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Spring and Autumn Fish Density, Biomass, and Diets in Michigan and Ontario Waters of the Western Basin of Lake Erie*

Patrick M. Kocovsky, William H. Edwards, Michael J. Porta,
Martin A. Stapanian, and Michael T. Bur
U.S. Geological Survey, Great Lakes Science Center
Lake Erie Biological Station, 6100 Columbus Avenue
Sandusky, OH 44870, USA

Abstract -- The Lake Erie Biological Station completed its fifth consecutive year of a collaborative, multi-agency assessment of forage fish populations throughout the western basin of Lake Erie in 2008. The objectives of this evaluation were to provide estimates of densities and biomasses of forage fishes throughout the western basin of Lake Erie to the interagency database for assessing seasonal and spatial distributions of forage fishes and to assess year class strength of key forage and predator species. We sampled 25 stations in Ontario and Michigan waters of the western basin of Lake Erie with bottom trawls in June and September 2008. We calculated density (number/ha) and biomass (kg/ha) of all forage fishes. We also examined stomach contents from white perch *Morone americana* and yellow perch *Perca flavescens*. Most species had strong year classes in 2008 following several consecutive weaker year classes. Freshwater drum *Aplodinotus grunniens* and rainbow smelt *Osmerus mordax* had the strongest year classes of the time series. We captured several individuals of the invasive tubenose goby *Proterorhinus marmoratus* at four sites near the mouth of the Detroit River, which may signal a range expansion. Diets of yearling and older yellow perch in 2008 were dominated by macroinvertebrates in both spring and autumn. White perch diets were dominated by zooplankton in June and macroinvertebrates and fish equally in September. Unlike the trend exhibited during 2005-2007, autumn diets of both species exhibited a decrease in the proportion of fish and an increase in the proportion of zooplankton during 2008. Recent analyses of other USGS data sets have underscored the value of nighttime sampling for indices of abundance of yellow perch and walleye. We will explore the possibility of adding nighttime sampling to our western basin program in the future.

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Introduction

The United States Geological Survey's (USGS) Lake Erie Biological Station has participated in a collaborative, multi-agency effort to assess forage fish populations in the western basin of Lake Erie since 2004. The primary long-term objective of the bottom trawl assessments is to contribute estimates of forage fish density and biomass to the interagency database for assessing seasonal and spatial distributions of forage fishes. The short-term objective is to estimate year-class strength of key forage and predator species. Indices of abundance of yellow perch *Perca flavescens* are provided to the Yellow Perch Task Group of the Lake Erie Committee of the Great Lakes Fishery Commission to estimate total allowable catch. Our data augment those collected by the Ontario Ministry of Natural Resources (OMNR) and the Ohio Department of Natural Resources (ODNR), who have cooperatively sampled forage fishes throughout the western basin of Lake Erie in August since 1987. Prior to 2004 most sites sampled by the USGS had been sampled either in August only (Ontario waters) or not at all (Michigan waters). The 2008 season was the fifth consecutive year of this collaboration.

We present estimated density and biomass of young-of-year (YOY) and yearling-and-older (YAO) forage fishes in the western basin of Lake Erie in June and September 2008 and trends in density and abundance of key species over the entire time series. We also present data on diets of yellow perch and white perch *Morone americana* collected at our trawl sites. These data augment our data on yellow perch and white perch diets at our East Harbor site, which have been collected for several years (e.g., Bur et al. 2008).

Methods

Trawling

Sampling sites in Ontario waters of the western basin of Lake Erie were selected from those sampled by OMNR in August. We sampled 19 sites in Ontario waters (Figure 1), which is about 55% of the sites sampled by OMNR in the western basin, and six sites from Michigan waters. Sites were sampled in two depth strata, ≤ 6 m (6 sites) and > 6 m (19 sites). Spring samples were collected during 9 - 11 June 2008. Autumn samples were collected during 22 - 24 September 2008. We used a 7.9-m (headrope) semi-balloon bottom trawl for all sampling. Prescribed trawling time was 10 minutes. We used NOTUS acoustic net mensuration gear (mention of a brand name does not imply endorsement by the U.S. Government) during 16 trawl samples in autumn to measure the horizontal opening of the net for estimating area trawled.

For small trawl catches, all fish were identified to species and enumerated. For large trawl catches (generally more than 1,000 fish), the number of individuals was estimated using a weight-based subsampling method. The entire catch, except larger individuals which were removed and enumerated and weighed by species prior to subsampling, was weighed and then a subsample of fish was weighed. All fish in the subsample were identified to species and enumerated. For each species, the total number of fish in the entire sample was estimated by multiplying the number of fish in the subsample by the ratio of the weight of the subsample to the weight of the entire sample. Subsamples of forage fish were placed on ice for examination in the laboratory. In the laboratory, a maximum of 30 fish of each species and age group were measured for total length (nearest mm), and weighed (nearest 0.01 g). Weights were not measured for YAO of predatory species.

For each trawl sample, we calculated density of each species and age group by dividing the number of fish of each species and age group captured in a trawl sample by the area swept by the trawl. Age group was determined using age-length keys for species in the western basin developed from historical ODNR samples. For all species except round goby *Neogobius melanostomus*, separate density and biomass estimates were made for YOY and YAO. All ages were combined for round goby, owing to difficulty in determining age based on length alone. Area swept was calculated as width of the trawl opening multiplied by the distance towed. The distance towed was estimated from the difference in starting and ending latitude and longitude. The average density of each species was calculated as the arithmetic mean of all samples within a season and was expressed as number per hectare (ha). Biomass for a species and age group was calculated for each trawl sample by multiplying average weight for a species and age group by the average density and was expressed as kilograms per ha.

Yellow perch and white perch diets

In both seasons, we removed stomachs from a maximum of five YAO yellow perch and five YAO white perch at each trawl station. Stomachs were removed and frozen in the field. In the laboratory, prey items were identified to the family, genus, or species depending on the taxon and degree of digestion, enumerated, and measured for total length. Diet data were reported as frequency of occurrence by species and by season and year. Only stomachs that contained food items were included in the analysis. We compare frequency of occurrence of zooplankton, benthic macroinvertebrates, and fish in the spring and autumn diets for yellow perch and white perch collected on this survey during 2005-2008 (Bur et al. 2007; Kocovsky et al. 2007, Kocovsky et al. 2008).

Results

Trawling

All 25 sites were successfully sampled in spring and autumn. Trawling was interrupted at one site each in spring and autumn owing to the net becoming snagged on bottom debris. In both cases the haul was repeated and a sample was obtained. All trawls were the prescribed 10-minutes in duration except one site in autumn east of Pelee Island, which was shortened to 5 minutes owing to the net becoming snagged on bottom debris on three consecutive attempts. Vessel speed averaged 2.0 kts and was not different among seasons (t-test of means, $t_{0.05, 48} = 0.3$, $P = 0.77$).

NOTUS net mensuration gear was used at 16 of 25 sites sampled in autumn (six sites < 6 m, 10 sites > 6 m depth). The grand mean of the horizontal net opening was 5 m (range 3.4 m - 5.6 m). The net opening did not vary with depth (t-test of means, $t_{0.05, 14} = 1.2$, $P = 0.25$). The net opening was slightly less at greater vessel speeds, but the overall trend was not significant (least-squares linear regression, $F_{1, 14} = 0.33$, $P > 0.1$). Given the similar vessel speed across seasons we applied the 5-m net opening to spring samples as well as autumn samples for estimating area trawled.

Several species had excellent reproductive success in 2008. Freshwater drum *Aplodinotus grunniens*, rainbow smelt *Osmerus mordax*, and round gobies had their highest densities (Table 1) and biomasses (Table 2) of the time series and large percentage increases over the previous year. Increases in densities were greater than an order of magnitude for YOY freshwater drum and rainbow smelt and for all ages of round goby. Yellow perch also had good reproductive success and its highest density of the time series, but a lesser percentage increase over previous years. White perch and gizzard shad *Dorosoma cepedianum* also had good reproductive success, although lesser increases over previous years. Walleye *Sander vitreus* reproductive success was moderate. Two other native species, white bass *Morone chrysops* and trout-perch *Percopsis omiscomaycus* had poor reproductive years. Both had low density and biomass for the time series. Total lengths of most species were typical for the time series (Table 3). During autumn sampling we captured nine unusual gobies, which we tentatively identified using external morphological characters as tubenose goby *Proterorhinus marmoratus*. All nine tubenose gobies were captured at the three northern-most sites in Michigan waters and at the western-most site in Ontario waters near the outflow of the Detroit River (Figure 1).

Diets

We found food items in 94% of yellow perch stomachs (n = 46) collected in spring. Benthic macroinvertebrates were consumed more frequently (86%) than zooplankton (30%) and fish (23%; Figure 2). We found Chironomidae in 47% of yellow perch stomachs with *Hexagenia sp.*, *Trichoptera sp.*, and *Dreissena sp.* among other benthic macroinvertebrates found less frequently (35%, 33%, and 30%, respectively). *Leptodora kindtii* was the most frequently consumed zooplankton (26%) by yellow perch collected during spring. We also found *Daphnia retrocurva* in three stomachs. Round goby was the most frequently consumed fish (12%) in spring.

During autumn, we found food items in 70% of yellow perch stomachs (n = 94). Benthic macroinvertebrates were found in 68% and fish in 41% of yellow perch stomachs collected in autumn (Figure 2). Zooplankton were nearly absent from autumn diets occurring in only 4 of 94 (4%) of stomachs we examined. The most frequently occurring benthic macroinvertebrates were *Dreissenia sp.* (38%), *Hexagenia sp.* (23%), and Chironomidae (12%). Unidentified fish occurred most often (21%) among fish consumed by yellow perch in autumn. We also found round goby and gizzard shad, although less frequently (15 % and 11%, respectively). *Bythotrephes sp*. was the only zooplankton taxon we found in autumn diets of yellow perch.

Percent composition of zooplankton in spring yellow perch diets has declined steadily since 2005 (Figure 2). Zooplankton has been absent or nearly so from autumn diets since 2006. Although the frequency of occurrence of fish in autumn diets of yellow perch increased from 2005 to 2007 (Kocovsky *et al*. 2007; Figure 2), the percentage of fish in 2008 decreased from 55% in 2007 to 41% in 2008. Benthic macroinvertebrates have been the most frequently consumed prey item during autumn since 2005 and since 2007 in the spring.

We identified prey items in 85% of white perch stomachs (n = 41) collected in spring. Spring white perch diet was dominated by zooplankton (76%) and benthic macroinvertebrates (41%; Figure 3). *Leptodora kindtii* was the most commonly consumed food item (61%), followed by *Daphnia retrocurva* (49%), Chironomidae (29%), and *Hexagenia sp* (15%). Unidentified fish and emerald shiner *Notropis atherinoides* represented the only fish species identified in the spring diets.

We identified prey items in 79% of the white perch stomachs (n = 19) collected in autumn. Unlike spring diets, autumn white perch diets were dominated by fish (53%) and benthic macroinvertebrates (41%, Figure 3). Of the fish species identified, round goby occurred most often (20%) followed by emerald shiner (13%), and unidentified fish. *Hexagenia sp.* (33%) occurred the most frequently of all diet items. Only two zooplankton species, *Bythotrephes longimanus and Leptodora kindtii*, were present in the autumn diet.

With the exception of 2006, zooplankton has been the most prevalent food item in the spring diets of white perch, followed by benthic macroinvertebrates and fish (Bur et al. 2006; Kocovsky et al. 2007, 2008; Figure 3). The occurrence of benthic macroinvertebrates in spring white perch diets has declined since 2006. Autumn white perch diets showed a decrease in zooplankton and an increase in fish from 2005 through 2007 (Kocovsky *et al*. 2008; Figure 2). Continued collection of white perch and yellow perch diets will allow for a more detailed analysis of diet trends in future years.

Discussion

Overall, reproductive success of forage and predator species was good compared to previous years in our time series. Several native, non-native, coolwater, and warmwater species had strong year classes. This contrasts to previous years when coolwater species had good reproductive success while warmwater species had poorer reproductive success (Kocovsky *et al*. 2008) or vice-versa (Kocovsky *et al*. 2007). Several species that had consecutive years of poor reproduction prior to 2008 rebounded. Among those, freshwater drum and rainbow smelt had particularly successful reproduction. The apparent success of the 2008 year class of freshwater drum follows two successive poor year classes following introduction of the virus that causes viral hemorrhagic septicemia (VHS). We observed fewer dead or dying freshwater drum with external evidence of VHS in 2008 than the previous two years, which may partially explain improved reproductive success. The apparently strong rainbow smelt year class is unusual because this species is typically rare in western Lake Erie.

Beginning with 2008 data, we are expanding the products of this sampling program to include an index of yellow perch abundance for use in estimating abundance of age-2 perch and in projecting harvest quotas. Index values will be provided to the Yellow Perch Task Group for inclusion in their report annually. The index of abundance from our East Harbor sampling program (Bur et al. 2008) has been a reliable predictor of abundance of age-2 yellow perch used in estimating recommended allowable harvest. We expect the index from our basin-wide survey to be at least as reliable a predictor as our East Harbor index because of the greater spatial and depth distribution of sites we sample throughout the western basin.

Our catch of several individuals of varying sizes of tubenose goby at four different sites separated by 20 km of open water suggests a range expansion may be underway. Tubenose gobies have been present in Lake Erie for a few years around the Bass Islands (D. Jude, University of Michigan, personal communication) but these are the first records from open waters of the western basin. Tissue samples from several individuals have been sent to the University of Toledo Lake Erie Center for genetic confirmation of species. We recommend personnel from other agencies carefully examine trawl samples for tubenose gobies in 2009. The primary external diagnostic characters are tubular protruding nostrils, a more slender body than round gobies, lateral and dorsal patches of gray pigment, and lack of black spot on the posterior margin of the anterior dorsal fin (Hubbs et al. 2004). Tubenose gobies prefer vegetated habitat (Hubbs et al. 2004), which suggests they will be most common in nearshore areas.

Our net mensuration work suggests that our previous estimate of horizontal net opening may be low. The estimated horizontal net opening of 5 m using NOTUS was larger than previous estimates of 3.9 m obtained using SCANMAR. Thus, density estimates for 2008 are lower than they would be had we used the previous estimate of 3.9 m as our net opening. Furthermore, perceived declines in reproductive success of some species in 2008 may be partly due to the higher estimate of area sampled. During September 2008 we completed a joint net mensuration exercise with ODNR and Habitat Solutions, to combine side-scan sonar imaging and measurements with NOTUS to obtain independent estimates of horizontal net opening. As of this writing the side-scan sonar results were not yet available. If the new NOTUS and side-scan acoustic estimates reveal that our previous estimate of 3.9 m was incorrect, then revision of past density and biomass estimates may be necessary.

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Table 1. Average density (number per hectare) of young-of-year (YOY) and yearling-and-older (YAO) forage fish of the most common species captured in bottom trawls during June and September 2008 in Ontario and Michigan waters of western Lake Erie. Percent relative standard error (%RSE) is 100*(standard error of the mean/mean). For round gobies, all ages are combined under YAO.

	Spring		**Autumn**			
Species	**YAO**	**%RSE**	**YOY**	**%RSE**	**YAO**	**%RSE**
Alewife	0	--	0	--	0	--
Gizzard shad	0	--	18.2	73.7	0	--
Rainbow smelt	15.5	78.6	308.0	51.9	0.2	100
Silver chub	0.8	81.0	0	--	1.1	85.6
Emerald shiner	1789	50.8	1.4	64.4	0.8	81.3
Spottail shiner	16.6	62.9	138.6	41.5	10.1	51.3
Mimic shiner	2.7	75.6	0		0	--
Trout-perch	26.7	40.9	73	44.8	23.0	24.9
White perch	11.5	31.7	949	24.6	68.6	26.6
White bass	1.3	39.1	3.6	30.3	0.2	99.4
Smallmouth bass	0	--	1.4	70.2	0	--
Logperch	0	--	1.0	51.1	3.5	48.1
Yellow perch	121.3	52.8	267.9	38.2	144.9	30.2
Walleye	5.1	36.0	1.7	36.0	1.0	43.6
Freshwater drum	0	--	3.4	72.7	3.2	75.0
Round goby	31.2	39.5	--	--	349	48.5

Table 2. Average biomass (kilograms per hectare) of young-of-year (YOY) and yearling-and-older (YAO) forage fish of the most common species captured in bottom trawls during June and September 2008 in Ontario and Michigan waters of western Lake Erie. Percent relative standard error (%RSE) is 100*(standard error of the mean/mean). All ages of round gobies are combined under YAO.

	Spring		Autumn			
Species	**YAO**	**%RSE**	**YOY**	**%RSE**	**YAO**	**%RSE**
Alewife	0	--	0	--	0	--
Gizzard shad	0	--	0.313	75.5	0	--
Rainbow smelt	0.087	76.7	0.245	53.0	0	--
Silver chub	0.070	87.5	0	--	0.032	74.2
Emerald shiner	5.549	48.5	0.004	76.4	0.001	98.4
Spottail shiner	0.102	66.6	0.090	35.2	0.049	56.4
Mimic shiner	0	--	0	--	0	--
Trout-perch	0.156	38.9	0.229	38.5	0.211	25.7
White perch	0.140	35.3	5.59	23.5	0	--
White bass	0.048	42.4	0.050	33.9	0	--
Smallmouth bass	0	--	0.016	64.6	0	--
Logperch	0	--	0.001	85.4	0.010	47.8
Yellow perch	2.305	56.5	1.288	34.0	0	--
Walleye	0	--	0.062	37.6	0	--
Freshwater drum	0	--	0.014	93.4	0	--
Round goby	0.114	38.8	--	--	1.150	39.5

Table 3. Mean total length (TL, mm), standard error (SE), and sample size (N) for young-of-year (YOY) and yearling-and-older (YAO) forage fish of the most common species captured during June and September 2008 in Ontario and Michigan waters of the western basin of Lake Erie. For round goby, all ages were combined under YAO.

	Spring YAO			**Autumn YOY**			**Autumn YAO**		
Species	**TL**	**SE**	**N**	**TL**	**SE**	**N**	**TL**	**SE**	**N**
Alewife	--	--	--	--	--	--	--	--	--
Gizzard shad	--	--	--	119.2	2.08	41	--	--	--
Rainbow smelt	100.6	1.72	50	53.4	0.64	172	128.0	--	1
Silver chub	202.6	8.48	5	--	--	--	145.9	9.31	7
Emerald shiner	73.2	0.72	309	75.4	5.51	7	92.0	--	1
Spottail shiner	74.4	2.85	82	42.8	1.11	252	105.4	3.81	17
Mimic shiner	44.0	--	1	--	--	--	--	--	--
Trout-perch	87.9	1.39	108	70.6	0.62	175	99.5	0.83	62
White perch	--	--	--	76.0	0.38	594	107.2	2.14	6
White bass	--	--	--	99.1	5.71	21	--	--	--
Smallmouth bass	--	--	--	92.3	5.54	9	--	--	--
Logperch	--	--	--	48.7	11.8	6	70.7	3.54	12
Yellow perch	--	--	--	81.8	0.44	346	--	--	--
Walleye	--	--	--	168.0	6.92	7	--	--	--
Freshwater drum	--	--	--	68.9	6.84	17	--	--	--
Round Goby	61.6	1.12	152	--	--	--	62.2	1.43	344

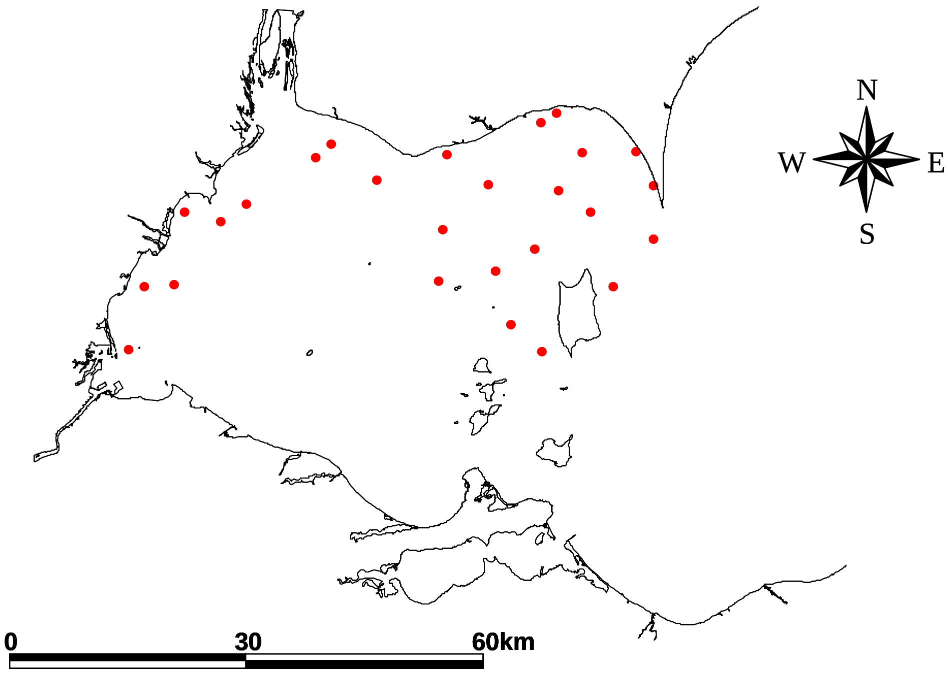

Figure 1. Location of sites sampled with a bottom trawl in June and September in the western basin of Lake Erie, 2008.

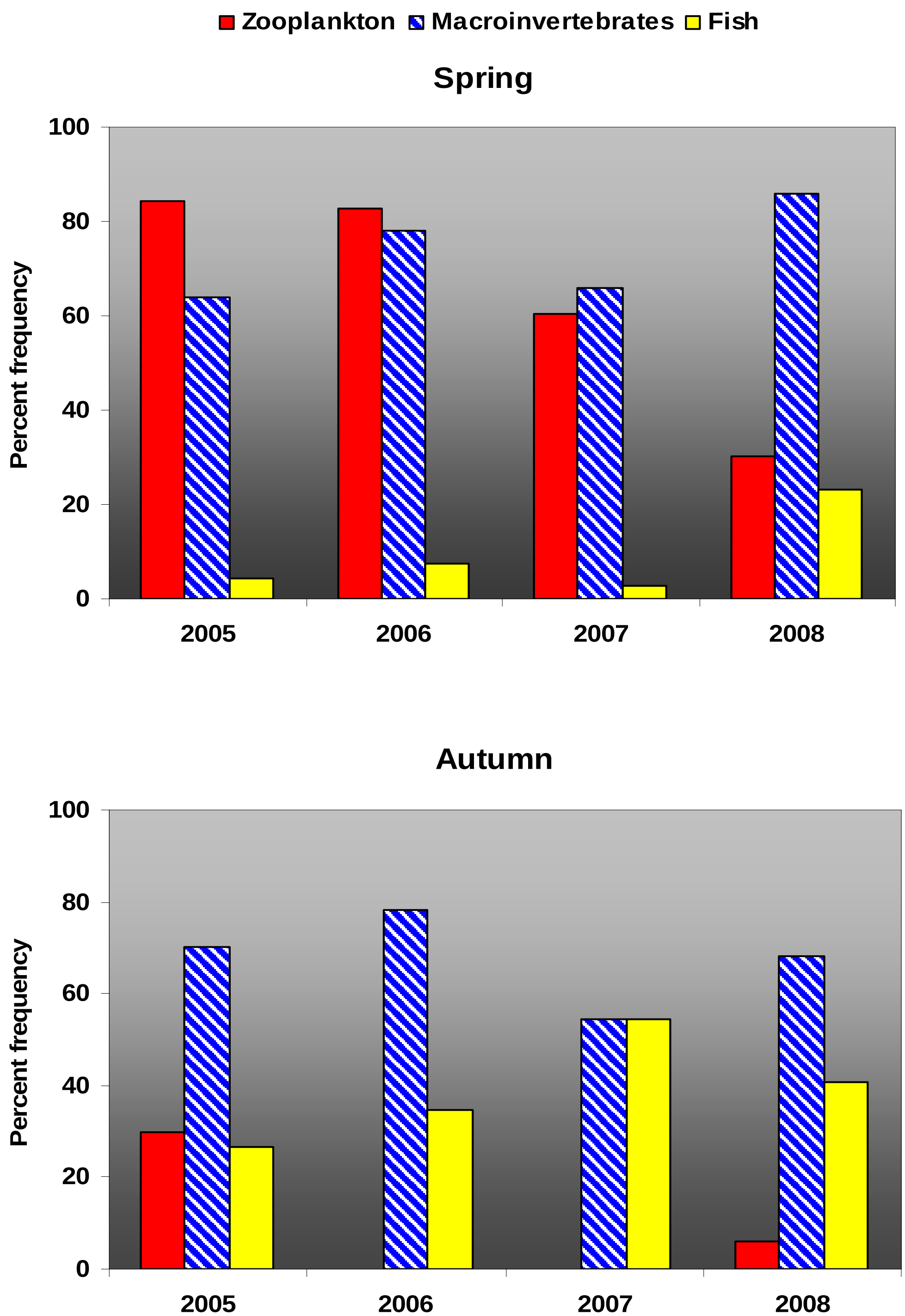

Figure 2. Percent frequency of occurrence of zooplankton, macroinvertebrates, and fish recorded during the diet analysis of yellow perch collected in Ontario and Michigan waters of western Lake Erie. Stomachs were collected in June and September during 2005-2008.

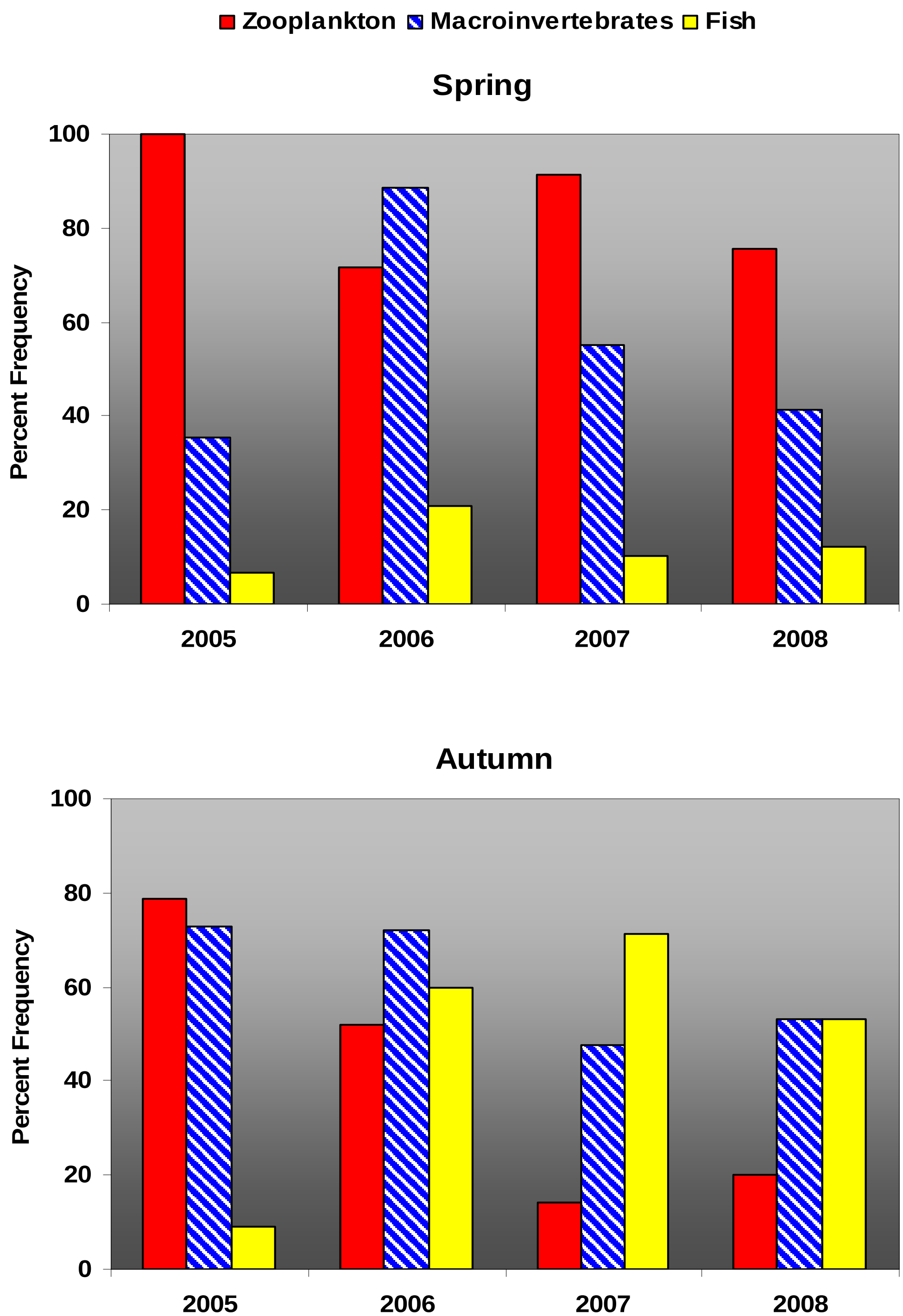

Figure 3. Percent frequency of zooplankton, macroinvertebrates, and fish in stomachs of yearling and older white perch collected in Ontario and Michigan waters of western Lake Erie. Stomachs were collected in spring and autumn during 2005-2008.