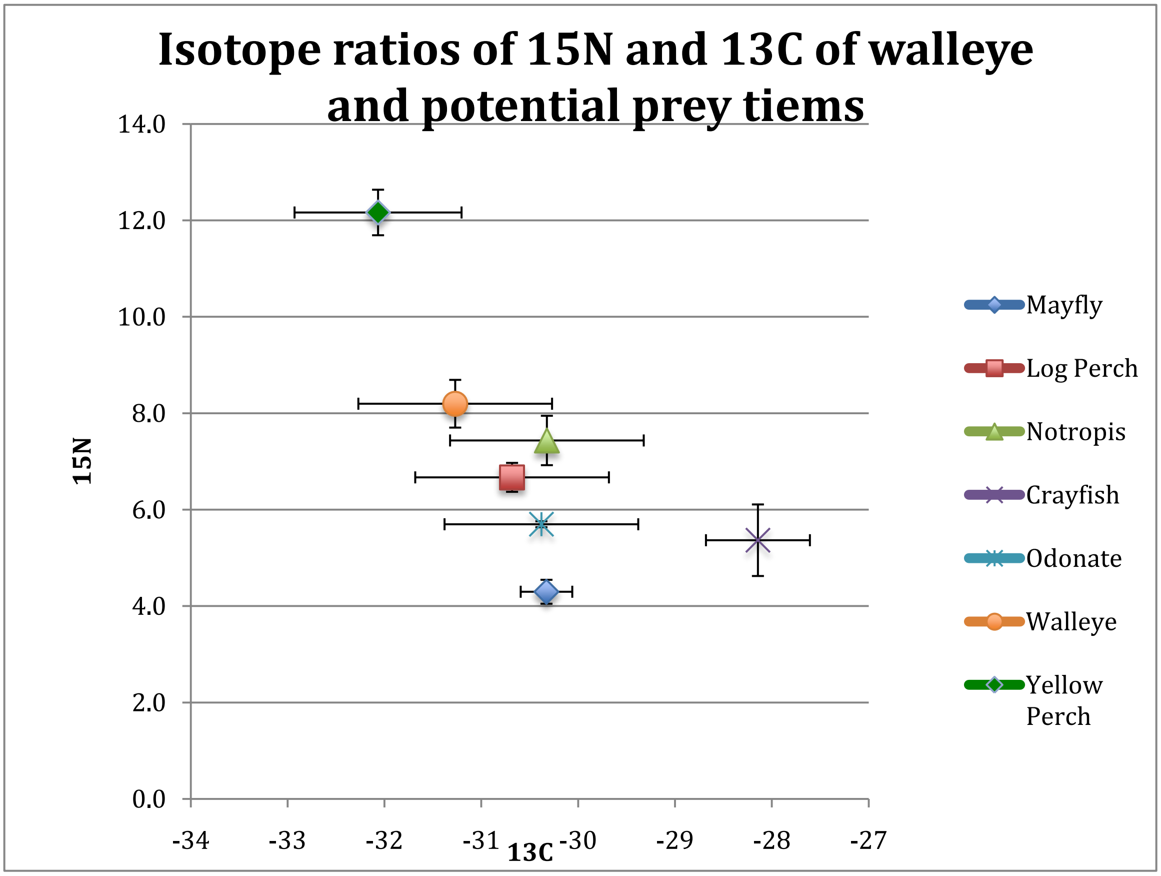

Figure 4: A graph of the d15N and d13C ratios. This graph includes yellow perch. Yellow perch is higher in nitrogen then walleye. This is why we speculate that it could be the missing prey item in our diet study as it accounts for nitrogen enrichment.

	site 1	site 2	*site 3	site 4
Sand shiner	170	2	264	0
log perch	1	0	0	0
white sucker	0	2	12	0
common shiner	0	7	32	2
large mouth bass	0	1	0	0
spot tail siner	0	7	16	135
Yellow perch	0	0	9	0
blunt nose minnow	0	0	16	0
unknown fish	1	0	0	0

Table 1: a table of all fishes caught sampling. Sand Shiners were the most abundant fish caught. Site 1 is the State park site, Site 2 the state forest, Site 3 Corbat road, and Site 4 is the township line between N. Allis and Bearinger Township.

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Total**
Crayfish	2	1	0	0	**3**
odonata	0	2	0	1	**3**
ephemeroptera	0	6	0	0	**6**

Table 2: a table of all macroinvertebrates caught sampling. *ehemeroptera* was the most abundant macroinvertebrates caught. Site 1 is the State park site, Site 2 the state forest, Site 3 Corbat road, and Site 4 is the township line between N. Allis and Bearinger Township.

Species	d15N	Stdev	d13C	Stdev
Minnow	7.4	0.5122	-30.32	0.7385
Log perch	6.7	0.2998	-30.68	0.1156
Mayfly	4.3	0.2483	-30.33	0.2663
Odonate	5.7	0.0616	-30.38	0.2332
Crayfish	5.4	0.7422	-28.14	0.5368
Walleye	8.2	0.495	-31.27	0.198

Table 3: Table of d15N and d13C values and standard deviation for each value for the walleye and potential prey items caught and sampled. Note that walleye's d15N is higher then all the other species.

Species	d15N	Stdev	d13C	Stdev
Minnow	7.4	0.5122	-30.32	0.7385
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Mayfly	4.3	0.2483	-30.33	0.2663
Odonate	5.7	0.0616	-30.38	0.2332
Yellow Perch	12.2	0.4726	-32.07	0.8621
Crayfish	5.4	0.7422	-28.14	0.5368
Walleye	8.2	0.495	-31.27	0.198

Table 4: Table of d15N and d13C values and standard deviation for each value for the walleye and potential prey items caught and sampled including hypothetical yellow perch. Note that the yellow perch has a higher d15N value then walleye. we find that this may account for the walleyes high d15N values.

	diet %
Source 1: Yellow perch	0.161159976
Source 2: Shiner	0.838840024

Table 5: a table of the results of our mixing model. From the percentages calculated one can see that the diet is comprised of 16% yellow perch and 84% minnow.

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