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Yellow Perch Population Assessment in Southwestern Lake Michigan

Redman, Rebecca A.; Dub, Joshua D.; Czesny, Sergiusz J.

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Prairie Research Institute, University of Illinois at Urbana Champaign
William Shilts, Executive Director

Illinois Natural History Survey
Brian D. Anderson, Director
1816 South Oak Street
Champaign, IL 61820
217-333-6830

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Rebecca A. Redman, Joshua D. Dub, and Sergiusz J. Czesny
University of Illinois
Prairie Research Institute
Illinois Natural History Survey

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Sergiusz Czesny,	Brian Anderson,
Principal Investigator	Director
Illinois Natural History Survey	Illinois Natural History Survey

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INTRODUCTION

Yellow perch (*Perca flavescens*) is an important commercial and sport fish throughout much of its range in North America. Its schooling behavior promotes sizable captures in commercial gears such as trap nets and gill nets, and the tendency of yellow perch to congregate nearshore in the spring makes this species accessible to shore anglers. The majority of yellow perch harvested in North America are taken from the Great Lakes; yellow perch provide the most important sport fisheries in the four states bordering Lake Michigan and until 1997 supported large-scale commercial fisheries in three of those states.

Lake Michigan yellow perch have undergone severe fluctuations in abundance in the past few decades. The population in the southern basin increased dramatically in the 1980s (McComish 1986), and the sport and commercial fisheries expanded accordingly. In Illinois waters alone, the estimated annual catch by sport fishermen doubled between 1979 and 1993, from 600,000 to 1.2 million fish (Muench 1981, Brofka and Marsden 1993). Between 1979 and 1989, the commercial harvest in Illinois tripled, in Wisconsin (excluding Green Bay) it increased six-fold, and in Indiana the harvest increased by over an order of magnitude (Brazo 1990, Hess 1990). However, the yellow perch fishery in Illinois waters during the early and mid-1990's was primarily supported by a strong year class spawned in 1988 (Marsden and Robillard 2004). Few or no young-of-the-year (YOY) yellow perch were found in lake-wide sampling efforts during 1994-1997 (Hess 1998), but significantly greater survival of the 1998 year class occurred. The 1998 year class dominated Lake Michigan Biological Station (LMBS) spring adult assessments between 2000 and 2004 (previous segments of F-123-R). During this period, LMBS trawling efforts detected moderate year class strength during 2002 and 2004. In 2005, the age structure of yellow perch began to shift towards younger fish so that 52% of the catch was age-3 (2002 year class) and the 1998 year class (age-7) contributed 37% of the catch. Additionally, age-0 CPUE from trawling assessments during 2005 and 2010 were the highest recorded in Illinois waters since 1988. During 2006-2008, the 2002 and 2003 year classes dominated LMBS spring adult assessments and sport harvest collections. Then, in 2009 and 2010 LMBS yellow perch samples (fishery independent and sport harvest) were dominated by the 2005 year class, while the 2002 and 2003 year classes also contributed significantly to the fishable population (Redman et al. 2011a). Despite the presence of multiple year classes within the population, lake wide assessments show that current yellow perch abundance remains low, particularly in comparison to abundance observed in the late 1980s and early 1990s (Makauskas and Clapp 2010). Thus, there continues to be concern about the survival and growth of yellow perch and sustainability of the population in Lake Michigan.

To protect yellow perch stocks, fisheries managers should set harvest targets in accordance with fluctuating population sizes. However, the ability to successfully set these harvest targets for yellow perch is hampered by insufficient information about population size, natural mortality, reproductive potential, and factors effecting the growth and survival of juveniles. The continued decline of the yellow perch population due to reduced survival of larvae to the age-0 stage has prompted researchers to narrow the focus of investigation to spawning behavior and success along with age-0 interactions and survival. Reproductive potential influences the ability of the population to respond to external forces such as overfishing or environmental fluctuations. Thus, accurate estimates of fecundity and knowledge of how reproductive potential varies over the life of yellow perch in Lake Michigan are crucial to the development of appropriate management strategies to ensure the persistence of this species. Fecundity (Brazo et al. 1975) and egg quality (Heyer et al. 2001) have been shown to increase with age in yellow perch. Additionally, marine larvae produced by younger spawners have been shown to experience higher mortality than larvae produced by older, more experienced spawners (O'Farrell and Botsford 2006). Thus, estimates of reproductive potential based on biomass estimates alone risk oversimplifying and overestimating reproductive output. Assessment of pelagic and demersal age-0 yellow perch along with additional juvenile (age-1 and age-2) life stages may permit prediction of future year-class strength. However, variability of larval yellow perch abundance data and age-0 catches is very high, and much remains unknown about the early life history of yellow perch in large lakes. Particularly, how the hydrodynamics of Lake Michigan influence the advection of larval yellow perch from nearshore spawning sites to the offshore pelagic zone as well as eventual settlement into benthic nearshore nursery habitat. The ability to couple physical and biological data will not only enhance our understanding of pelagic age-0 fish feeding behavior and early life-stage movement and survival rates, but also contribute to our ability to monitor year-class strength relative to other years. Characterizing the mechanisms influencing ontogenetic diet and habitat shifts will contribute to our basic understanding of the offshore pelagic stage of age-0 yellow perch in Lake Michigan. Annual assessment of pelagic larval yellow perch drifting offshore, abundance of age-0 yellow perch returning to nearshore habitat in the fall, and abundance and diet of age-1 and age-2 yellow perch, coupled with 20+ years of data collected on yellow perch in Illinois waters of Lake Michigan will help to identify critical bottlenecks that limit survival between early life stages and recruitment to the sport fishery.

Concurrent with the decrease in larval fish recruitment, zooplankton density in southern Lake Michigan has declined, and the assemblage structure has shifted. Nearshore densities of zooplankton in southern Lake Michigan during 1990–2010 were consistently lower than densities in the late 1980s, when yellow perch abundance and harvest were dramatically higher (Dettmers et al. 2003, Clapp and Dettmers 2004, Redman et al. 2011a). Furthermore, zooplankton taxonomic composition in June shifted from abundant cladocerans (about 30% by number) mixed with large-bodied copepods during 1988–1990 to abundant smaller copepods and rotifers, but few cladocerans during 1996-1998. *Daphnia retrocurva* dominated the daphnid community in nearshore waters of southern Lake Michigan during 1972-1984, but declines in abundance occurred following the invasion of *Bythotrephes cederstroemi* in 1986 (Madenjian et al. 2002, Barbiero and Tuchman 2004). Declines in several other Cladocerans species, such as *Eubosmina coregoni*, *Daphnia pulicaria*, and *Leptodora kindti*, have also been attributed to the invasion of this predatory cladoceran (Makarewicz et al. 1995, Barbiero and Tuchman 2004). Additionally, in earlier studies we evaluated how the shift in southern Lake Michigan's zooplankton assemblage influenced growth and survival of larval yellow perch using laboratory experiments (Graeb et al. 2004). One observation made during these experiments was that some yellow perch larvae failed to inflate their swim bladder (Czesny et al. 2005). Swim bladder inflation is usually associated with the nutritional state of fish larvae and can affect survival of these fish to later life stages. Thus, the status and composition of the zooplankton community in both nearshore and offshore waters of Lake Michigan greatly impacts the recruitment success of yellow perch.

Results of this project will help strengthen management strategies for this important sport fish species. These findings will be incorporated into yellow perch management decisions through multi-agency collaboration, which reflects a changing philosophy in the Great Lakes fisheries from jurisdictional to lake-wide management.

METHODS & RESULTS

<u>Study 101.</u> Yellow perch population assessment in southwestern Lake Michigan

Job 101.1A: Assess yellow perch population: Spring spawning assemblage
<u>Objective:</u> Monitor the age and size structure of yellow perch on spawning grounds and evaluate reproductive potential.

Adult yellow perch were collected from 9 May – 5 June, 2012 at Waukegan and Lake Forest, IL. We deployed monofilament gill nets consisting of 100-ft panels of 2.0, 2.5, 3.0, and 3.5-in mesh. Gill nets were set in 10, 15, and 20 meters of water for approximately 24 hours on three occasions. Annual effort during spring 2012 was nine net nights and mean CPUE (fish/net night) was relatively low at 3.7 ± 4.3 (SD) yellow perch (Figure 1). A total of 37 yellow perch were caught and mean total length was 261 ± 44 mm. Fish ranged from 4-14 years old (Figure 2). In 2012, ovaries were taken from 10 females ranging from 189-326 mm TL. Fecundity of these fish ranged from 15,659 - 107,477 eggs.

We compiled CPUE, length and fecundity data from 350 yellow perch collected during 2007-2012 to examine annual variation in relative abundance and size of gravid females as well as estimate the relationship between female length and fecundity. Mean CPUE of females was similar in 2007-2011 ranging from 10-14 fish/net night, but declined significantly in 2012 (CPUE = 1.8 fish/net night; $p < 0.05$; Figure 3). Annual variation was also detected in the length distribution of gravid female yellow perch collected during 2007-2012 ($p < 0.003$; Figure 4). Over the course of the study, we caught mature females ranging from approximately 175 - 365 mm TL. During 2007, the length distribution of females was slightly skewed towards fish less than 270 mm and skewed towards females over 260 mm during 2008. A slightly bimodal distribution was observed in 2009 with a significant contribution from females less than 230 mm and greater than 280 mm. The 2010 length distribution was slightly skewed toward females < 250 mm, while in 2011 the majority of females were between 230-320 mm TL. During 2012, females were present at a variety of sizes, but very few fish were caught. Based on these annual differences in relative abundance and size distribution we might expect reproductive output to vary annually given that fecundity increased exponentially with length (Figure 5). A slope heterogeneity test showed that the length-fecundity relationship of yellow perch differed among collection years, so regression equations were estimated separately for each year (Table 1). Fecundity ranged from approximately 12,156 eggs for a 178 mm female to 141,067 eggs for a 336 mm female. Our results showed larger females produced more eggs and as such temporal changes in the abundance and size structure of the spawning stock have the potential to impact egg production at the population level in Lake Michigan.

Job 101.1B: Assess yellow perch population: Fall
<u>Objective:</u> Monitor the age, size and sex structure of the population during a period when male and female yellow perch are more evenly distributed.

Due to poor weather conditions we were not able to conduct any overnight gill net sets for adult yellow perch during 1-30 September, 2012.

Job 101.2: Determine the age composition of angler-caught yellow perch
Objective: Estimate age composition and, if possible, sex composition of angler-caught fish to better parameterize a lake-wide catch-age model.

During 15 May – 6 June, 2012, anal spines were collected from 15 yellow perch harvested by boat anglers using the launch ramp at Waukegan Harbor. We also collected spines from 192 yellow perch harvested by pedestrian anglers at Waukegan and Montrose Harbors, IL during June and August. All yellow perch spines were cleaned, sectioned, and mounted for age determination. Seven spines were eliminated from age analysis due to damage during the preparation process or <75% reader agreement (N = 200). Yellow perch from this subsample ranged in age from 2-14 years and 132 - 367 mm in length (Figure 6). Age 3 – age 5 fish (2009-2007 year-classes) dominated the subsample and collectively comprised over 77% of the catch. Mean total length of age 3 fish was 206 ± 28 mm (SD); age 4 fish averaged 246 ± 33mm TL and mean length of age 5 fish was 263 ± 39 mm.

Job 101.3: Sample pelagic age-0 yellow perch and their food resources in offshore waters
Objective: Monitor the relative abundance of pelagic age-0 yellow perch and their zooplankton prey in offshore waters (≥ 3 miles from shore) of Lake Michigan.

Pelagic age-0 yellow perch and zooplankton were collected at fixed stations about 9 miles offshore of Waukegan, IL on three occasions between 1-30 July, 2012. Pelagic, age-0 fish were collected at the surface (0-2 m) using a 1-m x 2-m fixed frame floating neuston net equipped with 1000-µm mesh. A multi-net, opening/closing 1-m x 1.4-m mid-water Tucker trawl was used to sample pelagic, age-0 fish at the depth range of 2 to 38 m of water. This portion of the water column was separated into 6 depth strata (2-8, 8-14, 14-20, 20-26, 26-32, and 32-38 m) and each of these depth bins was sampled for 30 minutes. Both nets on the mid-water trawl were equipped with 1000-µm nitrex mesh nets. Each depth strata was sampled for zooplankton using replicate vertical hauls of a 0.5 diameter plankton net (64-µm mesh) equipped with an opening/closing mechanism. Fish and zooplankton were preserved in the field and sorted to species, enumerated, and measured in the laboratory. In the lab, fish were identified to species and total length was measured. Zooplankton samples were processed by examining up to three 5-ml subsamples taken from adjusted volumes that provided a count of at least 20 individuals of the most dominant taxa. Zooplankton were enumerated, identified to the lowest taxon possible and measured.

In 2012, only seven larval fish were collected during our sampling efforts: one yellow perch and six bloater. The larval yellow perch and bloater were collected in 8-14 and 20-32 meters of water, respectively. Mean annual crustacean zooplankton density was low, 5.01 ind./L ± 6.66 (std), throughout the study period. Overall, copepod nauplii (52%), calanoid copepods (23%), and cladocerans (18%) represented the majority of zooplankton captured. Bosmina spp. and Daphnia spp. were the most dominant cladoceran taxa present during 2012. The daytime distribution of crustacean zooplankton was heterogeneously distributed among depths and the highest densities were detected on 17 July in 20-26 meters of water (Figure 7).

Job 101.4: Sample demersal age-0 yellow perch and their food resources in nearshore waters
Objective: Determine the relative abundance of demersal age-0 yellow perch and the availability of their macroinvertebrate and zooplankton prey.

A bottom trawl with a 4.9-m head rope, 38-mm stretch mesh body, and 13-mm mesh cod end was used to sample age-0 yellow perch north of Waukegan Harbor. Daytime bottom trawling for age-0 yellow perch was conducted weekly from 2 August – 25 September, 2012 at four depth stations (3, 5, 7.5 and 10 m). Water temperature was also recorded at each depth station. All fish collected were counted and total length was measured to the nearest 1 mm for a subsample (30 individuals per species) of fish. Total effort during 2012 was approximately 110,443 m^2 and 22 age-0 yellow perch were collected; all yellow perch were collected during August. Mean annual CPUE of age-0 yellow perch during 2012 was 20.9 fish/100,000 m^2 (Figure 8).

Thirty-two zooplankton samples were collected at two historical sites near Waukegan Harbor, IL between 9 May – 16 October, 2012. Samples were immediately preserved in 10% sugar formalin. A 64-μm mesh, 0.5-m diameter plankton net was towed vertically from 0.5 m off the bottom to the surface at 10 m depth sites. In the lab, samples were processed by examining up to three 5-ml subsamples taken from adjusted volumes that provided a count of at least 20 individuals of the most dominant taxa. Zooplankton were enumerated, identified to the lowest taxon possible and measured. Mean June-July zooplankton density (includes rotifers and veligers) in 2012 was 14.7 ind./L (Figure 9), which is higher than has been recorded in recent years. This increase is largely attributable to the detection of higher densities of rotifers during this sampling period compared to previous years. Mean June-July (months combined) crustacean zooplankton density was 3.16 ind./L, which continues to be well below the critical density of 10 ind./L suggested for effective foraging of larval yellow perch (Bremigan et al. 2003).

Zooplankton densities varied seasonally with densities of total zooplankton (includes rotifers and veligers) at <6 ind./L during May and June. Densities increased to 27.8 ind./L in July, peaked during August at approximately 45.5 ind./L, and then declined during each subsequent month (Figure 10). Mean monthly crustacean zooplankton density was low during May, June, and July (<5 ind./L), increased to 9.7 ind./L during August and then declined to less than 5 ind./L during September and October (Figure 10). Copepod nauplii dominated the zooplankton assemblage during May whereas rotifers dominated the assemblage during June – October (Figure 11). Copepod nauplii, calanoid copepods and bosmina also contributed significantly to the zooplankton assemblage during this time period. Other cladocerans (e.g. *Polyphemus*, *Ceriodaphnia*, *Leptodora*, *Diaphanosoma*, *Chydoridae*) that were commonly found in samples during 1988-1990 remain either rare or absent in samples.

Benthic invertebrates were collected monthly during August and September in 7.5 meters of water at a site north of Waukegan Harbor. A petite ponar grab (with 232 cm^2 sampling area) was used to collect these samples due to poor conditions for SCUBA divers. During each sampling event, two replicate ponar grabs were collected and preserved in 95% ethanol. Back at the laboratory, all samples were sieved through a 363-μm mesh net to remove sand. Organisms were then sorted from the remaining sediment debris and identified to the lowest taxon possible, typically to genus. Total length (mm) and head capsule width (where applicable) were measured for each individual. All taxa were enumerated and total density estimates were calculated by dividing the total number of organisms counted by the sample area. Based on ponar grabs, mollusks, nematods and oligochaetes dominated the benthic invertebrate community near Waukegan during August and September, but their percent composition varied monthly (Figure 12). Amphipods, chironomids and ostracods were also collected, but in much smaller quantities. Most of the mollusks collected during August and September (76-88%, respectively) were identified as members of Pelecypoda; gastropods (freshwater snails) and members of the bivalve family Sphaeriidae were also present in smaller quantities.

We examined the stomachs of 21 age-0 yellow perch collected during August 2012; two of these stomachs were empty. Mean length of yellow perch used for diet analysis was 53 ± 8 mm TL (SD). Overall, the diet of age-0 yellow perch was dominated by zooplankton (60%) and smaller quantities of benthic invertebrates, which is consist with previous trends. More specifically, age-0 yellow perch primarily consumed copepods, chironomids and smaller quantities of cladocerans (Figure 13). Hydracarina and ostracods were also found in the diet of age-0 yellow perch, but in much smaller quantities (3% of all items). The majority of copepods consumed by age-0 yellow perch were Calanoida spp. (95% of copepods consumed). Chydoridae and Bosmina spp. were the most dominant cladoceran taxa found; small quantities of Daphnia spp. were also present in the diet of some age-0 yellow perch.

Job 101.5: Sample juvenile (age-0 through age-2) yellow perch in nearshore waters
Objective: Collect age-0 yellow perch in nearshore waters in a manner consistent with guidelines developed by the Yellow Perch Task Group's lakewide age-0 yellow perch assessment. Monitor the abundance and diet of juvenile yellow perch.

2012 sampling

To fulfill our commitment to the Yellow Perch Task Group's lakewide age-0 yellow perch assessment, we sampled yellow perch on four occasions during 1 – 31 August, 2012. We fished 10-m gill net panels of 6, 8, 10, and 12 mm mesh, but to achieve gear consistency among the four jurisdictions only yellow perch caught in 6 and 8 mm mesh are reported to the Yellow Perch Task Group. During each sampling event, nets were fished for approximately four hours in 3-10 meters of water at historical sites near Waukegan Harbor, IL. Total effort during August 2012 was 40.8 hours during which we caught 135 yellow perch in 6 and 8 mm mesh and 107 yellow perch in 10 and 12 mm mesh. We also sampled juvenile yellow perch on one occasion during both September and October. Total effort during September and October was 10.0 hours during which we captured 98 yellow perch and 19 fish from other species (mainly round goby). All fish collected in these assessments were processed in the laboratory for size information and a subsample of fish was used for diet analysis. CPUE of yellow perch (all mesh sizes combined) was 6 fish/hr during August, increased to 15 fish/hr in September and then declined to less than 2 fish/hr in October (Figure 14). Yellow perch collected in small mesh gill nets during 2012 ranged from 53-174 mm TL. Mean length of yellow perch caught in 6 and 8 mm mesh panels was 68 ± 19 (SD) and 78 ± 19 mm TL, respectively. Mean length of yellow perch caught in 10 and 12 mm panels was 97 ± 17 and 123 ± 11 mm TL, respectively.

Stomach analysis

We examined the stomachs of a subset of juvenile yellow perch (N=17) collected during 2012. Length of yellow perch used for diet analysis ranged from 55-76 mm TL and mean length was 67 ± 6 mm TL (SD). Overall, the diet of juvenile yellow perch was dominated by zooplankton (83%) and smaller quantities of benthic invertebrates. Cladocerans (mainly Bosmina spp. and smaller quantities of Chydoridae spp.) dominated their diet (Figure 13). Calanoid copepods and chironomids were also found in the diet of these fish, but in much smaller quantities.

Job 101.6: Data analysis and report preparation
Objective: Analyze data and prepare reports, manuscripts and presentations.

Data from the above jobs were processed, analyzed, and summarized. This annual report was prepared from the data.

CONCLUSIONS

Spawning stock

To improve our annual assessment of the yellow perch population we targeted fish in deeper waters (10-20m) with gill nets set during the spring. Unfortunately, poor weather conditions prohibited efforts to sample adult yellow perch during the fall month when sex ratios are more evenly distributed. Mean CPUE was the lowest since implementation of spring gill net surveys in 2007, at 3.7 fish/net night. Despite low relative abundance, catch continued to be dominated by the 2005 year class which comprised over 30% of total catch, followed by the 2006 and 2007 year classes. Overall, lakewide CPUEs show a long-term decline in the abundance of adult yellow perch and current abundance remains well below levels detected in the late 1980s and early 1990s.

Investigation of the female spawning stock in southwestern Lake Michigan from 2007-2012 indicated that fecundity increased exponentially with length. Fecundity ranged from approximately 12,000 eggs for a 178 mm female to over 140,000 eggs for a 336 mm fish. Trending with overall adult CPUE, relative abundance of females in 2012 was significantly lower than 2007-2011. Given the persistent contribution of the 2005 year class to adult CPUE, continued monitoring of the spawning stock will allow for an assessment of fecundity for this year class over time. Additionally, our results indicated that the size distribution of the spawning stock differed considerably on an annual basis. As such, the abundance and size composition of the female spawning stock can potentially impact reproductive potential at the population level. Our data set does support the contention that estimates of population level reproductive potential should account for size composition of spawners rather than spawner biomass alone.

To determine the age structure of yellow perch harvested by boat anglers, anal spines were collected from fish at the Waukegan launch ramp between mid-May and early June. Fish harvested by boat anglers during 2012 ranged from 4-10 years old and data collected since 2008 (previous segments of F-123R) indicates that this harvest is skewed towards larger females. Yellow perch spines were also collected from pedestrian anglers at Waukegan and Montrose harbors during the spring with 92% of harvested fish coming from Montrose harbor. Pedestrian angler harvest ranged from age-2 through age-14; however 82% of yellow perch harvested were age-3 through age-5. Overall, sport anglers (boat and pedestrian combined) primarily harvested yellow perch from the 2007-2009 year-classes and fish from these year classes will be extremely important for future spawning and should be protected.

2012 Year class

CPUE of age-0 yellow perch collected in bottom trawls during 2012 was low compared to that detected during 2005 and 2010. Previously, relatively high CPUE in 1998 led to a comparatively strong year class as seen by its dominance in LMBS 2000-2004 fyke netting (previous segments of F-123-R). A similar pattern occurred with the 2002 and 2005 year classes. Both of these year classes were caught in relatively high abundance at age-0 and were detected at significant levels in our adult assessments by age 4. The 2002 year class contributed significantly to adult assessments and angler catches during 2006-2008 and 2009 was the first year the 2005 year class dominated both our adult assessment and sport harvest collections (previous segments of F-123-R). These results suggest that strong CPUE of age-0 yellow perch is a reasonable indicator of recruitment success. Thus, because CPUE levels were higher in 2010 compared to during 1998, within a couple years hopefully the 2010 year class will appear more readily in our adult assessments as we saw with the 1998, 2002 and 2005 year classes. Despite all this, yellow perch year class strength remains very erratic from year to year and recent CPUEs are extremely low compared to sampling in the late 1980s (1987 and 1988). So even with measureable year classes in 2002, 2004, 2005, and 2010, their levels were nowhere near that of the late 1980s; as such, they probably are not sufficiently strong to support extensive fishing pressure.

The forage base available to young yellow perch has changed in species composition and abundance over the last several decades, and many of these changes are linked to exotic species invasions. Mean zooplankton densities were significantly higher during 1988 in comparison to 1989-1990 and 1996-2012 (Dettmers et al. 2003, previous segments of F-123-R). Zooplankton densities since 1996 have barely reached even half of the densities found during the late 1980s when multiple strong year classes were produced. These shifts within the zooplankton community may be related to the establishment of several recent invaders. The spiny water flea (*Bythotrephes longimanus*) was first detected in Lake Michigan during 1986 and was established in offshore waters lake-wide by 1987 (Barbiero and Tuchman 2004). Barbiero and Tuchman (2004) attributed a dramatic reduction in several native cladocerans species to the establishment of this exotic cladoceran in offshore waters of Lake Michigan. Declines in once dominant benthic macroinvertebrate groups such as *Diporeia*, cladocerans and sphaeriids in nearshore waters of Lake Michigan are attributed to bottom-up effects of decreased phosphorus loading during 1980-1987 and continued declines of *Diporeia* coinciding with the invasion of zebra mussels during the 1990s (Madenjian et al. 2002) and quagga mussels during the early 2000s (Nelepa et al. 2009). Dreissenid mussels have drastically reduced phyto- and zooplankton levels (Vanderploeg et al. 2012) and altered the abundance of benthic macroinvertebrates in the Great Lakes (Leach 1993; Stewart et al. 1998). The presence of these invaders and other exotic species have had major impacts on the food web and may exacerbate and alter the complex set of factors that affect yellow perch year-class strength. Over the last three decades, yellow perch year class strength has been linked to zooplankton availability for first feeding larvae (Dettmers et al. 2003; Redman et al. 2011b). Foraging success of yellow perch larvae in Green Bay was poor when zooplankton density dropped below 10 ind./L (Bremigan et al. 2003) and June-July zooplankton densities in six of the last ten years have been at or below this level within Illinois waters of Lake Michigan. Our results indicate higher densities of rotifers during June and July compared to previous years. While rotifers may be preyed upon by newly hatched yellow perch larvae (Fulford et al. 2006) prolonged consumption may result in reduced growth and survival (Graeb et al. 2004). Thus, continued monitoring of nearshore zooplankton and benthic invertebrate densities is needed to further explore the role of food availability in yellow perch recruitment success.

Juvenile yellow perch

Relative abundance of juvenile yellow perch sampled in small mesh gill nets was greatest during September at 15 fish/hr. Peak CPUE was similar to 2011, however, in 2011 maximum relative abundance occurred in August. Age-0 yellow perch return to the benthic nearshore areas during fall months when they possess sufficient swimming capabilities or favorable winds are present (Weber et al. 2011). Observed peaks in CPUE during September in 2012 and August in 2011 may correspond with the return of age-0 yellow perch to benthic nearshore habitats. During ontogeny yellow perch undergo several diet shifts from zooplankton to benthic invertebrates and when gape becomes large enough, to piscivory (Creque and Czesny 2011). Diets of juvenile yellow perch were comprised primarily of zooplankton, and to a lesser extent, benthic invertebrates. Assessing the age structure and diets of juvenile yellow perch sampled from small mesh gill nets will allow us to examine variability in return of age-0 yellow perch to benthic nearshore areas as well as factors influencing growth, which may be crucial for future survival beyond the first growing season. Integrating these results with other sampling efforts will allow us to capture a complete view of yellow perch life history in Illinois waters of Lake Michigan.

Management Implications

In summary, the fishable yellow perch population was supported by multiple consecutive year classes (2005-2008) with the 2005 year class being the dominate age group. Our 2012 sport harvest data suggests that anglers primarily harvested fish from the 2007-2009 year classes. There is a need to protect all these year classes (2005-2009) so that they can reach their full reproductive potential. Our data continue to show evidence that the Lake Michigan yellow perch population is supported by multiple year classes. However, poor recruitment during 1999-2001, 2008-2009 and 2011 taken with the continued trend of low abundance of adult yellow perch throughout Lake Michigan (Makauskas and Clapp 2010) raises concerns about the growth and survival of yellow perch. Our long-term data still clearly demonstrate that recruitment is highly variable and low when compared to recruitment during the 1980s. Thus, it remains important to conserve the adult stock to the greatest degree possible so that the spawning stock can reach full reproductive potential and their offspring can take advantage of beneficial recruitment conditions when they occur. Given the current population characteristics, management for limited harvest is necessary to protect the future of the Lake Michigan yellow perch population.

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TABLES

Table 1. Linear regression equations describing the relationship between female total length and fecundity of yellow perch collected in gill nets during 2007-2012.

Year	No. Ovaries	Slope (α)	Intercept (β)	P-value	Adj. R^2
2007	13	3.921	-4.925	<0.001	0.87
2008	75	3.500	-3.936	<0.001	0.83
2009	104	3.120	-3.153	<0.001	0.92
2010	105	3.768	-4.502	<0.001	0.92
2011	42	3.345	-3.517	<0.001	0.79
2012	10	3.336	-3.416	<0.001	0.95

FIGURES

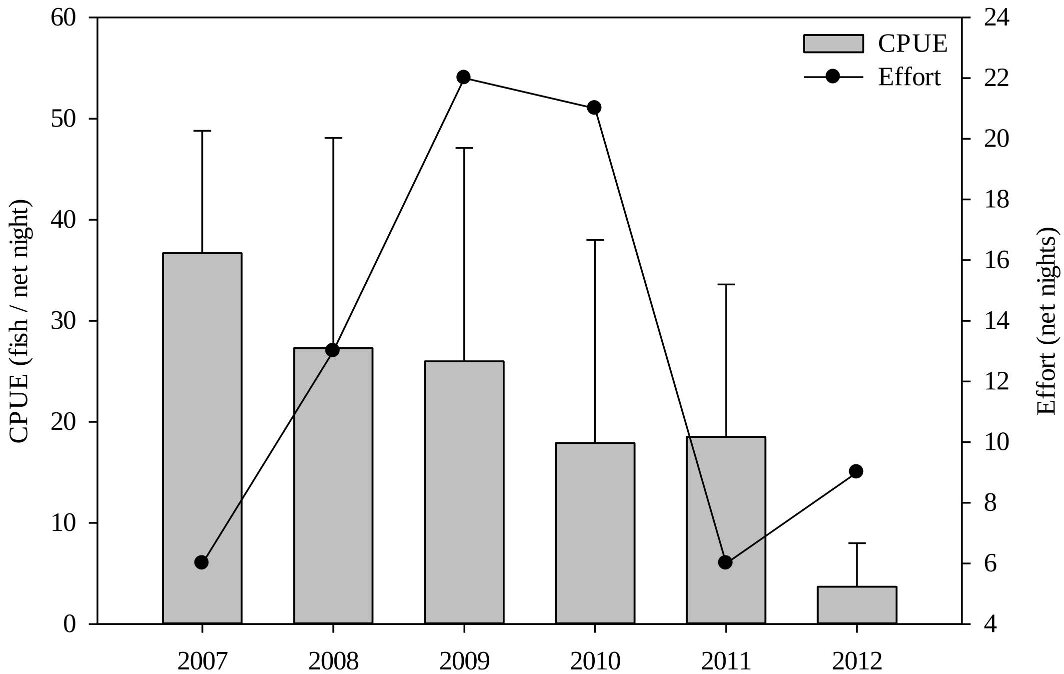

Figure 1. Annual mean CPUE (+ 1 SD) of yellow perch collected in gill nets at Waukegan and Lake Forest, Illinois during spring 2007-2012.

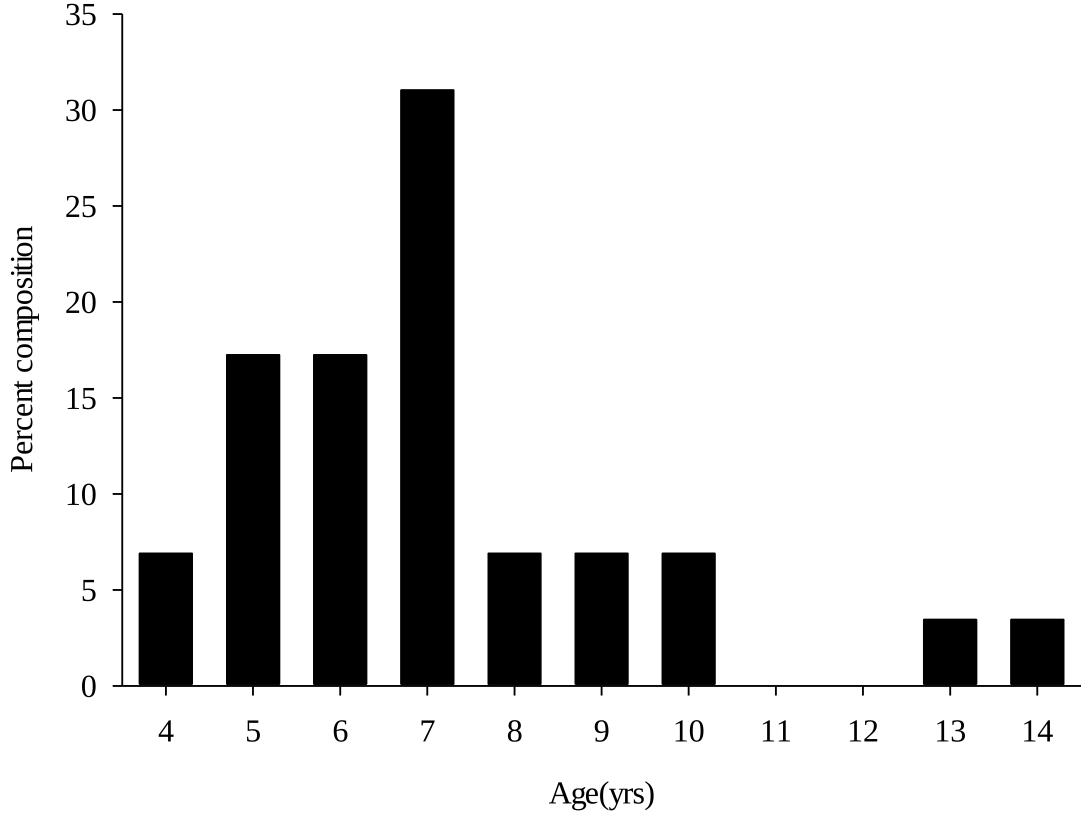

Figure 2. Age composition of adult yellow perch collected using gill nets at Waukegan and Lake Forest, IL during the spring of 2012.

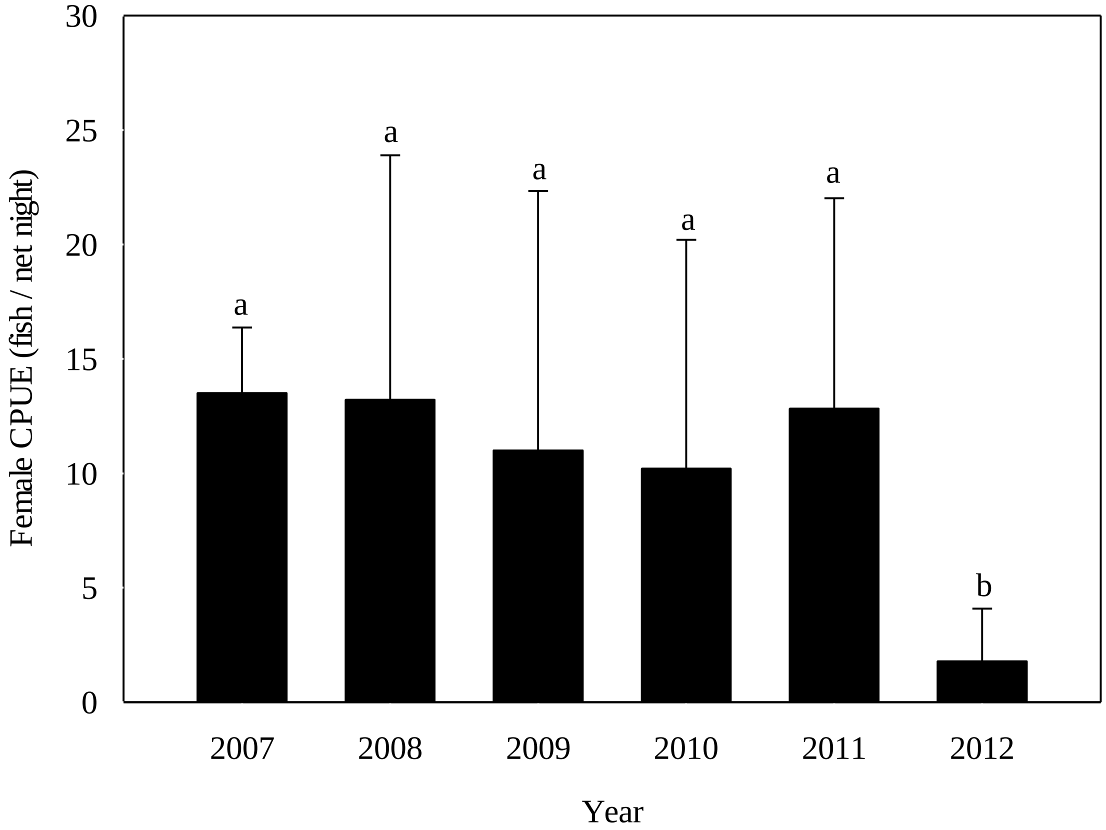

Figure 3. Mean CPUE (+ 1 SD) of gravid female yellow perch collected in gill nets at Waukegan and Lake Forest, Illinois during spring 2007-2012. Letters denote annual CPUE differences.

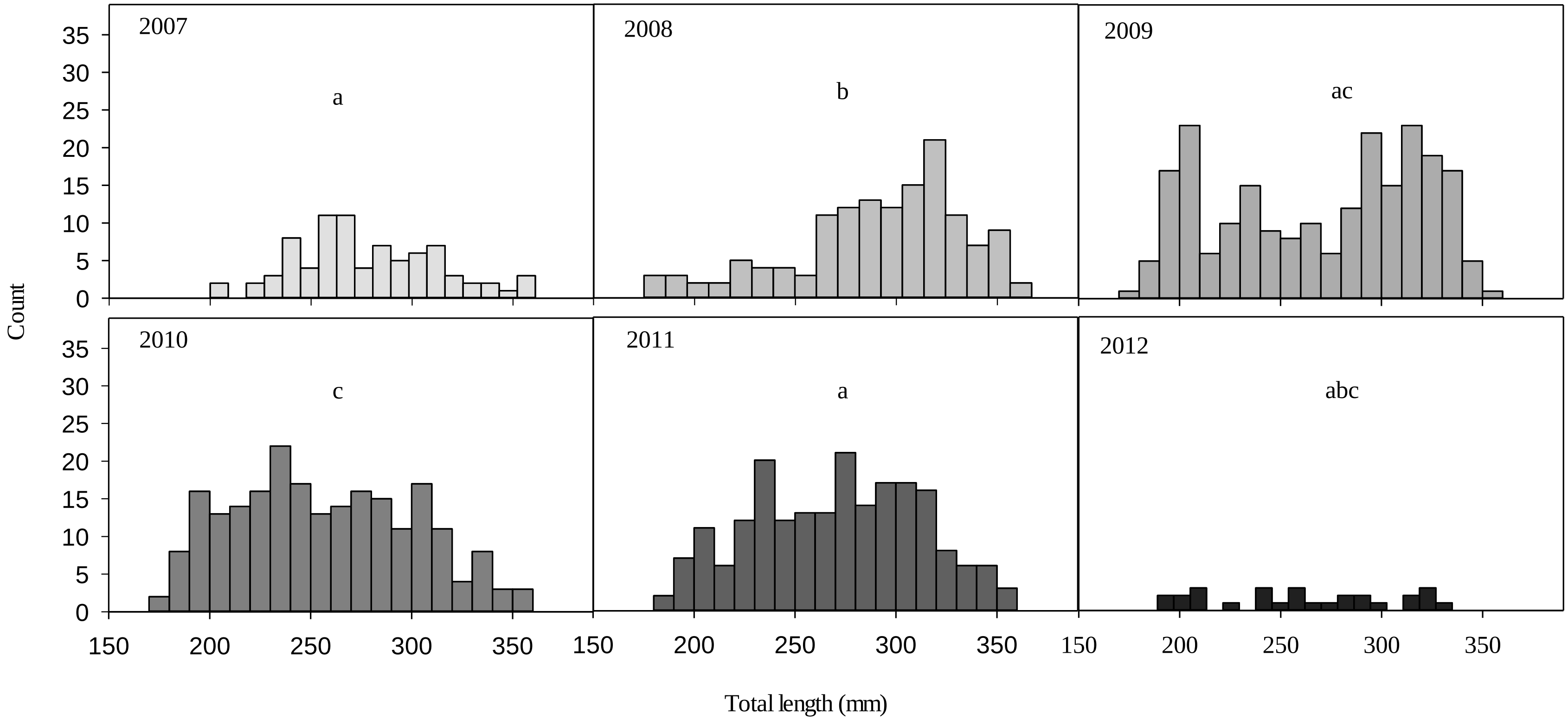

Figure 4. Annual length distributions of gravid female yellow perch collected during 2007-2012 using gill nets at Waukegan and Lake Forest, IL. Length distributions with different letters were significantly different.

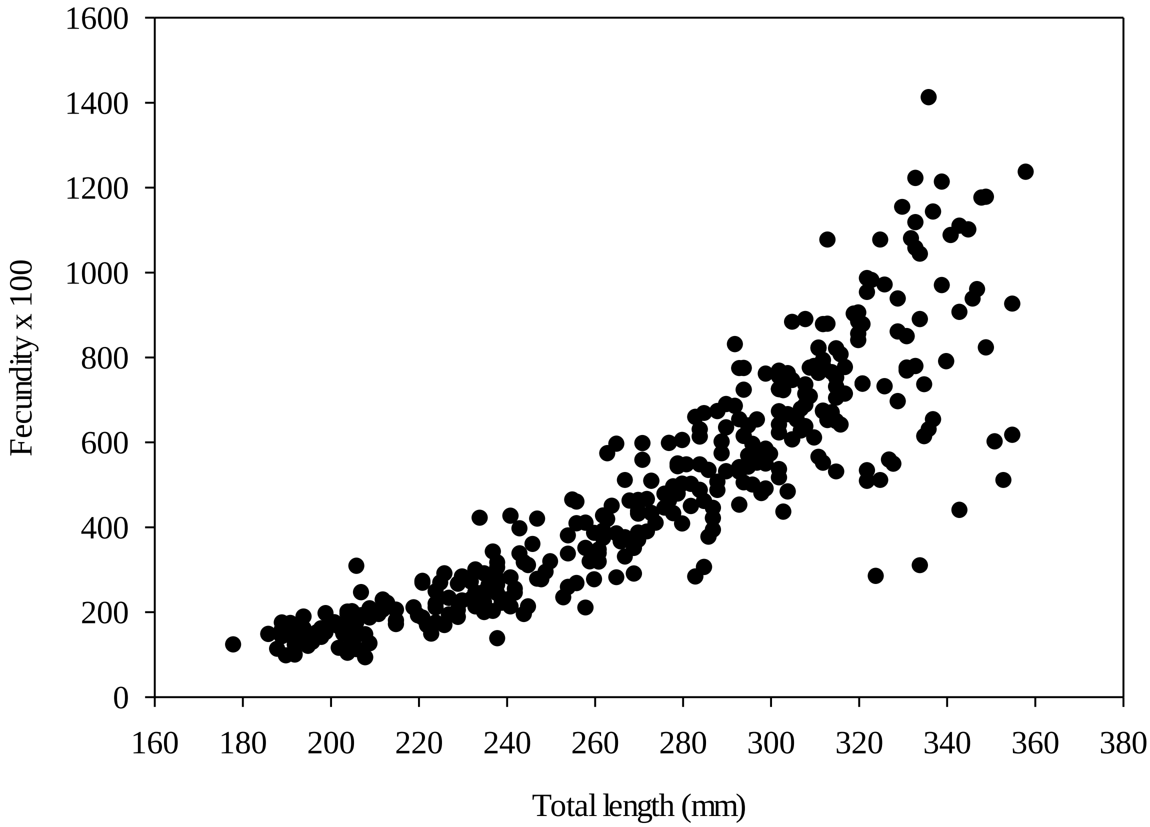

Figure 5. Relationship between total length and fecundity of yellow perch collected in gill nets during 2007-2012.

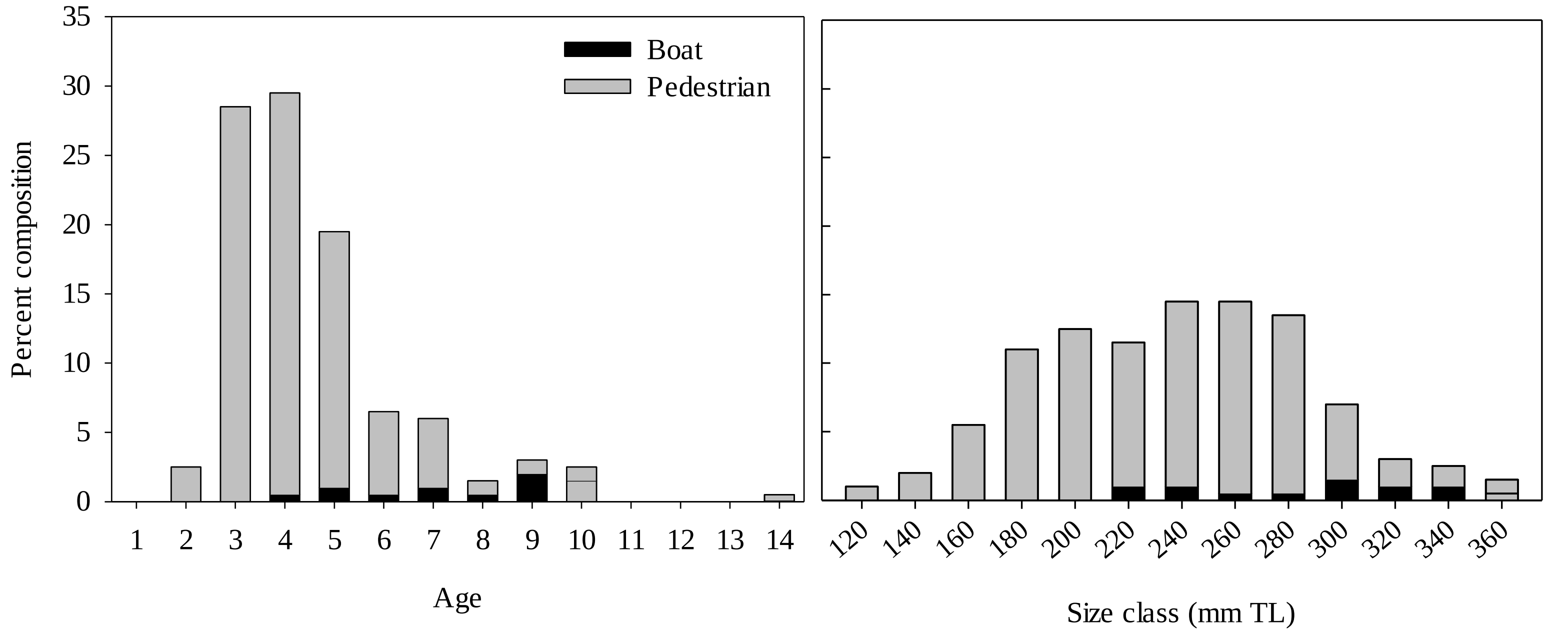

Figure 6. Age and length distributions of yellow perch harvested by boat anglers using the launch ramp at Waukegan Harbor and pedestrian anglers at Waukegan and Montrose Harbors during 2012.

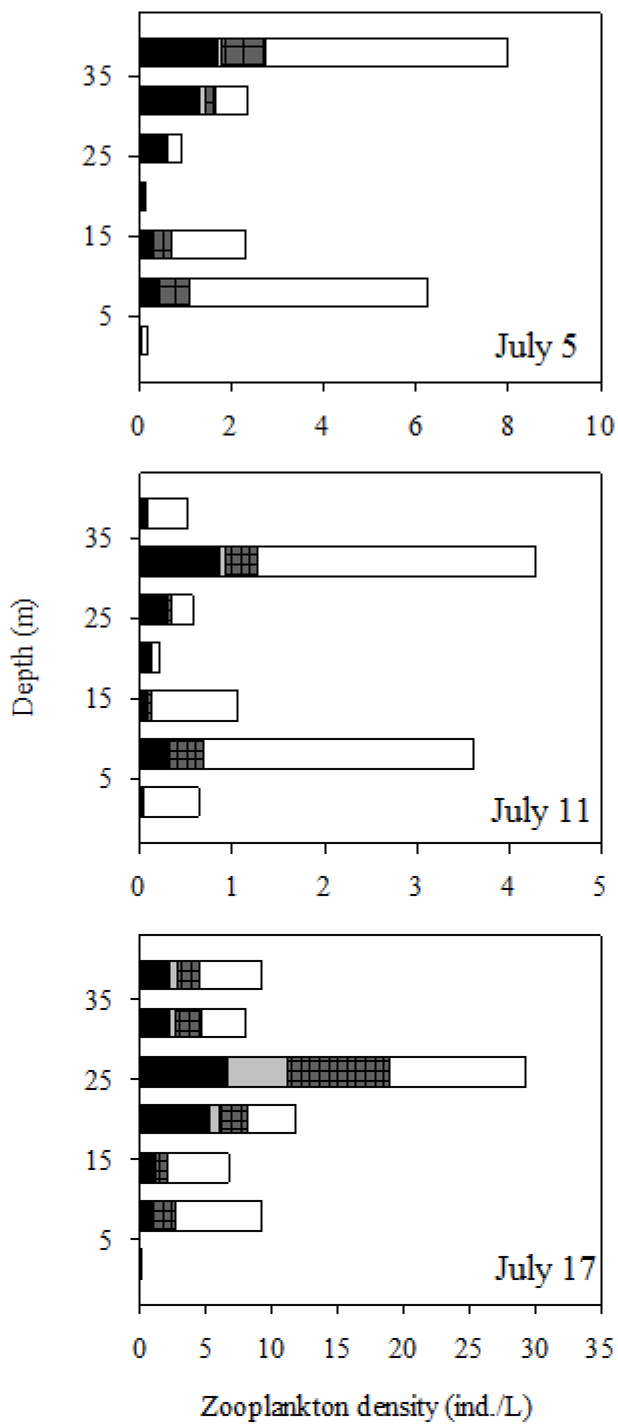

Figure 7. Vertical distribution of crustacean zooplankton collected 9 miles offshore of Waukegan during each sampling event in 2012. Bar colors represent the composition of each zooplankton group: calanoid copepods (black), cyclopoid copepods (grey), copepod nauplii (white), cladocerans (dark grey, cross-hatched).

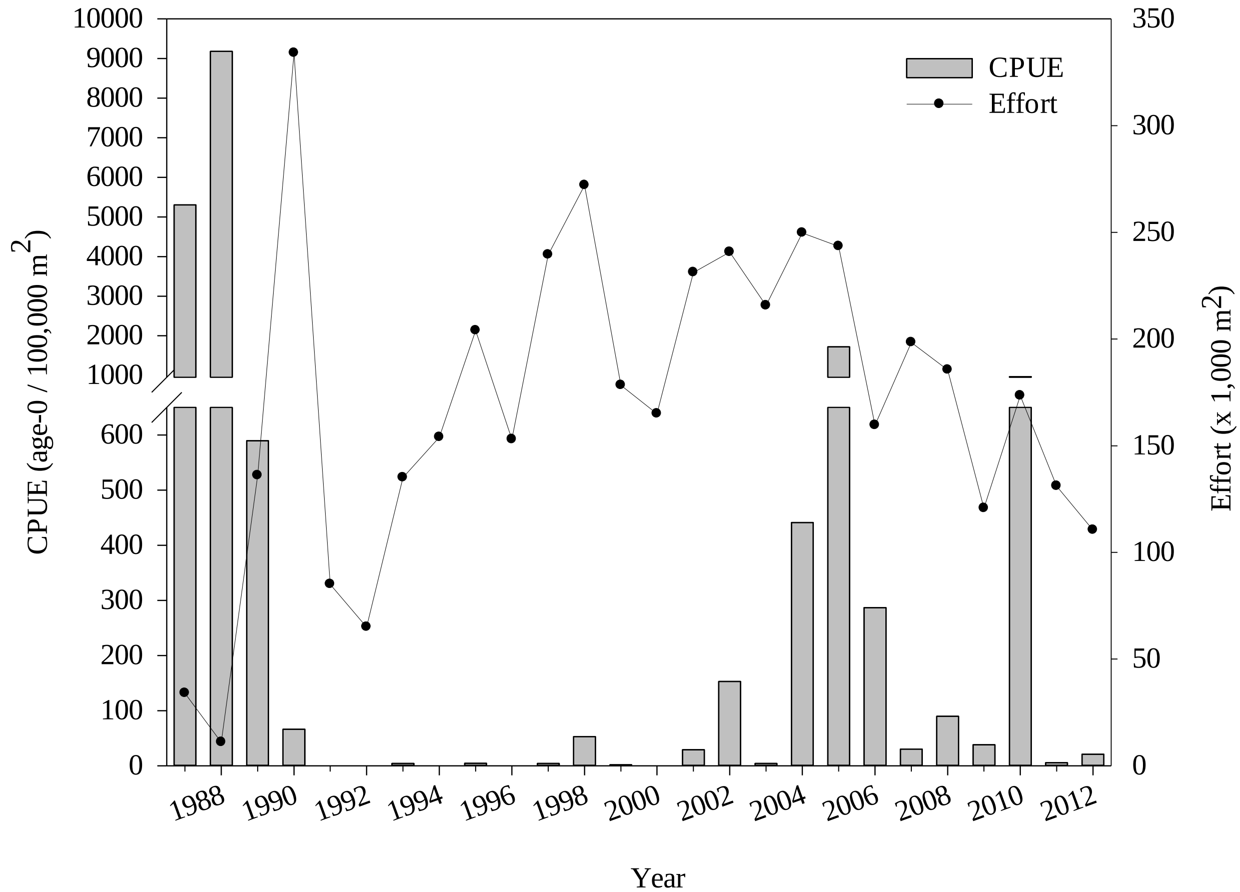

Figure 8. Relative abundance of age-0 yellow perch collected by daytime bottom trawls north of Waukegan Harbor, IL during 1987-2012.

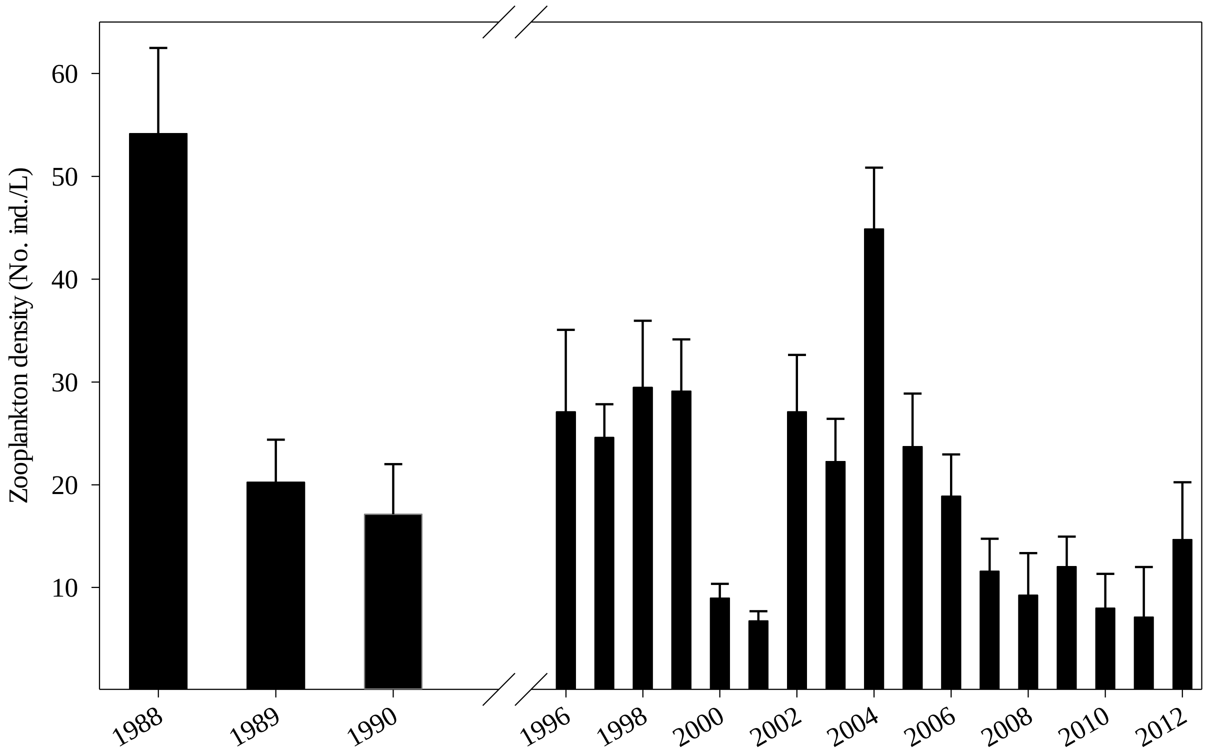

Figure 9. Mean density of zooplankton (+ 1 SE) present in Illinois waters of Lake Michigan near Waukegan during June-July for years 1988-2012.

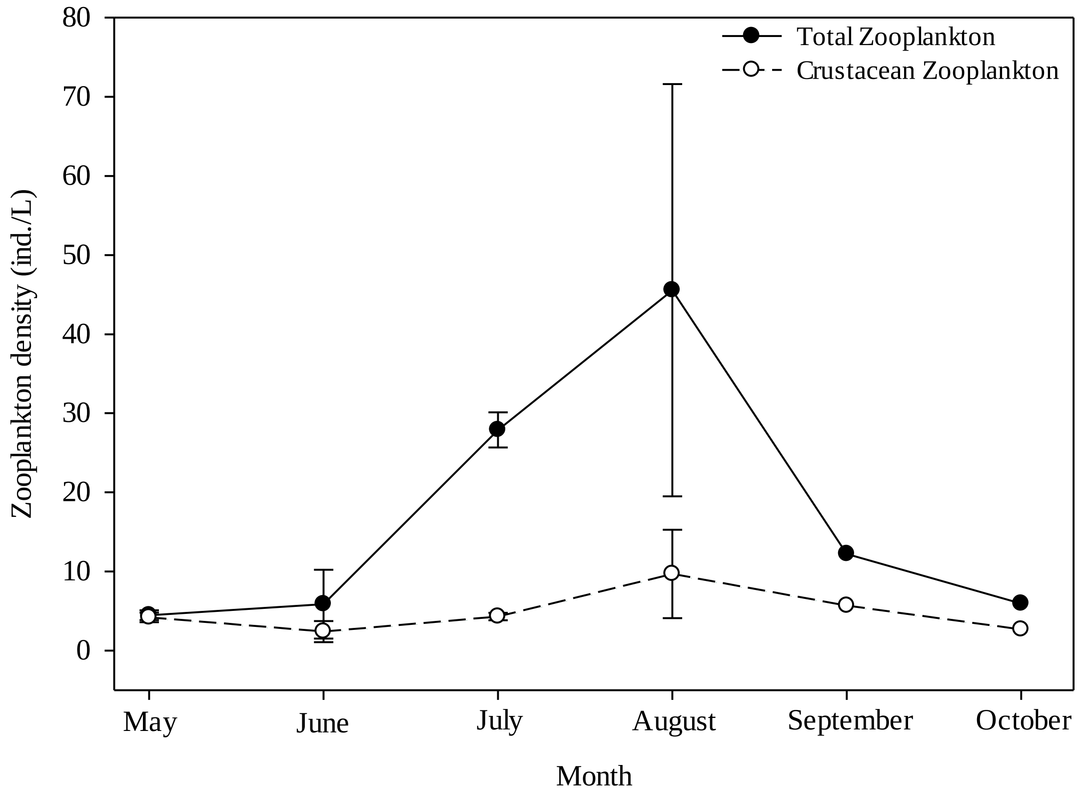

Figure 10. Mean monthly zooplankton density (± 1 SD) in nearshore Illinois waters of Lake Michigan near Waukegan during May – October, 2012. Closed circles (●) represent total zooplankton, whereas open circles (○) represent crustacean zooplankton.

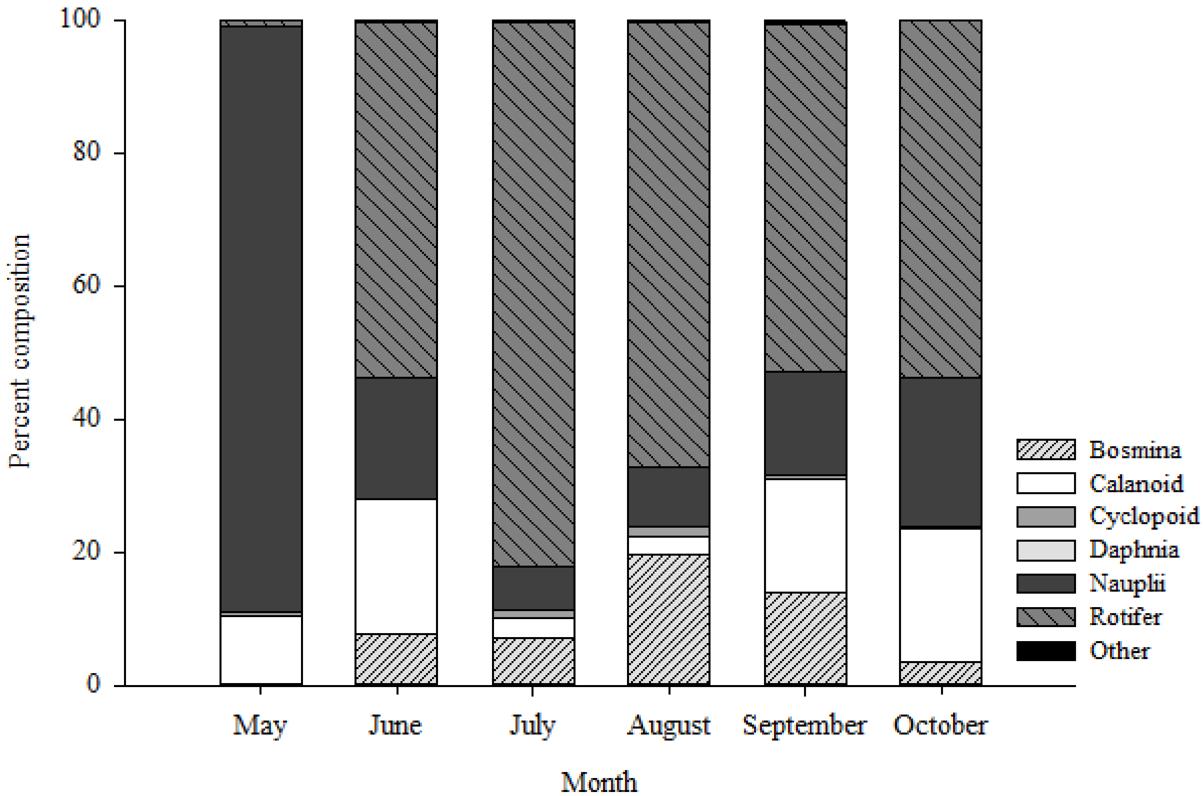

Figure 11. Monthly percent composition of zooplankton found in nearshore Illinois waters of Lake Michigan near Waukegan during May – October, 2012.

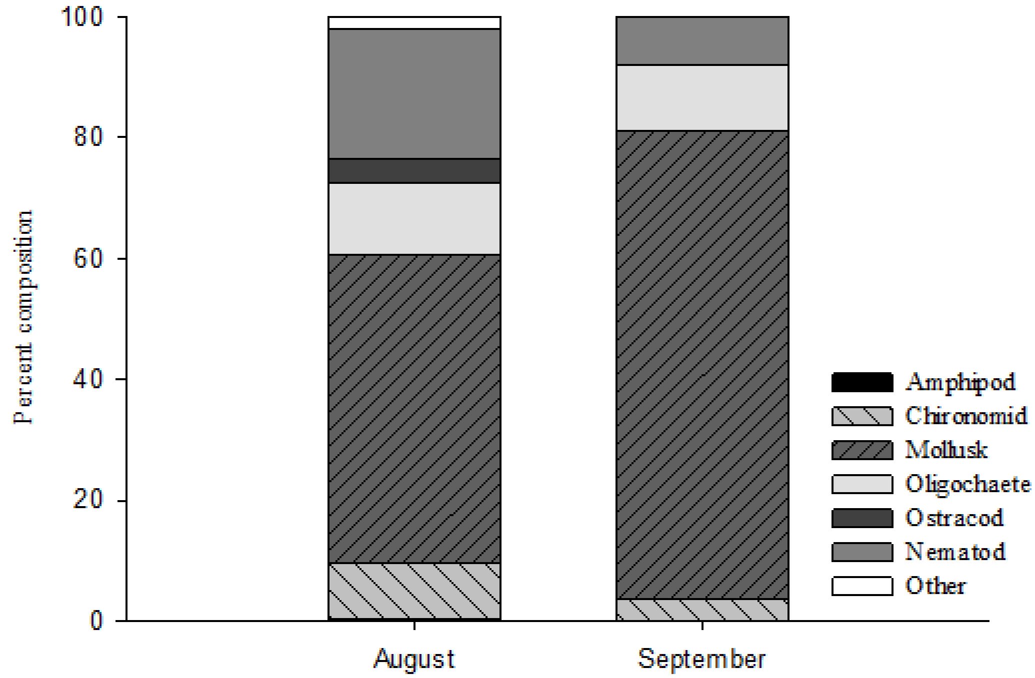

Figure 12. Percent composition of benthic invertebrates found in Lake Michigan substrate near Waukegan using a ponar grab during August and September, 2012.

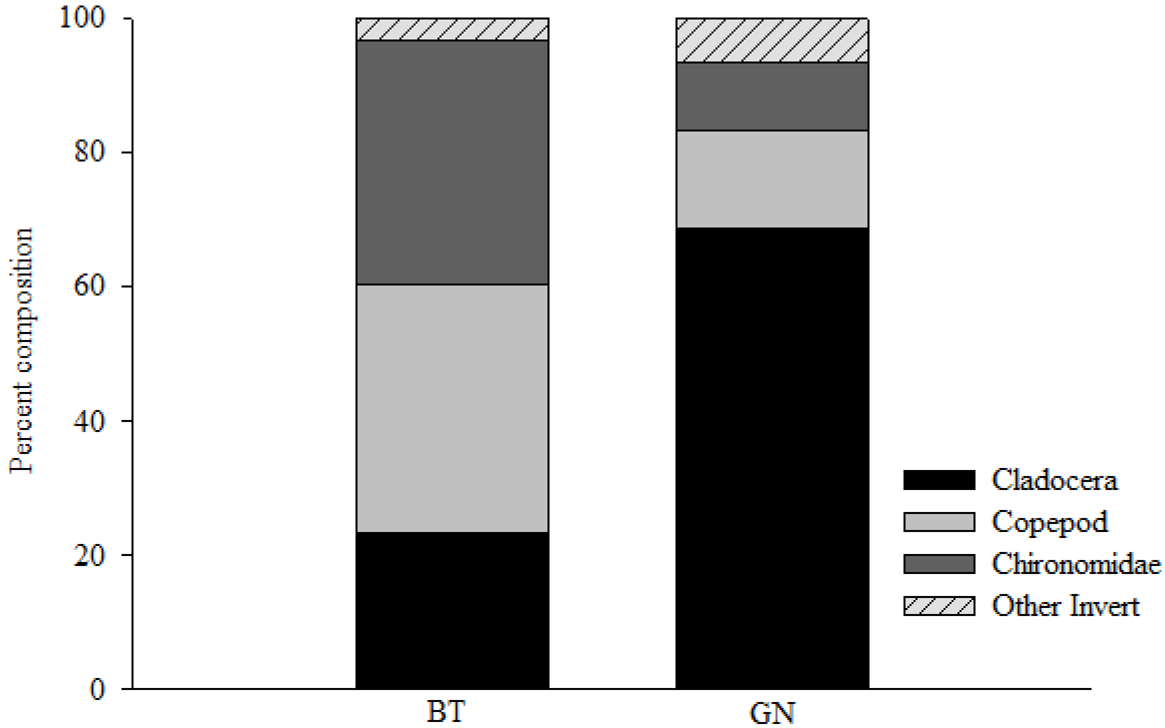

Figure 13. Diet composition of age-0 yellow perch collected in a bottom trawl (BT) and a subsample of juvenile yellow perch collected in small mesh gill nets (GN) near Waukegan Harbor, IL during 2012.

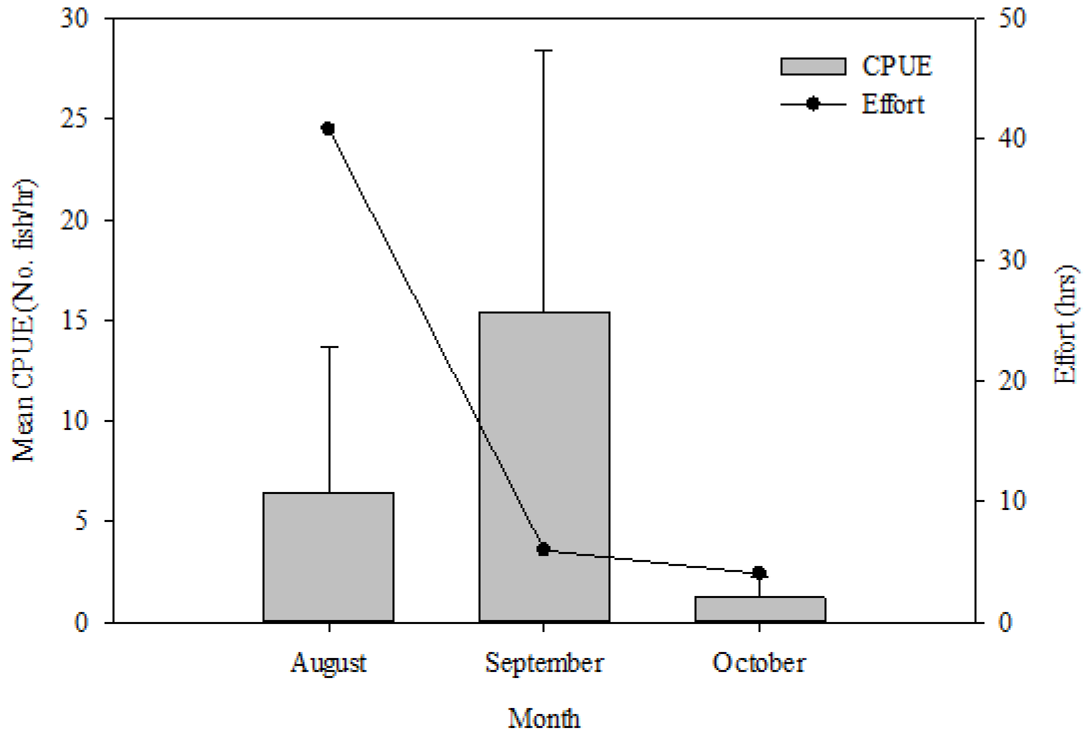

Figure 14. Mean monthly CPUE (+ 1 SD) of yellow perch collected in small mesh gill nets fished in 3-10 meters of water near Waukegan Harbor, IL during August - October, 2012.