Zooplankton Availability to Larval Walleye (*Sander vitreus*) in Black Lake, MI, USA

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Abstract

Black Lake has very few small walleye even though it is stocked with walleye annually and is known for supporting large trophy size fish. The Black Lake Association wanted to find out why natural recruitment of walleye is low. Low recruitment of larval walleye could be caused by limited food (zooplankton) availability. This study focused on quantifying the zooplankton food source to assess whether it could support larval walleye. Zooplankton samples were collected near known spawning areas from April to August, 2011, with a zooplankton net. The species of zooplankton that are best suited as a good food source based on size and number appeared at the same time of year as the larval walleye in the lake. Daphnia densities, which are considered to be an ideal food source, peaked at 400 individuals per m^3. In addition, calanoids which are smaller yet also a good food source peaked at 7000 individuals per m^3. Abundance of zooplankton doesn't appear to be limiting larval walleye recruitment.

Introduction

Zooplankton are small, aquatic invertebrates that are a main food source for small, young-of-year fish. Because they are at the bottom of the aquatic food chain a strong, two-way interaction exists between fishes and zooplankton (Crowder *et al*. 1987). Fish can directly impact zooplankton populations through predation. Conversely, fish populations and recruitment can be influenced by the timing of availability, relative abundance and composition of the zooplankton community. Because of this linkage between prey availability and growth of larval fishes (Mills *et al*. 1989a) this food chain reaction can affect the recruitment of larval fish to the juvenile stage.

Different sizes and species of zooplankton are selectively consumed by the larvae of different species of fish. This idea is linked to the importance of suitable or preferred zooplankton prey being available when the larvae begin to feed. Rapid growth is crucial for survival in larval fishes and proper nutrition is key to rapid growth. The availability of particular zooplankton species to larval fish is determined by a range of factors including prey size, prey vulnerability, prey visibility, and prey motion (Mills *et al*. 1989a). In studies conducted on larval yellow perch (*Perca flavescens*) and rainbow trout (*Oncorhynchus mykiss*), larvae more commonly chose small to intermediate sized zooplankton even though they are smaller then the optimum size for maximum growth (Confer *et al*. 1990). This could be caused by reduced visual acuity of larvae or a lesser ability to discriminate prey size (Li *et al.* 1985). The gape size of the larval fish also influences prey selectivity. Small larval fish typically will not pursue larger zooplankton such as Daphnia because the larvae are limited by their gape size and can not physically eat prey that large (Wong and Ward 1972)

Zooplankton abundance may be impacted by the presence of zebra mussels (*Dreissena polymorpha*). Zebra mussels have been associated with changes across trophic levels since their introduction to the Great Lakes in 1986. They are known to increase water clarity and decrease the abundance of small zooplankton (Fahnenstiel *et al*. 1995). Zebra mussels and zooplankton consume the same phytoplankton, and the young-of-the-year (YOY) fish eat the zooplankton. Zebra mussels have the potential to reduce phytoplankton abundance, thus outcompeting zooplankton by rapidly filtering the water column (Fahnenstiel *et al.*1995). If the zooplankton numbers plummet, then there is not enough food for the fish and they die as well. This food chain shows the direct effects as well as indirect effects on more then one trophic level (Crowder *et al.* 1987). In contrast, in Oneida Lake, New York, it was found that the introduction of zebra mussels did not negatively impact the yellow perch population (Mayer *et al.* 2000)

For the past few years walleye *(Sander vitreus*) recruitment in Black Lake, Michigan, has been poor. Poor recruitment could be due to either low reproductive success of the walleye or low availability of zooplankton to larvae. Walleye are an important sport fish in Black Lake and play economical and ecological roles in the area. Because the declines in the local population are concerning, The Black Lake Association and the Hammond Bay Area Anglers Association were interested in identifying whether egg production or zooplankton were limiting recruitment.

The objective of this project was to assess if zooplankton availability is low and thus potentially limiting walleye recruitment in Black Lake. Zooplankton availability was evaluated based on the abundance of different taxonomic groups and the timing of appearance of zooplankton and larval walleye in the lake. Zooplankton abundance was compared to values reported in the literature to determine if it was sufficient for larval walleye survival. Temporal trends in zooplankton abundance were compared to the presence of larval walleye to identify temporal overlap.

Methods

The study was conducted in Black Lake, which is located in Presque Isle and Cheboygan counties, Michigan, USA. The lake has an area of 41 square kilometers and an average depth of seven meters. The three sampling sites within the lake were located near tributaries and known spawning areas for walleye (Figure 1). Larval walleye sampling co-occurred at the same sites.

Zooplankton were collected weekly in April, May and June, and then once a month in July and August 2011. Vertical tows starting at 10 m depth were performed using a 0.5 m diameter zooplankton net. A flow meter was attached to the net to calculate sampling efficiency to correct for the volume of water actually sampled. The efficiency percentage of each tow was calculated based on factory calibrations. Two replicate tows were conducted at each of the three sites. The zooplankton were then transferred to a clean container and preserved in 70% ethanol and taken back to the lab for processing. A Henson Stempel pipette was used to take 10-ml subsamples.

Zooplankton were identified down to the lowest practical taxonomic level and enumerated. Copepods were identified to order and Cladocerans to genus. Zooplankton counts per tow were converted to density (#/m^3) based on the volume of water sampled corrected for sampling efficiency. Mean density (+/- standard error) per sample site per date was calculated for each taxonomic group.

Results

The most abundant zooplankton found throughout data collection were calanoids which ranged from 150 to 7000 individuals per m^3 (Figure 2). Daphnia were least abundant, ranging from 0 to 400 individuals per m^3 (Figure 3). Cyclopoids were intermediate in abundance with ranges from 170 to 2700 individuals per m^3 (Figure 5). Copepod nauplii were very abundant through the spring and summer with ranges from 1300 to 13000 individuals per m^3 (Figure 4). Densities peaked for all taxonomic groups in mid June, which overlapped with the presence of larval fishes (Ingersoll 2012) (Figures 2-5).

Discussion

Zooplankton densities of all taxonomic groups peaked in mid June. Ingersoll (2012) found larval fish numbers peaked in mid June, however, no larval walleye were collected. This could have been from the water temperature not being at optimum (20 degrees Celsius) until late June, which might have caused larval walleye mortality (Ingersoll 2012). The peaks in larval fish numbers correlates with the same time the zooplankton numbers rise and shows there is a food source available when larval fishes are abundant in the lake. Across all species, zooplankton abundance peaked on the June 18^{th} sampling and again on August 6^{th}.

Daphnia densities were the lowest of the zooplankton sampled at only 400 individuals per m^3. Even though Daphnia are the largest prey and provide the best reward in nutrition, larval fish do not always select for larger prey (Confer *et al.* 1990). Larval fish can select smaller prey to optimize foraging efficiency so they can maximize growth and survival (Mills *et al.* 1989b). Because of the high density of 7000 individuals per m^3 of calanoids, (which are smaller then Daphnia) these zooplankton may be the chosen food source for larval fish in the lake. Copepod nauplii, the smallest zooplankton sampled, had the highest density peaking at 1300 individuals per m^3. Nauplii, however, are not a reliable or common food source for larval fish since they provide such little nourishment (Confer and Lake 1987). No studies have been conducted quantifying what prey densities are ideal for larval walleye. However, Mills *et al.* (1986) found no significant relationship between median prey selected and prey density in yellow perch. Therefore, the reason for having very little natural recruitment is unlikely to be due to the availability of zooplankton.

Kaiser (2012) collected walleye eggs to estimate spawning in Black Lake. His research estimated that there may only have been be one walleye spawn at the Black Lake study site he sampled. There may be other possible spawning sites in Black Lake that have yet to be tested. Since both studies from Kaiser and Ingersoll showed low numbers of eggs and larvae, it can not give a definitive answer as to why there is such a low recruitment. Further studies should continue the search for a reason explaining the low recruitment in Black Lake.

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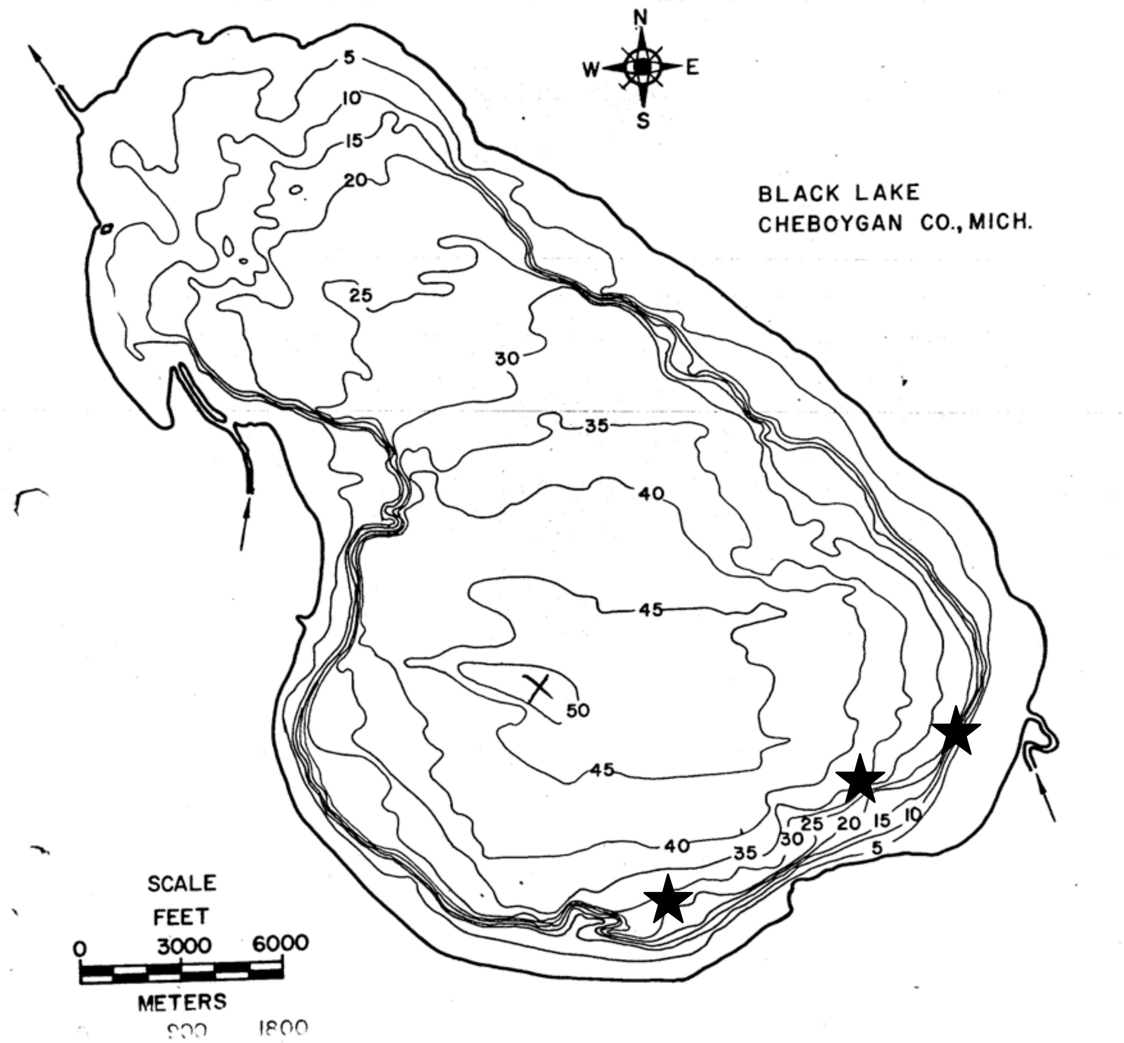

Fig 1. Map of Black Lake with stars showing the location of the three sampling sites.
http://sitemaker.umich.edu/umbs/files/black.gif

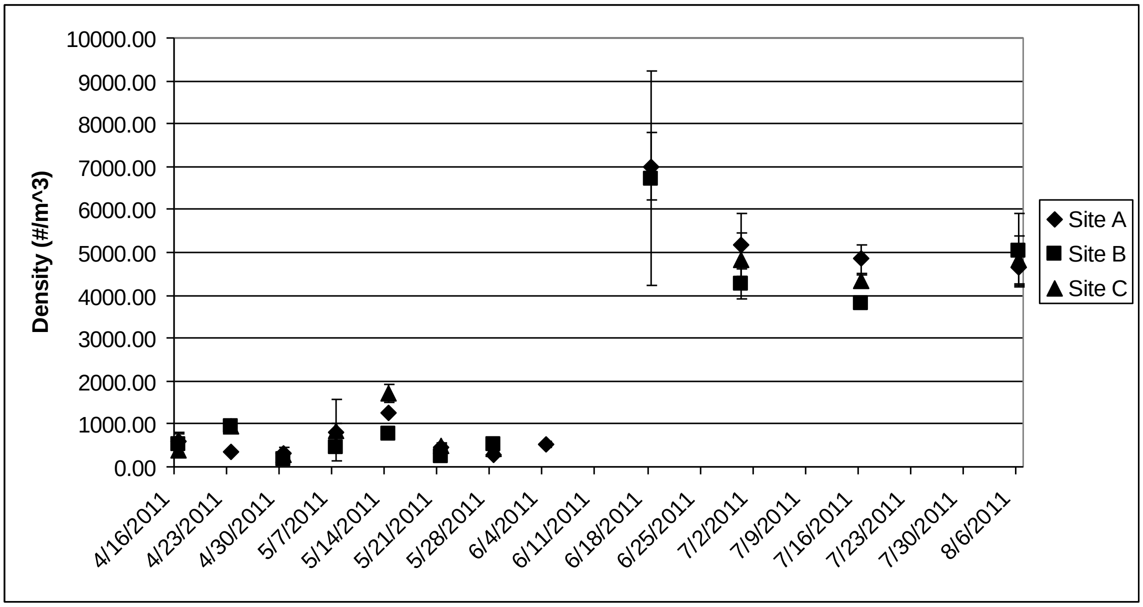

Fig 2. Mean density of Calanoids (#/m^3 +/- standard error) over time at each of the three study sites.

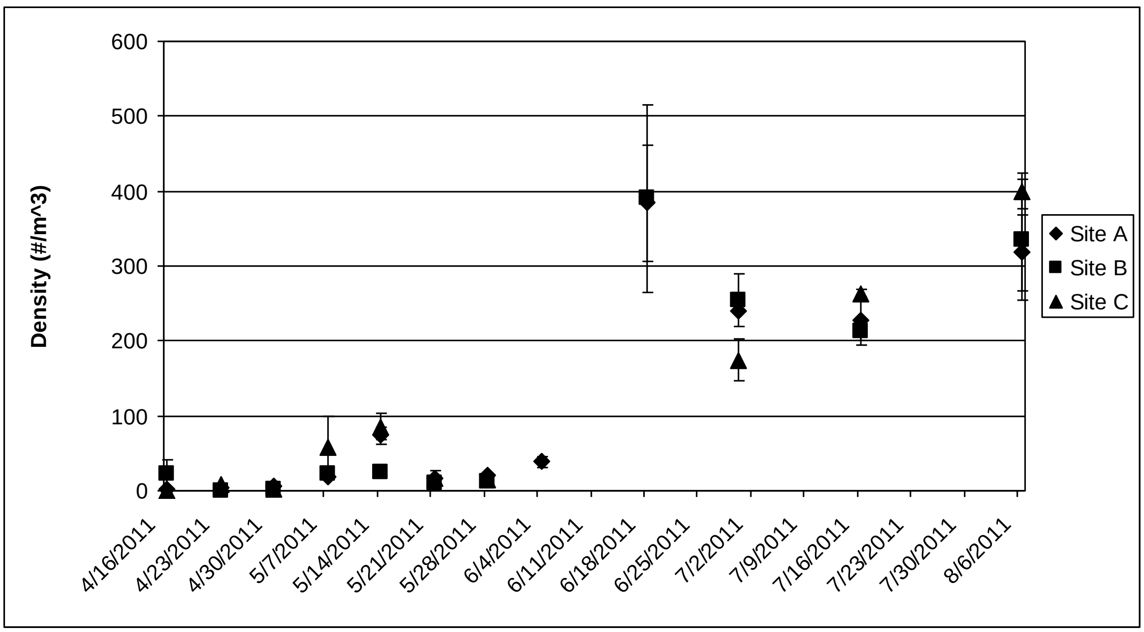

Fig 3. Mean density of Daphnia spp. (#/m^3 +/- standard error) over time at each of the three study sites.

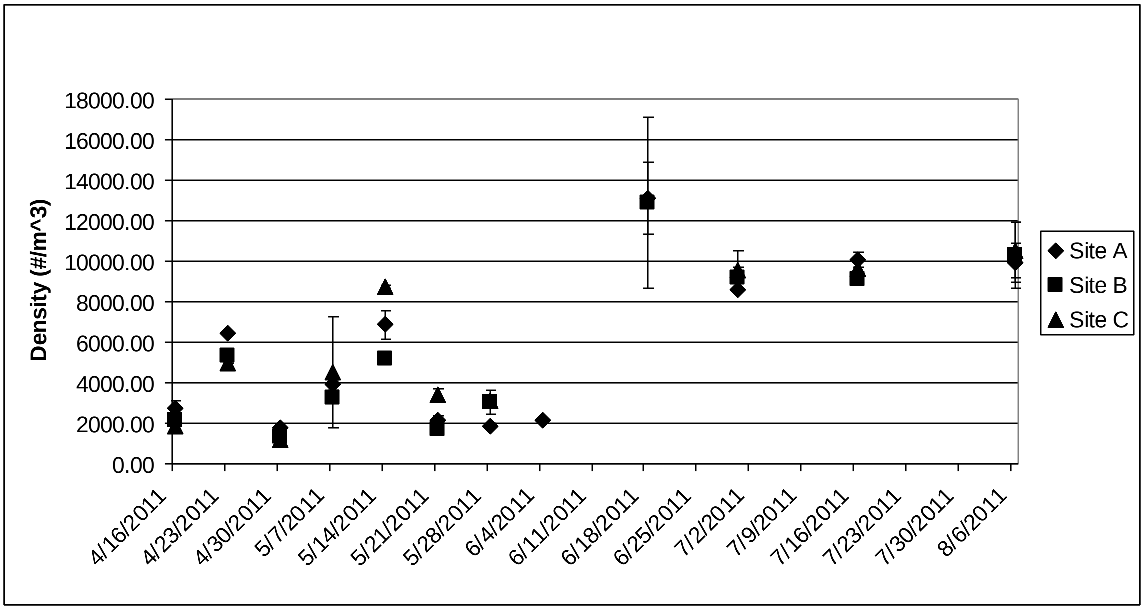

Fig 4. Mean density of nauplii (#/m^3 +/- standard error) over time at each of the three study sites.

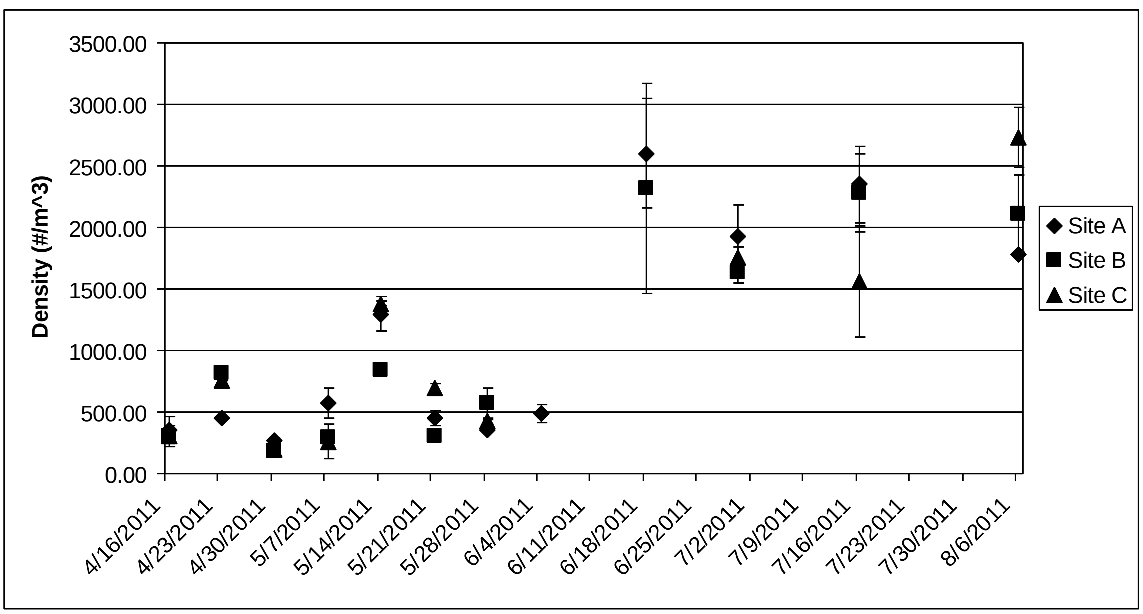

Fig 5. Mean density of Cylopoids (#/m^3 +/- standard error) over time at each of the three study sites.