Comparison of Spring and Autumn Bottom Trawl Sampling in the Western Basin of Lake Erie

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

Abstract

In 2006, the Lake Erie Biological Station participated for the third consecutive year in a collaborative, multi-agency effort to evaluate forage fish populations throughout the western basin of Lake Erie. The objectives of this evaluation are to determine the best time of year for sampling in order to estimate year-class strength and to develop a method for estimating basin-wide density and biomass of forage fishes. We sampled 25 stations in Ontario and Michigan waters of the western basin of Lake Erie with bottom trawls in June and September 2006. We calculated density (number per hectare) and biomass (kilograms per hectare) of all forage fishes and compared species diversity across political jurisdictions, seasons, and depth strata. We also examined stomach contents from white perch *Morone americana* and yellow perch *Perca flavescens* to describe diets of these two species. Compared to previous years, density and biomass estimates were lower for coolwater species and higher for warmwater species. The outbreak of viral hemorrhagic septicemia that resulted in mass mortality of several species in spring and early summer may have negatively affected recruitment of freshwater drum *Aplodinotus grunniens*. Species diversity was higher in autumn, higher in Ontario waters, and generally increased with depth. Average water depth in Ontario waters is deeper than in Michigan and likely accounts for some of the difference in species diversity across political jurisdictions. We recommend adding night sampling in a subset of the sites sampled during daylight to examine whether time of day sampled affects estimates of density, biomass, and species diversity.

* Reported to: Great Lakes Fishery Commission
Lake Erie Committee Meeting
Ypsilanti, Michigan
22-23 March, 2007

Provisional Data, not to be cited without permission

Introduction

The United States Geological Survey's (USGS) Lake Erie Biological Station (LEBS) has conducted annual forage fish surveys in the western basin of Lake Erie since 1961. The primary purpose of these bottom trawl surveys is to determine year-class strength of important prey and predator species. These data are provided to management agencies and several subcommittees of the Lake Erie Committee of the Great Lakes Fishery Commission to assist them in monitoring and managing the Lake Erie fish community. Since 1987, the Ontario Ministry of Natural Resources (OMNR) and the Ohio Department of Natural Resources (ODNR) have cooperatively sampled forage fishes throughout the western basin of Lake Erie in August. The ODNR also conducts forage fish sampling in the western basin monthly from May through September.

A research question that has emerged from the various western basin sampling efforts is: during what times of the year (spring, summer, or autumn) should sampling be conducted to best estimate year class strength of prey fishes? To address this question, LEBS began a cooperative effort with ODNR and OMNR in 2004 to trawl in the spring (June) and autumn (September) at sites in Canadian and Michigan waters of the western basin. In previous years, most of these sites had been sampled either in August only or not at all. The 2006 season was the third consecutive year of this collaboration to determine the relative value of spring, summer, and autumn samples for assessing prey fish communities. The short-term goal is to determine what sampling period is best for determining year class strength of forage fishes. A longer-term goal is to develop a protocol for a basin-wide estimate of forage fish density and biomass. As this data set expands, we will also be able to quantify geographical and seasonal variability in prey species abundance, distribution of prey species within the western basin, and relationships between abundance indices generated from spring samples and autumn samples.

Here we present data for density and biomass of important forage fishes in the western basin of Lake Erie and diets of yellow perch *Perca flavescens* and white perch *Morone americana* in June and September 2006. We compare spring versus autumn values for yearling-and-older (YAO) for each species, make preliminary observations on performance of the various indices, and compare the seasonal geographic and depth distributions of the various forage fishes.

Methods

Trawling

Sampling sites in Ontario were chosen from those sampled by OMNR in summer. We selected 19 sites from Ontario waters of Lake Erie (Figure 1), which is about 55% of sites sampled by OMNR in the western basin, and six sites from Michigan waters. Sites were sampled in three depth strata (3-6 m, 6-9 m, and 9-12 m), except one site in Michigan waters (nearest the mouth of the Maumee River) that was only 2.1-2.3 m deep. Spring samples were collected 13 June through 15 June 2006. Autumn samples were collected 19 September through 21 September 2006. We used a 7.9-m (headrope) semi-balloon bottom trawl with a mean horizontal opening of 3.9 m for all trawling. The trawl was towed for 10 minutes, on bottom, at an average speed of 3.7 km/hr (range 3.5-4.1 km/hr).

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 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 entire sample to the weight of the subsample. Subsamples of forage fish were placed on ice for later examination in the laboratory. In the laboratory, fish were measured for total length (nearest mm), and weighed (nearest 0.01 g). For small numbers of fish (30 or fewer), all fish captured were measured and weighed. For larger numbers, subsamples of 30 fish were measured and weighed. Weights were not taken for YAO of predatory species.

For each trawl tow, 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. Area swept was calculated as width of the trawl opening (3.9 m, measured using SCANMAR acoustic net mensuration gear) multiplied by the distance towed. The distance towed was measured as the difference in starting and ending latitude-longitude determined using differential Global Positioning System. 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

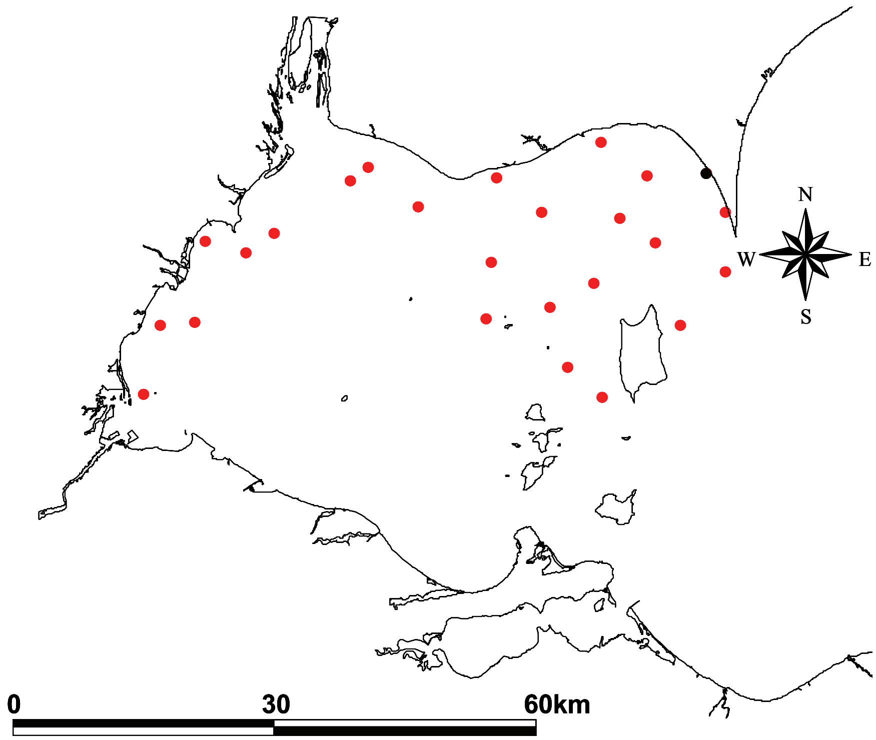

Figure 1. Location of sites sampled (red and black filled circles) with a bottom trawl in June and September in the western basin of Lake Erie, 2006. The sampling site represented by the black filled circle was sampled only in June.

species and age group by the average density and was expressed in kilograms per ha.

For round goby *Neogobius melanostomus*, values were reported for all ages combined. For the remaining species, age groups considered were young-of-year (YOY) and yearling-and-older (YAO). Ages were determined using age-length keys for species in the western basin developed from historical ODNR samples. Average density and biomass for a species and age group within a season were calculated as the arithmetic mean of all samples within a season. We calculated 95% confidence limits around each mean to estimate magnitude of differences, and compared spring and autumn species richness with a paired t-test. Estimated densities and biomasses were log-transformed (to account for order-of-magnitude differences in estimates) for calculating correlation coefficients among density and biomass estimates. We also calculated correlation coefficients between depth and species diversity for YOY and YAO. All statistical analyses were conducted using the statistical software R (R Development Core Team 2006).

Yellow perch and white perch diets

In both seasons, we removed stomachs from a maximum of five yellow perch and five white perch, all age-2-and-older, at each trawl station. Stomachs were frozen in the field and transported to the laboratory. Prey items in stomachs were identified in the laboratory to the lowest reasonable taxonomic level, enumerated, and measured. Weights were calculated for individual invertebrates from length measurements and by appropriate length-weight regressions (see Bur et al. 2007). Diet data were reported as frequency of occurrence and mean percent weight (Wallace 1981) by species and by season. Only stomachs that contained food items were included in the analysis. This was the second year in which diet data were collected. Therefore, no long-term trends were reported.

Results

Trawling

All 25 sites were sampled in spring and all but one site were sampled in autumn. We were unable to sample one site in autumn (ON-50, black sampling point on Figure 1) because commercial fishing gear was present. Michigan waters (mean ± 95% confidence limit, 5 ± 1.8 m) were shallower on average than Ontario waters (9.1 ± 0.8 m).

Twenty-three different species were captured in trawls. Unusual captures included: a YOY rock bass *Ambloplites rupestris* in Canadian waters near the mouth of the Detroit River and several age-0 bluegill *Lepomis macrochirus* captured at two stations northwest of Pelee Island and one station northeast of Pelee Island. We also captured several smallmouth bass *Micropterus dolomieu* at four sites, two each in Michigan and Ontario waters, nearest the mouth of the Detroit River.

Average species diversity was higher in autumn (7.1 ± 1.2 species) than in spring (4.6 ± 1.1 species). The difference was significant in both Ontario (autumn: 8.8 ± 1.0 species, N = 18 sites; spring: 5.6 ± 1.1 species, N = 19 sites, $P < 0.0001$) and Michigan (autumn: 4.3 ± 3.2 species, N=6 sites; spring 1.7 ± 1.1 species, N= 6 sites, $P = 0.04$) waters. Species diversity was lower in Michigan waters than in Ontario waters in both spring ($P < 0.0001$) and autumn ($P = 0.014$). There were positive correlations between species diversity and depth for both age groups (Table 1).

Table 1. Pearson product-moment correlation coefficients (N, *P*-value for H*a*: $r > 0$) between water depth and species diversity for young-of-year (YOY) and yearling-and-older (YAO) forage fish species in the western basin of Lake Erie.

	Autumn depth	Spring depth
Spring YAO	*	0.57 (24, 0.001)
Autumn YOY	0.39 (23, 0.03)	*
Autumn YAO	0.49 (23, 0.008)	*

Density of YAO forage species in spring was highest for emerald shiner *Notropis atherinoides*, white perch, and round goby and lowest (zero) for alewife *Alosa pseudoharengus* and gizzard shad *Dorosoma cepedianum* (Table 2). The very high average density for emerald shiner was heavily influenced by a single sample that was estimated to contain nearly 10,000 individuals. Autumn densities of YOY were highest for white perch, emerald shiner, and trout-perch *Percopsis omiscomaycus*, and lowest for silver chub *Macrhybopsis storeriana*, logperch *Percina caprodes*, and walleye *Sander vitreus*. Densities of YAO in spring were highly correlated with autumn densities of both YAO ($r = 0.77$, N = 14 species, $P = 0.0006$) and YOY ($r = 0.83$, N = 10 species, $P = 0.001$). Biomass estimates for YAO in spring were highest for white perch, trout perch, and yellow perch and lowest for alewife and gizzard shad (Table 3). Autumn YOY biomass estimates were highest for white perch, trout perch, and yellow perch and lowest for silver chub, logperch, and walleye. Biomass estimates for autumn YOY were positively correlated with biomass estimates of YAO in spring ($r = 0.79$, N = 9 species, $P = 0.006$). Mean total lengths are reported in Table 4.

Trout-perch, white perch, white bass *Morone chrysops*, emerald shiner, yellow perch, and round goby were captured at all or most sites in Ontario waters in spring and autumn. Of those six species, only round goby was captured in Michigan waters in spring. Trout-perch, white bass, and emerald shiner remained largely absent from Michigan waters in autumn.

Yellow perch and white perch diets

Stomach samples were collected from 69 yellow perch and 81 white perch. Nearly all (93%) of these stomachs contained food items. During spring, yellow perch diets were dominated by zooplankton (55% mean percent weight) and benthic macroinvertebrates (44%) (Table 5). *Daphnia spp.* were the dominant zooplankton consumed by weight (49%) and percent frequency (58%). *Leptodora kindtii*, *Bosmina sp.*, Copepoda, and Sididae collectively contributed less than six percent of the spring diet by weight. Among benthic macroinvertebrates consumed, Chironomidae dominated by weight (19%) and was the most frequently consumed prey by yellow perch during spring (65%). Rotifers, Sphaeriidae, and *Hexagenia sp.* were the next most dominant benthic invertebrates by weight. White perch was the only fish identified in yellow perch stomachs during spring, contributing 1% by weight.

Table 2. Average density (number per hectare) of young-of-year (YOY) and yearling-and-older (YAO) forage fish of various species captured in bottom trawls during spring and autumn 2006 in Ontario and Michigan waters of western Lake Erie. Percent relative standard error (%RSE) is 100%*(standard error of the mean/mean). Asterisks indicate where it was not possible to calculate RSE owing to insufficient sample size. For round gobies, all ages are combined under YAO.

	Spring		**Autumn**			
Species	**YAO**	**%RSE**	**YOY**	**%RSE**	**YAO**	**%RSE**
Alewife	0	*	0.36	69.4	0	*
Gizzard shad	0	*	4.17	58.3	0	*
Rainbow smelt	6.54	73.4	41.61	45.3	0.83	60.7
Trout-perch	67.34	45.6	181.74	33.2	20.77	28.2
White perch	103.62	48.5	565.37	36.9	149.84	39.7
White bass	7.86	30.6	5.07	33.2	0.17	97.6
Freshwater drum	0.74	47.6	0.17	99.6	1.16	2.39
Silver chub	1.27	84.6	0	*	2.46	57.2
Emerald shiner	2,758	56.6	227.00	30.7	15.42	40.6
Spottail shiner	12.11	58.2	6.85	16.96	29.58	60.3
Mimic shiner	0.42	101	0.17	99.6	0.17	99.6
Smallmouth bass	0.21	101	2.26	61.5	0.19	99.9
Logperch	0.21	101	0	*	0.39	70.2
Yellow perch	12.91	27.2	66.12	33.8	6.47	43.3
Walleye	1.01	66.7	0	*	0.52	55.1
Round goby	180.25	46.6	*	*	27.96	36.2

Table 3. Average biomass (kilograms per hectare) of young-of-year (YOY) and yearling-and-older (YAO) forage fish of various species captured in bottom trawls during spring and autumn 2006 in Ontario and Michigan waters of western Lake Erie. Percent relative standard error (%RSE) is 100%*(standard error of the mean/mean). Asterisks indicate where it was not possible to calculate RSE owing to insufficient sample size. For round gobies, all ages are combined under YAO.

	Spring		**Autumn**			
Species	**YAO**	**%RSE**	**YOY**	**%RSE**	**YAO**	**%RSE**
Alewife	0	*	0.001	74.9	0	*
Gizzard shad	0	*	0.068	73.4	0	*
Rainbow smelt	0.026	68.7	0.028	48.8	*	*
Trout-perch	0.345	47.2	0.591	31.4	0.172	28.7
White perch	1.487	53.7	2.930	33.5	*	*
White bass	0.330	30.8	0.036	62.4	*	*
Freshwater drum	0.007	74.9	0.002	98.0	*	*
Silver chub	0.020	94.3	0	*	0.095	44.0
Emerald shiner	23.664	63.9	0.106	31.3	0.029	46.2
Spottail shiner	0.098	60.2	0.026	53.6	0.347	58.7
Mimic shiner	<0.001	100.0	<0.001	97.6	<0.001	97.3
Smallmouth bass	*	*	0.011	60.9	*	*
Logperch	<0.001	95.0	0	*	<0.001	73.6
Yellow perch	0.187	29.7	0.185	50.2	*	*
Walleye	0.012	96.0	0	*	*	*
Round goby	0.565	41.0	*	*	0.131	33.4

Table 4. Mean total length (TL), standard error (SE), and sample size (N) for young-of-year (YOY) and yearling-and-older (YAO) forage fish of various species captured during spring and autumn 2006 in Ontario and Michigan waters of the western basin of Lake Erie. Asterisks indicate no fish were sampled, or in the case of SE, that only one individual of a species was measured. 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	*	*	*	70.0	11	2	*	*	*
Gizzard shad	*	*	*	96.3	10.13	23	*	*	*
Rainbow smelt	83.1	2.99	40	50.3	0.81	144	*	*	*
Trout-perch	81.7	0.89	136	70.6	0.44	289	98.2	0.56	103
White perch	*	*	*	71.8	0.74	237	*	*	*
White bass	*	*	*	97.9	5.22	15	*	*	*
Freshwater drum	*	*	*	110.0	*	1	*	*	*
Silver chub	107.0	15.35	6	*	*	*	159.7	7.89	10
Emerald shiner	74.5	0.56	385	39.0	0.61	383	77.1	3.67	15
Spottail shiner	92.5	2.34	59	75.0	1.64	35	105.8	0.77	90
Mimic shiner	63.0	*	1	60.0	*	1	60.0	*	1
Smallmouth bass	*	*	*	91.6	7.99	5	*	*	*
Logperch	74.0	*	1	58.0	9	2	*	*	*
Yellow perch	*	*	*	84.7	0.67	87	*	*	*
Walleye	*	*	*	*	*	*	*	*	*
Round goby	115.0	*	1				63.6	2.8	122

Five benthic taxa were identified in yellow perch stomachs in autumn (Table 5). Benthic macroinvertebrates dominated the autumn diet by mean percent weight (68%). The dominant benthic invertebrate in autumn diets by weight and percent frequency was Chironomidae (28% and 46% respectively). Collectively, *Dreissena sp., Hexagenia sp.*, rotifers, and Sphaeriidae accounted for nearly 40% of the diet by weight. Fish composed 32% of autumn diets by weight. Round goby, emerald shiners, and trout perch collectively accounted for 23% of the diet by weight. Unidentified fish accounted for the remaining 9%. Zooplankton were notably absent from autumn yellow perch diets (Table 5).

Spring white perch diets were dominated by zooplankton (56% mean percent weight) (Table 6). *Daphnia sp*. was the most abundant zooplankton taxon (53 %) with *Bosmina sp.*, Copepoda, and Sididae making up the remaining 3% by weight. White perch consumed 11 different benthic macroinvertebrate taxa during spring for a combined 38% of mean percent weight. Chironomidae occurred most frequently in white perch stomachs (79%) and accounted for the most prey weight among benthic invertebrates (29%). Emerald shiners and round goby together contributed 6% of the spring diet by weight.

Benthic macroinvertebrates were the dominant prey found in white perch diets in autumn contributing 42% mean percent by weight followed by fish (36%) and zooplankton (22%). White perch fed most frequently on Chironomidae (56%) which also dominated the benthic invertebrate portion of autumn diets. Amphipoda and *Hexagenia sp.* were the next dominant invertebrates by weight, contributing 4% and 3% respectively. Round goby contributed the most by weight to the fish portion of white perch diets (22%) with emerald shiner and smallmouth bass collectively adding another 5%. The zooplankton portion of autumn white perch diets was almost exclusively Copepoda with only one white perch consuming a single *Daphnia sp.*

Yellow perch and white perch diets in 2006 exhibited a decrease in percent composition of zooplankton in both spring and autumn diets compared to 2005 (Figures 2 & 3). Conversely, the percent composition of benthic macroinvertebrates increased in the spring diets of both yellow perch and white perch, and in the autumn diet for yellow perch. Fish consumption by both yellow perch and white perch during autumn also increased. Continued collection of yellow perch and white perch diets will allow for a more detailed analysis of diet trends in future years.

Discussion

The 2006 sampling season was the third year in an ongoing, collaborative effort to assess the value of spring, summer, and autumn sampling for estimating year class strength and population status of important forage species, and to better understand how forage fishes are distributed spatially and with respect to depth within the western basin of Lake Erie. Because we sampled the same sites in both spring and autumn, we can make direct comparisons of how average catch varied by season and how catch varied for a site across seasons. Our data, coupled with ODNR data from spring and autumn samples in Ohio waters, will help us to better quantify prey population status as well as geographic and seasonal dynamics in the western basin of Lake Erie.

For the second year in a row we captured smallmouth bass YOY in autumn. Smallmouth bass were captured at four sites (two each in Ontario and Michigan waters) with depths of 5.6-7.0 m. We also captured several YOY bluegill, another warmwater species, at four sites in deeper Ontario waters (depths 7.7-10.4 m). Catching even small numbers of smallmouth bass in trawls is typically an indication of a strong year class, because trawls are generally not effective at sampling habitat typically used by smallmouth bass. Bluegill is also a rare species in trawls in deeper water, although we typically catch bluegill and other *Lepomis sp.* at shallow sites near East Harbor.

Estimated densities and biomasses in spring of YAO white perch, emerald shiner, and round goby were high compared to previous years (Kocovsky et al. 2005; Bur et al. 2006) while those of walleyes, yellow perch, and rainbow smelt *Osmerus mordax* were low. These differences did not extend consistently to autumn; densities of YOY rainbow smelt and yellow perch were high compared to previous years, whereas densities of trout-perch, white perch, and white bass were moderate. Walleyes were entirely absent from all sampling sites in autumn, indicating a complete year class failure. Density of YOY emerald shiners was comparatively low. Autumn biomass estimates were high compared to the previous two years (Kocovsky et al. 2005; Bur et al. 2006) for white perch, and moderate for rainbow smelt, trout-perch, and emerald shiners. Despite these inconsistencies in estimates of year class strength provided by density and biomass estimates, 2006 was generally a weaker year for coolwater species (e.g., walleye, yellow perch) than for warmwater species (e.g., smallmouth bass, white perch). Yellow perch, which has a slightly higher thermal range than walleye (Hokanson 1977), had

Table 5. Diet of age-2 and older yellow perch collected during spring and autumn 2006 in Ontario and Michigan waters of western Lake Erie, expressed as mean percent (%) weight of all prey items and percent frequency of occurrence (% Frequency).

	Spring (n=44)		**Autumn (n=25)**	
Prey Item	**Mean % Weight**	**% Frequency**	**Mean % Weight**	**% Frequency**
Leptodora kindtii	2.5	5.0	0.0	0.0
Bosmina sp.	0.3	7.5	0.0	0.0
Daphnia sp.	19.6	25.0	0.0	0.0
Daphnia retrocurva	29.6	50.0	0.0	0.0
Copepoda	2.5	22.5	0.0	0.0
Sididae	0.0	2.5	0.0	0.0
Total Zooplankton	**54.5**		**0.0**	
Amphipoda	0.0	0.0	0.0	0.0
Chironomidae	19.1	65.0	28.4	45.5
Oligochaeta	0.0	2.5	0.0	0.0
Rotifera	9.2	45.0	10.4	13.6
Sphaeriidae	8.1	17.5	9.9	13.6
Hirudinea	2.6	2.5	0.0	0.0
Trichoptera sp.	0.0	5.0	0.0	0.0
Dreissena sp.	0.2	10.0	11.7	22.7
Hexagenia sp.	5.0	12.5	7.5	13.6
Total Benthos	**44.2**		**67.9**	
Emerald shiner	0.0	0.0	4.6	4.5
White perch	1.3	2.5	0.0	0.0
Trout perch	0.0	0.0	4.6	4.5
Round goby	0.0	0.0	13.7	13.6
Unidentified fish	0.0	5.0	9.2	13.6
Total fish	**1.3**		**31.6**	

Table 6. Diet of age-2 and older white perch collected during summer and autumn 2006 in Ontario and Michigan waters of western Lake Erie, expressed as mean percent (%) weight of all prey items and percent frequency of occurrence (% Frequency).

	Spring (n=44)		**Autumn (n=25)**	
Prey Item	**Mean % Weight**	**% Frequency**	**Mean % Weight**	**% Frequency**
Leptodora kindtii	0.0	0.0	0.0	0.0
Bosmina sp.	0.0	11.3	0.0	0.0
Daphnia sp.	34.2	37.7	0.0	4.0
Daphnia retrocurva	19.3	39.6	0.0	0.0
Copepoda	0.0	48.1	21.8	48
Sididae	2.6	15.1	0.0	0.0
Total Zooplankton	**56.1**		**21.8**	
Amphipoda	0.0	5.7	3.6	4.0
Ostracoda	0.0	5.7	0.0	8.0
Chironomidae	29.0	79.2	33.8	56.0
Nematoda	0.0	0.0	0.0	0.0
Oligochaeta	0.0	0.0	0.0	0.0
Rotifera	1.0	5.7	0.2	4.0
Sphaeriidae	0.1	15.1	1.7	20.0
Hirudinea	4.0	13.2	0.0	0.0
Gastropoda	0.0	1.9	0.0	0.0
Decapoda	2.1	3.8	0.0	0.0
Trichoptera sp.	0.2	7.5	0.0	0.0
Dreissena sp.	0.0	1.9	0.1	24.0
Hexagenia sp.	2.0	11.3	3.1	24.0
Total Benthos	**38.4**		**42.5**	
Emerald shiner	1.3	7.5	4.0	4.0
Smallmouth bass	0.0	0.0	1.3	4.0
Round goby	4.2	7.5	22.1	24.0
Unidentified fish	0.0	7.5	8.3	36.0
Total fish	**5.5**		**35.7**	

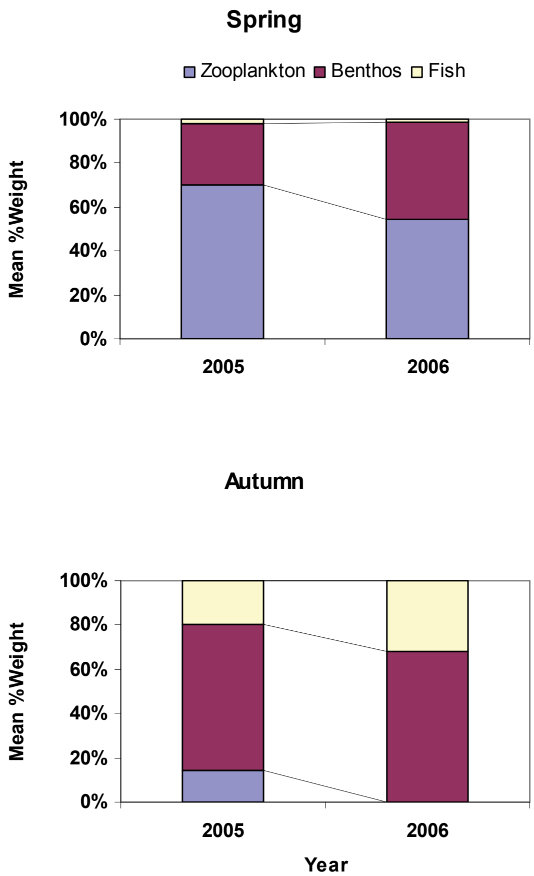

Figure 2. Mean percent weight of zooplankton, benthos, and fish in stomachs of age-2 and older yellow perch collected in Ontario and Michigan waters of western Lake Erie. Stomachs were collected in spring and autumn during 2005-2006.

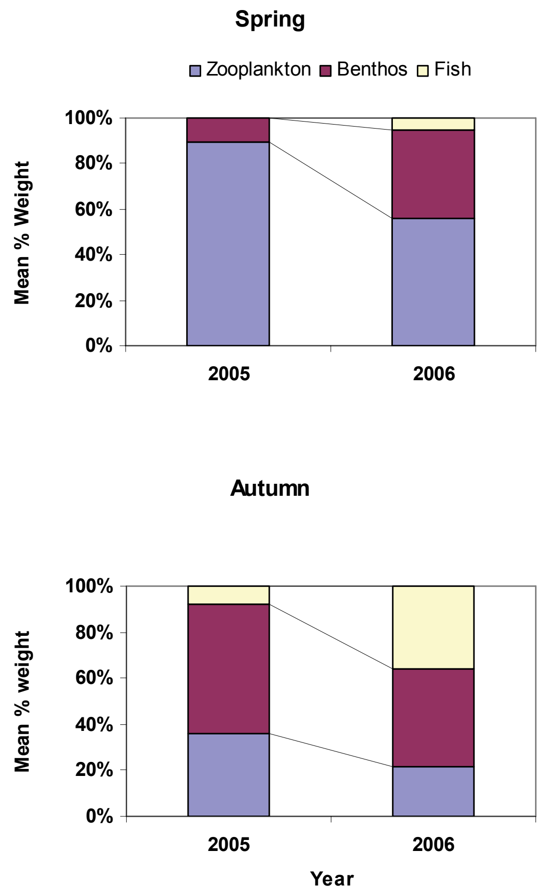

Figure 3. Mean percent weight of zooplankton, benthos, and fish in stomachs of age-2 and older white perch collected in Ontario and Michigan waters of western Lake Erie. Stomachs were collected in spring and autumn during 2005-2006.

better reproductive success compared to 2004 and 2005. In contrast, the USGS East Harbor survey (Bur et al. 2007), which has historically been a reliable indicator of yellow perch year class strength in the western basin of Lake Erie (Belore et al. 2006), indicated that yellow perch reproductive success was low in 2006.

Density and biomass of YOY freshwater drum *Aplodinotus grunniens* was low compared to the other common, native species and compared to the two most abundant non-native species. Freshwater drum was one of the species affected most by viral hemorrhagic septicemia (VHS), which resulted in mass mortality of adult drum in spring 2006. Other species that suffered mass mortalities, although not as severe as freshwater drum, were yellow perch and white perch.

Density and biomass estimates for YOY of each species of forage fish were generally well correlated in 2006, which suggests that either is a suitable measure of year class strength. In previous years, density and biomass estimates were not as well correlated (Kocovsky et al. 2005, Bur et al. 2006). We will continue to explore the relationship between density and biomass estimates in the future.

As was the case in previous years, emerald shiners were absent from Michigan waters in spring, as were white perch, white bass, trout-perch, and yellow perch. Of these five species, only white perch were present in Michigan waters in autumn, regardless of water depth or presence of aquatic macrophytes. We also did not capture any emerald shiners at the two western-most sites in Ontario waters nearest the mouth of the Detroit River. Habitat conditions, which include water depth, substrate, and presence of macrophytes, seem to be driving the absence of emerald shiners, white bass, trout-perch, and yellow perch from the far western portion of the western basin of Lake Erie.

Through its three-year history, this survey has demonstrated that depth and time of year sampled can affect estimates of density and biomass of forage fishes as well as species diversity. Stapanian et al. (in press) have also demonstrated that time of day sampling is conducted can affect estimates of density. Stapanian et al. (in press) reported that densities of several fish species were higher when sampling was conducted at night and they suggested that recruitment may be underestimated if night sampling is not included in a monitoring program. The sampling sites reported in Stapanian et al. (in press) were restricted to the East Harbor area of Lake Erie, and thus may not be representative of the western basin. We recommend that night sampling be added during autumn to compare indices of abundance across time of day as well as across seasons and depth strata. Doing so may provide a more complete assessment of year class strength of forage species and provide additional comparisons for determining an optimal sampling strategy for the western basin of Lake Erie.

References

Belore, M., A. Cook, D. Einhouse, T. Hartman, K. Kayle, R. Kenyon, C. Knight, T. MacDougall, and M. Thomas. 2006. Report of the Lake Erie yellow perch task group. Report to the Great Lakes Fishery Commission, Lake Erie Committee Meeting, Windsor, Ontario, March, 2006.

Bur, M. T., M. A. Stapanian, P. M. Kocovsky, W. H. Edwards, and J. M. Jones. 2006. Surveillance and Status of Fish Stocks in Western Lake Erie, 2005. Report to the Great Lakes Fishery Commission, Lake Erie Committee Meeting, Windsor, Ontario, March, 2006.

Bur, M. T., M. A. Stapanian, P. M. Kocovsky, W. H. Edwards, and M. J. Porta. 2007. Surveillance and Status of Fish Stocks in Western Lake Erie, 2007. Report to the Great Lakes Fishery Commission, Lake Erie Committee Meeting, Ypsilanti, Michigan, March, 2007.

Hokanson, K. E. F. 1977. Temperature requirements of some percids and adaptations to the seasonal temperature cycle. Journal of the Fisheries Research Board of Canada 34:1524-1550.

Kocovsky, P. M., M. T. Bur, and M. A. Stapanian. 2005. Comparison of spring and autumn bottom trawl sampling in the western basin of Lake Erie. Report to the Great Lakes Fishery Commission, Lake Erie Committee Meeting, Niagara Falls, Ontario, March, 2006.

R Development Core Team. 2006. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Stapanian, M. A., M. T. Bur, and J. V. Adams. In Press. Temporal trends of young-of-year fishes in Lake Erie and comparison of diel sampling periods. Environmental Monitoring and Assessment.

Wallace, R. K. 1981. An assessment of diet-overlap indexes. Transactions of the American Fisheries Society 110:72-76.