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NOTE

Age-0 and Age-1 Yellow Perch Diet in Southeastern Lake Michigan

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ABSTRACT. *Age-0 yellow perch (*Perca flavescens*) were collected during October 1998 and age-1 yellow perch were collected during June 1999 from southeastern Lake Michigan off St. Joseph and Muskegon, Michigan, to evaluate diets relative to recent ecosystem changes. Size range of yellow perch examined was 72 to 118 mm. In October at a 15-m site off Muskegon, both* Gammarus *spp. and Isopoda were found in nearly 71% of age-0 yellow perch stomachs, and accounted for 71 and 26% of the diet by weight respectively. The following spring at the 15-m site (June 1999),* Gammarus *spp. and Isopoda were only a small part of age-1 yellow perch diet, and Chironomidae and* Mysis relicta *dominated the diet. In October at depths of 25 to 35 m,* M. relicta*, was found in 100 and 80% of the age-0 yellow perch containing food off Muskegon and St. Joseph, respectively, and comprised over 96% of the diet by weight.* Gammarus *spp., Isopoda, and* M. relicta *were eaten in higher numbers than would be expected based on their low abundance in the environment. The high occurrence of* Gammarus *spp. and Isopoda in yellow perch diet may indicate ongoing changes in the nearshore benthic community.*

INDEX WORDS: *Yellow perch, fish diets, Lake Michigan.*

INTRODUCTION

The ecology of the nearshore regions of southeast Lake Michigan has undergone widespread changes over the past two decades. Recent changes include possible disruption of the pelagic food web by zebra mussels (*Dreissena polymorpha*) (Marsden *et al.* 1993), major declines in the amphipod *Diporeia* (Nalepa *et al.* 1998), and invasion by *Bythotrephes cederstroemi* (Evans 1988). These changes could affect the diet and competitive interactions of fishes in Lake Michigan, including yellow perch (*Perca flavescens*), which feed on both zooplankton and zoobenthos (Crowder *et al.* 1981).

Although yellow perch abundance in Lake Michigan has fluctuated widely among years (Wells 1977, Jude and Tesar 1985), a relatively large year-class occurred in 1998 following nearly 10 years of poor recruitment (D. Jude, Ann Arbor, Michigan, Center for Great Lakes and Aquatic Sciences, University of Michigan, personal communication). The high relative abundance of age-0 yellow perch provided an opportunity to evaluate diet relative to the environmental changes which have occurred in the southeastern portion of the lake.

METHODS

Age-0 and age-1 yellow perch were collected from southeast Lake Michigan as part of a National Oceanic and Atmospheric Administration (NOAA) biological monitoring program. Sampling occurred on 19 October 1998 and 7 June 1999 off Muskegon,

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Michigan, and on 28 October 1998 off St. Joseph, Michigan. Yellow perch were caught during daytime periods using a 7.6-m semi-balloon bottom trawl (13-mm stretch mesh cod-liner). Trawling was conducted along the 15-, 25-, and 35-m bottom depth contours off Muskegon and along the 25- and 35-m contours off St. Joseph. The two sampling areas reflect marked differences in the abundance of *Diporeia*. Abundances have declined to near-zero off St. Joseph, while abundances are still relatively high off Muskegon (Nalepa *et al.* 1998). Muskegon is located approximately 120 km north of St. Joseph.

Fish were immediately frozen upon capture. In the laboratory, fish were measured (total length ±1 mm), and stomachs were removed. All whole prey organisms were identified and counted; partial prey were counted if they met pre-determined criteria. Prey lengths were measured using a computer image analysis system. Prey length was converted to dry-weight using prey species-specific body length to dry-weight calculations (Johnson and Brinkhurst 1971, Nalepa and Quigley 1980, Smock 1980, Shea and Makarewicz 1989, Makarewicz and Jones 1990, Prejs *et al.* 1990). Diet is reported as frequency of occurrence (percent of fish containing a given prey type) and percent of the total calculated dry-weight for all fish combined from each sample. Data collected each month as part of the NOAA monitoring program from depths of 15 to 45 m off Muskegon and St. Joseph were used to estimate prey densities. For October 1998, stomach analyses for depths of 25 and 35 m were combined because only one fish containing food was caught at the 35-m depth off Muskegon, and five fish off St. Joseph. During June 1999, yellow perch were caught only along the 15-m contour off Muskegon.

RESULTS AND DISCUSSION

Stomach contents from 101 age-0 yellow perch ranging in length from 72 to 118 mm (mean = 91 mm) were examined during October 1998. Fourteen age-1 yellow perch ranging in length from 77 to 109 mm (mean = 87 mm) were examined during June 1999. More yellow perch from the 25- to 35-depth contours off Muskegon and St. Joseph in October had empty stomachs than from the 15-m contour off Muskegon in October and June (Table 1). Yellow perch with empty stomachs were excluded from further diet analyses. Other fish species collected in trawls included spottail shiners (*Notropis hudsonius*), alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), slimy sculpin (*Cottus cognatus*), and bloater (*Coregonus hoyi*). Mean water column temperatures ranged from 13°C during October to 11°C during June.

Large macroinvertebrates were the main prey eaten by age-0 yellow perch in October 1998 and by age-1 yellow perch in June 1999. At the 15-m site off Muskegon in October 1998, *Gammarus* spp.

TABLE 1. Frequency of occurrence (percent) and percent of total dry-weight for diet items found in age-0 yellow perch in October 1998 and age-1 yellow perch in June 1999 in southeastern Lake Michigan off Muskegon and St. Joseph, Michigan at 15- and 25–35-m depth intervals. N = total number of fish examined.

	October 1998 Muskegon, 15 m		October 1998 Muskegon, 25–35 m		October 1998 St. Joseph, 25–35 m		June 1999 Muskegon, 15 m	
Prey	Frequency	Percent wt.	Frequency	Percent wt.	Frequency	Percent wt.	Frequency	Percent wt.
Gammarus spp.	70.6	71.0	0	0	0	0	7.7	7.1
Isopoda	70.6	25.8	0	0	0	0	15.4	5.2
Mysis relicta	5.9	0.6	100	99.3	79.5	96.2	46.2	32.0
Bythotrephes cederstroemi	5.9	0.4	0	0	33.3	0.8	0	0
Ostracoda	0	0	0	0	28.2	3.0	0	0
Chironomidae	23.5	1.0	11.1	0.6	0	0	76.9	55.2
Dreissena polymorpha	17.6	0.5	0	0	0	0	0	0
Gastropoda	11.8	0.5	0	0	0	0	0	0
Zooplankton	0	0	0	0	0	0	38.5	0.4
N	17		24		60		14	
Percent empty	0.0		62.5		35.0		7.1	

TABLE 2. Densities (no./m^2) of various prey items in Lake Michigan collected from nearshore (15- to 45-m) sites off Muskegon and St. Joseph, Michigan, during October 1998 and June 1999. Data were collected at 1 to 3 sites during each respective month as part of a NOAA monitoring program (T. Nalepa and S. Pothoven, unpublished data). NA = no prey density data were available.

	October 1998 Muskegon	October 1998 St. Joseph	June 1999 Muskegon
Gammarus spp.	0	0	0
Isopoda	0	0	0
Mysis relicta	47	NA	23
Bythotrephes cederstroemi	39	NA	0
Ostracoda	NA	NA	NA
Chironomidae	271	7	161
Dreissena polymorpha	1,700	0	203
Gastropoda	NA	NA	408
Zooplankton	370,800	NA	270,000
Diporeia	4,320	14	2,243

and Isopoda were found in nearly 71% of the age-0 yellow perch, and accounted for 71 and 26%, respectively, of the diet by weight (Table 1). The following spring (June 1999) at 15-m off Muskegon, *Gammarus* spp. and Isopoda were only a small part of the age-1 yellow perch diet, and Chironomidae and *Mysis relicta* were mainly eaten. At the 25- to 35-m site in October 1998, age-0 yellow perch fed mainly on *M. relicta*, which occurred in 100 and 80% of the fish containing food off Muskegon and St. Joseph, respectively, and accounted for almost all of the diet by weight at both sites (> 96%) (Table 1).

Zooplankton and other benthic prey were a smaller part of the age-0 and age-1 yellow perch diet. *B. cederstroemi* and Ostracoda were found in about a third of the age-0 yellow perch stomachs off St. Joseph in October, but accounted for a small fraction of the diet by weight (Table 1). *B. cederstroemi* were eaten mainly by yellow perch larger than 90 mm. Zebra mussels and Gastropoda were eaten by about 18 and 12%, respectively, of the age-0 yellow perch from 15 m off Muskegon in October, but each comprised < 1% of the diet by weight (Table 1). Zooplankton were eaten by 38% of the age-1 yellow perch at 15 m off Muskegon in June, but comprised < 1% of the diet by weight (Table 1).

The dominant prey eaten by age-0 and age-1 yellow perch were not the most abundant prey available based on data from nearshore (15 to 45 m) monitoring stations off Muskegon and St. Joseph (Table 2). No *Gammarus* spp. or Isopoda were collected off Muskegon or St. Joseph during fall 1998 or off Muskegon in spring 1999, but they accounted for a large part of the diet (Tables 1 and 2). In contrast, *Diporeia*, which were still relatively abundant off Muskegon, were not found in any yellow perch stomachs. *Gammarus* spp. and isopods may be more available to yellow perch than *Diporeia* because they are found on structures such as rocks or zebra mussels that provide grazing area for predators (Thayer *et al.* 1997), whereas *Diporeia* burrow into the bottom sediments (Balcer *et al.* 1984). A laboratory study reported yellow perch (120 to 130 mm) selectively ate *Gammarus* and isopods in treatments with zebra mussels compared to those without (Thayer *et al.* 1997).

M. relicta densities off Muskegon were low in October and June, but they accounted for much of the diet during both months (Tables 1 and 2). Mysid densities were not available off St. Joseph. Although *M. relicta* is not abundant at depths less than 50 m (McDonald *et al.* 1990), their high lipid content makes them a desirable prey for yellow perch when they are available (Gardner *et al.* 1985). Previous studies have not reported *M. relicta* in age-0 yellow perch diets (Crowder *et al.* 1981, Baker *et al.* 1992, Schneeberger 1991). However, age-0 yellow perch were collected from deeper water (> 15-m depth) where mysids are more abundant and later in the year than these studies. Mysids have been reported in the diets of older yellow perch than were examined in this study in southeast Lake Michigan (Wells 1980).

The high occurrence of *Gammarus* spp. and Isopoda in yellow perch diets suggests ongoing changes in the nearshore benthic community are occurring. Neither have been reported as an important prey item for age-0 or older yellow perch in southeastern Lake Michigan throughout the year (Wells 1980, Crowder *et al.* 1981, Baker *et al.* 1992). *Gammarus* spp. densities in spring 1999 at an 18-m site off St. Joseph were 42/m^2 (T. Nalepa, unpublished data) and higher compared to historical densities throughout southeast Lake Michigan (Nalepa and Quigley 1980, Winnell 1984, Nalepa 1989). Zebra mussels may be providing habitat for *Gammarus* spp. and Isopods in areas where they were not previously abundant (Stewart and Haynes 1994, Thayer *et al.* 1997); in contrast, zebra mussels have been implicated in the decline of *Diporeia* (Nalepa *et al.* 1998). Increases in these large benthic prey items would likely benefit age-0 yellow perch once they are large enough to consume benthic macroinvertebrates (Thayer *et al.* 1997).

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