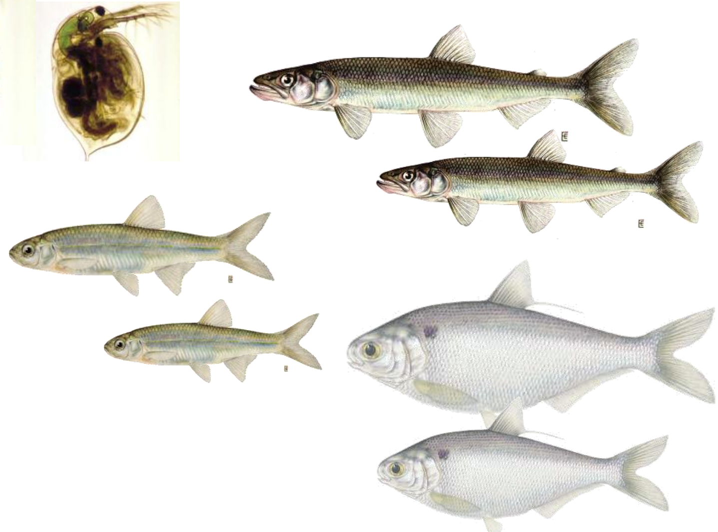
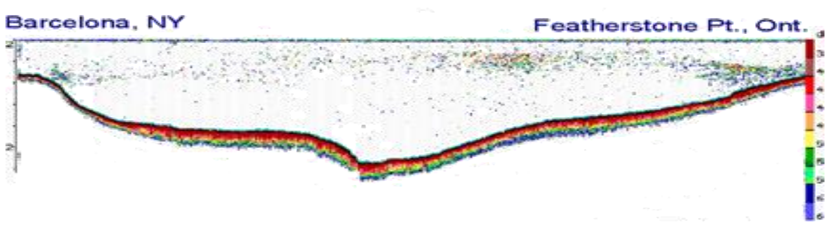
Report of the
Lake Erie
Forage Task Group

March 2013





Members:

Jim Markham	- New York Department of Environmental Conservation, (NYS DEC) {Co-Chair}
Mike Hosack	- Pennsylvania Fish and Boat Commission, (PFBC) {Co-Chair}
John Deller	- Ohio Department of Natural Resources, (ODNR)
Patrick Kocovsky	- United States Geological Survey - Great Lakes Science Center (USGS)
Tom MacDougall	- Ontario Ministry of Natural Resources, (OMNR)
Alicia Pérez-Fuentetaja	- The State University of New York, (SUNY- Buffalo State College)
Mike Thomas	- Michigan Department of Natural Resources, (MDNR)
Elizabeth Trometer	- United States Fish and Wildlife Service, (USFWS)
Eric Weimer	- Ohio Department of Natural Resources, (ODNR)
Larry Witzel	- Ontario Ministry of Natural Resources, (OMNR)

Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

1.0 Charges to the Forage Task Group in 2012-2013

1. Continue to describe the status and trends of forage fish and invertebrates in each basin of Lake Erie.
2. Continue the development of an experimental design to facilitate forage fish assessment and standardized interagency reporting.
3. Continue hydroacoustic assessment of the pelagic forage fish community in Lake Erie, incorporating new methods in survey design and analysis while following the GLFC's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible.
4. Continue the interagency lower-trophic food web monitoring program to produce annual indices of trophic conditions which will be included with the annual description of forage status.

2.0 Status and Trends of Forage Fish Species

2.1 Synopsis of 2012 Forage Status and Trends

General Patterns

- Relative forage abundance was above average in 2012
- Rainbow smelt densities decreased in all jurisdictions with the exception of the Ontario waters of the east basin, where it increased
- Emerald shiner densities increased and were above average in west and central basins
- Age-0 alewife abundance was above average in east basin
- Predator growth was above average in all basins
- Round goby densities below average in all basins

Eastern Basin

- Forage fish abundance during 2012 was high in Ontario (ON) and well below average in New York (NY)
- Age-0 rainbow smelt increased 2.5-fold in ON but decreased 74% in NY
- Yearling-and-older (YAO) rainbow smelt density increased in ON, but was below average basin-wide and at record low densities in NY
- Age-0 yellow perch abundance was above average in NY and below average in ON
- Age-0 alewife abundance increased in 2012; above average density basin wide, second highest abundance index in ON
- Age-0 gizzard shad increased in ON, decreased in NY
- Fourth highest density of age-0 emerald shiners in ON survey; all age groups below avg. abundance in NY following record numbers in 2011
- Spottail shiner remain at low densities throughout basin
- Round goby densities increased slightly basin wide, but remain below 10-year average
- Average length of age-0 and -1 rainbow smelt increased (ON); both age groups above average size in 2012
- Predator diets were diverse, dominated by fish species, primarily rainbow smelt and round goby
- Predator growth remains good; age-2 to -6 smallmouth bass remain at or near record long length-at-age in Long Pt. Bay, ON, and age 2 and 3 bass cohorts in NY near maximum mean lengths.
- Lake trout growth remains high and stable.
- Mean density of all forage fish (YAO smelt-size acoustic targets) was 17,182 fish/hectare (ha) in 2012, a 83% increase from 2011
- YAO smelt-size acoustic target densities were highest south of Long Point, ON

Central Basin

- Forage fish abundance was above average in 2012
- Increase in forage abundance was primarily due to Age-0 white perch and both age groups of emerald shiner
- Emerald shiner indices were some of the highest in the time series in Ohio waters
- Age-0 yellow perch abundance increased from 2011 and was above average
- Basin wide, smelt indices were well below average
- Round goby abundance was well below average
- Mean length of forage species was at or above average
- Mean length of walleye was above average for fish up to age-6
- Predator diets were primarily gizzard shad and emerald shiners
- Acoustic densities of emerald shiner were high and spread throughout the basin

West Basin

- Forage abundance and biomass at above average levels
- Age-0 gizzard shad catches increased from 2011, but were still below long term mean
- Age-0 and YAO rainbow smelt catches remain low
- Age-0 and YAO emerald shiner increased from 2011; both above long-term mean
- Age-0 white perch increased almost 4 times from 2011 levels; highest since 2004
- Round goby abundance decreased in 2012; third lowest since first year of invasion (1997)
- Age-0 yellow perch (4th lowest in series) and walleye recruitment (7th lowest in series) decreased from 2011; both were below long-term mean; white bass recruitment increased and was slightly below long-term mean
- Size of age-0 walleye, yellow perch, white bass, white perch, and smallmouth bass were all above long term means; age-0 walleye in 2012 were largest in time series
- Fall walleye diets showed reliance on gizzard shad and emerald shiners

2.2 Eastern Basin (L. Witzel, J. Markham, and M. Hosack)

Rainbow smelt are the principal prey fish species of piscivores in the offshore waters of eastern Lake Erie (Figure 2.2.1). In 2012, rainbow smelt once again was the most abundant forage species captured in all east basin jurisdictions (Table 2.2.1). Yearling-and-older (YAO) rainbow smelt abundance was below average in all jurisdictions, particularly in New York where record low densities were observed. Age-1 rainbow smelt from the moderately weak 2011 year class accounted for 82% of the YAO smelt catch in Ontario's October trawl assessment. Age-0 rainbow smelt recruitment index in 2012 was the 5th highest in Ontario's 29-year survey, but contrasted with New York's trawl assessment which ranked the 2012 smelt year class as fourth weakest in their 21-year time series. Age-0 rainbow smelt abundance was about three to four times greater in Ontario than in Pennsylvania and New York, respectively. Mean length of age-0 (63 mm FL) and age-1 (110 mm FL) rainbow smelt increased in 2012 (Figure 2.2.2).

The contribution of non-smelt fish species to the forage fish community of eastern Lake Erie was dominated in 2012 by alewife, emerald shiner, round goby, and gizzard shad in Ontario and by trout-perch, alewife, emerald shiner, round goby, and age-0 yellow perch in New York (Table 2.2.1). Emerald shiner was above average density in Ontario and below average density in New York and Pennsylvania. Spottail shiner abundance remained low throughout all eastern basin regions in 2012 (Table 2.2.1). Age-0 alewife was observed in above average numbers across all east basin jurisdictions in 2012, particularly in Ontario where catches were the second highest in survey history. Age-0 gizzard shad abundance increased in Ontario but decreased in New York in 2012.

Round goby emerged as a new species among the eastern basin forage fish community during the late 1990's. Round goby numbers continued to increase at a rapid rate and by 2001 were the most or second most numerically abundant species caught in agency index trawl gear across areas surveyed in eastern Lake Erie. Annual round goby abundance estimates from 2000 to 2007 were variable and increasing. Beginning in 2007, round goby densities began decreasing, reaching low ebb in Ontario waters in 2010 and in New York waters in 2011. Goby abundance in 2012 increased slightly compared to 2011, but remains well below the 10-year average across all jurisdictions (Table 2.2.1).

Rainbow smelt remain the dominant prey of angler-caught walleye sampled each summer since 1993. Beginning in 2001, prey fish other than rainbow smelt made a small but measurable contribution to the walleye diet. Collections beginning in 2006, and continuing in 2007 and 2008, were especially noteworthy because several other prey fish species contributed measurably to walleye diets. Round goby remain the largest component of the diet of adult smallmouth bass caught in New York gill net surveys since 2000. Gobies were first observed in the summer diet of yellow perch in Long Point Bay in 1997 and have been the most common prey fish species found in perch stomachs since 2002.

Fish species continue to comprise the majority of the diets of both lake trout and burbot caught in experimental gill net surveys during August in the eastern basin of Lake Erie. Rainbow smelt have been the dominant food item in Lean strain lake trout since coldwater surveys began in the early 1980s in Lake Erie, occurring in 85 – 95% of the stomachs. However, in years of low YAO rainbow smelt abundance such as 2006 and 2010, round goby became prominent in the diets of both Lean and Klondike strain lake trout. Rainbow smelt dominated lake trout diets again in 2012, occurring in 93% of Lean strain and 79% of Klondike strain lake trout. Round goby were less prominent in lake trout diets during 2012 than 2011, occurring in 7% of Lean strain and 16% of Klondike strain fish. Round goby have occurred more frequently in the diets of Klondike than Lean strain lake trout during all eight years that Klondike trout have been collected in coldwater index gill nets. Gizzard shad, which are an uncommon prey item in eastern basin coldwater fishes, were found in 5% of Lean lake trout and 10% Klondike lake trout in 2012.

The occurrence of rainbow smelt in burbot stomachs containing food increased to 55% in 2012 (46% in 2011) and was coincident with a decrease in occurrence of round goby from 50% to 45%. Gobies have increased in the diet of burbot since this invasive species first appeared in the eastern basin in 1999. They were the main prey item in the burbot's diet in seven of the last 10 years.

Mean length of age-2 and age-3 smallmouth bass cohorts sampled in 2012 autumn gill net collections (New York) have remained stable over the past 6 years and are among the highest in the 32-year history of this survey. Beginning in the late 1990s coincident with the arrival of round goby, several age classes of smallmouth bass in Long Point Bay, Ontario have exhibited a trend of increasing length-at-age. In 2012, length-at-age for each of age-2 to age-6 smallmouth bass cohorts remained at or near maximum values observed during the 27-year time series of OMNR's Long Point Bay gillnet survey. Length-at-age trends from New York's juvenile walleye (age-1 and age-2) assessment were slightly above long-term average sizes. Mean size-at-age (length and weight) of lake trout in 2012 were consistent with the recent 10-year average (2002 – 2011) and condition coefficients (K) remain high. Klondike strain lake trout have significantly lower growth rates compared to Lean strain lake trout. Lake trout growth in Lake Erie continues to be stable and among the highest in the Great Lakes.

2.3 Central Basin (J. Deller and M. Hosack)

Routine bottom trawl surveys in the central basin began in Ohio in 1990 and Pennsylvania in 1982. In 2012, overall forage abundance in the Ohio waters increased over 2.5 times (4409 fish/ha) 2011densities and was well above average (2144 fish/ha; Figure 2.3.1). High forage fish abundance in 2012 can be attributed to basin-wide increases in age-0 white perch and emerald shiners (all age groups) in Ohio.

Rainbow smelt and emerald shiners are the primary forage species in the central basin. In 2012, agency trawl indices for emerald shiner varied. Age-0 and YAO indices in Ohio were some of the highest in the time series, whereas indices were well below average in Pennsylvania (Tables 2.3.1 and 2.3.2). Rainbow smelt densities were generally lower throughout the basin in 2012 compared to 2011. Age-0 indices for rainbow smelt in Ohio increased from 2011, but were below average in both Ohio and Pennsylvania. Yearling-and-older indices decreased in Ohio and were well below average in both Ohio and Pennsylvania.

Round goby first appeared in central basin trawl surveys in 1994 and since then, densities of this exotic species have tended to be higher in eastern relative to western areas of the basin. This pattern was not observed for both age groups in 2012. Yearling-and-older round goby densities did increase from west to east; however, young-of-the-year indices were highest in eastern Ohio and lowest in Pennsylvania (Tables 2.3.1 and 2.3.2). Round goby indices for both age-0 and YAO decreased from 2011 in Ohio, and were below average in Ohio and Pennsylvania.

Clupeid densities in the central basin did not follow typical patterns in 2012. Age-0 alewives were captured in both Ohio and Pennsylvania trawl surveys (Table 2.3.1). This species has not been caught in the central basin since 2007, despite being regularly encountered in Ohio prior to 2004. The highest densities of age-0 alewives were found in Pennsylvania followed by eastern Ohio. The age-0 gizzard shad index in western Ohio decreased from a record high in 2011 and was below average. The eastern Ohio index increased from 2011 and was above average.

A strong year class of yellow perch occurred in both eastern and western Ohio in 2012 (Table 2.3.1). Age-0 yellow perch indices were the highest in Ohio since 2007. Since 2005, yellow perch cohorts in the central basin have tended to be strongest in the east relative to the west. Yearling-and-older yellow perch were also strongest in the east relative to the west (Table 2.3.2). Ohio YAO yellow perch indices were below average.

Age-0 white perch indices were also strong in all areas of the central basin (Table 2.3.1). Basin wide, the age-0 indices were the highest in the time series in Pennsylvania and western Ohio and third highest in eastern Ohio. Yearling-and-older white perch indices increased in western Ohio from 2011 and were above average (Table 2.3.2). Indices in eastern Ohio decreased from 2011 and both eastern Ohio and Pennsylvania were below average.

Historically, diets of adult walleye and white bass collected from the fall gillnet survey in Ohio have been comprised of gizzard shad, rainbow smelt and emerald shiner. In 2012, rainbow smelt were absent in diet samples from eastern Ohio. The proportion of gizzard shad (by dry weight) in the diets of adult walleye and white bass dramatically increased from 2011 in eastern Ohio samples. The change in composition of white bass and walleye diets from 2011 to 2012 reflect the changes in gizzard shad and rainbow smelt densities in the eastern Ohio trawl survey. Adult walleye diets in the central basin were comprised of 96% gizzard shad in the east and 76% in western Ohio waters. In 2011, gizzard shad comprised 30% of adult walleye diets in the east and 79% in the west. Emerald shiners made up the remainder of walleye diets in 2012. White bass diets from the fall gillnet survey showed similar shifts in composition, with gizzard shad comprising 41% of the diets in the east, and 35% west. In 2011, gizzard shad comprised 2% of adult white bass diets in the east and 8% in the west. The remainders of white bass diets in 2012 were comprised of emerald shiners and zooplankton in east (31% and 24%, respectively) and west (50% and 11%, respectively) samples. Round goby continue to be the primary diet item consumed by smallmouth bass in the central basin, comprising 80% of the total diet in the east, and 91% in the west.

Mean length of walleye collected in Ohio's fall gillnet survey in 2012 was above average for cohorts up to age-6, a consistent pattern since 2009. White bass size-at-age remains high and is generally at or above average for all cohorts in both the east and west areas of Ohio. Mean length-at-age of yellow perch cohorts to age-5 from fall surveys in Ohio increased from 2011 and were at the average. Lengths-at-age for yellow perch cohorts age-6 and greater were below average. Mean lengths of most age-0 forage and predator species increased from 2011 and were at or above average.

2.4 West Basin (E. Weimer and P. Kocovsky)

History

Interagency trawling has been conducted in Ontario and Ohio waters of the western basin of Lake Erie during August since 1987, though missing effort data from 1987 has resulted in the use of data since 1988. This interagency trawling program was developed to measure basin-wide recruitment of percids, but has been expanded to provide basin-wide community abundance indices. In 1992, the Interagency Index Trawl Group (ITG) recommended that the Forage Task Group (FTG) review its interagency trawling program and develop standardized methods for measuring and reporting basin-wide community indices. Historically, indices from bottom trawls had been reported as relative abundances, precluding the pooling of data among agencies. In 1992, in response to the ITG recommendation, the FTG began the standardization and calibration of trawling procedures among agencies so that the indices could be combined and quantitatively analyzed across jurisdictional boundaries. SCANMAR was employed by most Lake Erie agencies in 1992, by OMNR and ODNR in 1995, and by ODNR alone in 1997 to calculate actual fishing dimensions of the bottom trawls. In the western basin, net dimensions from the 1995 SCANMAR exercise are used for the OMNR vessel, while the 1997 results are applied to the ODNR vessel. In 2002, ODNR began interagency trawling with the new vessel R/V Explorer II, and SCANMAR was again employed to estimate the net dimensions in 2003. In 2003, a trawl comparison exercise among all western basin research vessels was initiated, and fishing power correction (FPC; Table 2.4.1) factors have been applied to the vessels administering the western basin Interagency Trawling Program (Tyson et al. 2006). Presently, the FTG estimates basin-wide abundance of forage fish in the western basin using information from SCANMAR trials, trawling effort distance, and catches from the August interagency trawling program. Species-specific abundance estimates (number/ha or number/m^3) are combined with length-weight data to generate a species-specific biomass estimate for each tow. Arithmetic mean volumetric estimates of abundance and biomass are extrapolated by depth strata (0-6m, >6m) to the entire western basin to obtain a FPC-adjusted, absolute estimate of forage fish abundance and biomass for each species. For reporting purposes, species have been pooled into three functional groups: clupeids (age-0 gizzard shad and alewife), soft-rayed fish (rainbow smelt, emerald and spottail shiners, other cyprinids, silver chub, trout-perch, and round gobies), and spiny-rayed fish (age-0 for each of white perch, white bass, yellow perch, walleye and freshwater drum).

Hypoxic conditions have been observed during previous years of interagency bottom trawl assessment in the west basin. Due to concerns about the potential effects of hypoxia on the distribution of juvenile percids and other species, representatives from task groups, the Standing Technical Committee, researchers from the Quantitative Fisheries Center at Michigan State University and Ohio State University (OSU) developed an interim policy for the assignment of bottom trawl status. Informed by literature (Eby and Crowder 2002, Craig and Crowder 2005) and field study (ODNR/OSU/USGS) concerning fish avoidance of hypoxic waters, an interim policy was agreed upon whereby bottom trawls that occurred in waters with dissolved oxygen less than or equal to 2 mg per liter would be excluded from analyses. The policy has been applied retroactively from 2009. Currently, there is no consensus among task groups on the best way to handle this sort of variability in the estimation of year-class strength in Lake Erie. In part, this situation is hampered by a lack of understanding of how fish distribution changes in response to low dissolved oxygen. This interim policy will be revisited in the future following an improved understanding of the relationship between dissolved oxygen and the distribution of fish species and their various life stages in Lake Erie. Please refer to the Habitat Task Group Report, section 2c, for current research on fish distribution changes in response to seasonal hypoxia (Habitat Task Group 2012).

2012 Results

In 2012, hypolimnetic dissolved oxygen levels were not below the 2 mg per liter threshold at any site during the August trawling survey. This represents the first year since 2008 in which no sites were excluded from analysis due to low dissolved oxygen. In total, data from 71 sites were used in 2012 (Figure 2.4.1).

Total forage abundance was above average in 2012, 2.8 times higher than in 2011 (Figure 2.4.2). Increases in soft-rayed fish and spiny-rayed fish (2.7 and 3.4 time increase, respectively) were responsible for this trend; clupeids increased only 2% compared to 2011. Total forage biomass in 2012 increased 37% (Figure 2.4.3). Relative biomass of clupeid, soft-rayed, and spiny-rayed species was 12.5%, 6.5%, and 81%, respectively, and differed from their respective historic averages of 28%, 8%, and 64%. Mean length of most age-0 sportfish in 2012 increased compared to 2011 (Figure 2.4.4). Mean lengths of select age-0 species include walleye (167 mm), yellow perch (68 mm), white bass (76 mm), white perch (58mm), and smallmouth bass (94 mm). These lengths are at or well above average (138 mm, 67 mm, 68 mm, 58 mm, and 79 mm, respectively).

Spatial maps of forage distribution were constructed using FPC-corrected site-specific catches (number/ha) of the functional forage groups (Figure 2.4.5). Abundance contours were generated using kriging techniques to interpolate abundance among trawl locations. Clupeid catches were highest around Sandusky Bay and North Bass Island. Soft-rayed fish were most abundant near the mouth of the Detroit River, Pigeon Bay, and along the shoreline east of Sandusky Bay. Spiny-rayed abundance was highest from Pelee Island west to the edge of the Ohio reef complex in the center of the basin. Relative contributions of the dominant species to the overall catch were as follows: age-0 white perch (75%), age-0 gizzard shad (7%), and age-0 emerald shiners (5%). Total forage abundance averaged 6,443 fish/ha across the western basin, increasing 2.8 times from 2011, and above the long-term average (5,268 fish/ha). Clupeid density was 483 fish/ha (average 1,065 fish/ha), soft-rayed fish density was 663 fish/ha (average 572 fish/ha), and spiny-rayed fish density was 5,298 fish/ha (average 3,631 fish/ha).

Recruitment of individual species is highly variable in the western basin. Age-0 yellow perch (68.1 fish/ha) decreased relative to 2011, while age-0 walleye (6.4 fish/ha) was similar to 2011 (Figure 2.4.6); both remain well below average. Age-0 white perch (4,838 fish/ha) increased sharply to the highest index since 2004. Age-0 white bass (171.5 fish/ha) increased, but remains below average. Age-0 smallmouth bass (0.6 fish/ha) declined to half the average. Age-0 and YAO rainbow smelt were low in 2012 (0.7 fish/ha and 0.2 fish/ha, respectively). Age-0 gizzard shad (482.8 fish/ha) were similar to 2011, and were below average, while alewife remain missing (Figure 2.4.7). Catches of age-0 emerald shiners (323.8 fish/ha) and YAO emerald shiners (140.7 fish/ha) increased and were well above average. Catches of round gobies (37.1 fish/ha) decreased from 2011, and represents the third lowest abundance since their discovery in 1997. Overall, 2012 catches of all shiner species increased and were well above average (Figure 2.4.8).

Adult walleye diets (by dry weight) taken from fall gillnet catches were dominated by gizzard shad (79%), emerald shiners (10%), and unidentified fish remains (10%) in the western basin. Yearling walleye relied on gizzard shad (52%), emerald shiner (38%) and unidentified fish remains (10%). In 2012, age-2-and-older yellow perch were collected for diet analyses from the western basin during spring (June) and fall (September) by the U.S. Geological Survey. Benthic macroinvertebrates had the highest occurrence during spring and fall (94.8% and 71.2%, respectively). *Dreissena sp*. and *Hexagenia sp*. were common in both time periods, whereas *Chironomidae* and *Trichoptera* were only common in spring samples. *Hemimysis sp*. was detected in spring samples at very low occurrence (1.3%). Zooplankton occurred in less than 5% of yellow perch diets during both spring and fall and *Bythotrephes sp*. was only detected in fall diets at low occurrence (1.7%). In contrast to 2011 data, fish prey had higher occurrence than zooplankton prey in both time periods with a dramatic increase in fish prey occurrence from spring (6.5%) to fall (37.3%) during 2012. Fish prey occurrence was uniform across prey taxa in spring, but round goby were the most commonly occurring fish prey in fall samples (11.9%). High occurrence of fish prey in diets during the fall of 2012 deviated from a decreasing historical trend.

Assessing diet composition by percent dry weight further revealed seasonal yellow perch foraging patterns. Similar to frequency of occurrence results, benthic invertebrates contributed most to diets by weight in spring (91.3%) and fall (62.9%). Zooplankton only contributed 3% to age-2-and-older yellow perch diets in spring and 1.9% in fall. The predominant benthic macroinvertebrate in diets was *Dreissena sp*., which contributed over 30% to diet weight in both seasons. A large increase in fish prey contributions to diet weight were observed from spring to fall (34.4%) and the major fish prey contributors in fall were round goby, unidentified fish, and gizzard shad (10.9%, 8.7%, and 5.1%, respectively). Evaluating diet contributions by percent weight provided an alternative index of prey importance to age-2-and-older yellow perch with implications for evaluating energy contributions from prey resources. Thus, future age-2-and-older diet composition data should include results from both prey occurrence and percent composition by weight analyses.

Table 2.2.1 Indices of relative abundance of selected forage fish species in Eastern Lake Erie from bottom trawl surveys conducted by Ontario, New York, and Pennsylvania for the most recent 10-year period. Indicies are reported as arithmetic mean number caught per hectare (NPH) for the age groups young-of-the-year (YOY), yearling-and-older (YAO), and all ages (ALL). Long-term averages are reported as the mean of the annual trawl indices for the most recent 10-year period (2002-2011) and for the two most recent completed decades. Agency trawl surveys are described below. Pennsylvania FBC (PA-Fa) did not conduct a fall index trawl survey in 2006, 2010, and 2011 and the 2008 survey was a reduced effort of four tows sampled in a single day.

	Age	Trawl	Year										10-Yr & Long-term Avg. by decade		
Species	**Group**	**Survey**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**10-Yr**	**2000's**	**1990's**
Rainbow	**YOY**	ON-DW	1657.7	509.2	326.9	148.2	1293.0	991.3	1256.0	0.9	132.2	7058.1	1185.8	1391.5	431.7
Smelt	**YOY**	NY-Fa	413.6	1580.4	1416.6	64.9	2128.9	2889.6	507.9	1259.6	1146.1	1733.4	1433.4	1524.9	1450.9
	YOY	PA-Fa	560.2	NA	NA	47.7	15.1	260.2	NA	47.9	12.3	592.2	153.3	138.2	550.8
	YAO	ON-DW	367.8	277.1	222.7	1654.3	77.3	232.8	136.2	7.6	565.6	205.8	338.5	360.7	358.6
	YAO	NY-Fa	22.1	640.1	997.8	3016.6	546.5	176.9	162.9	395.2	2624.1	282.1	895.9	753.4	581.6
	YAO	PA-Fa	22.3	NA	NA	407.2	1.8	1006.3	NA	0.0	12.3	32.4	209.5	164.5	378.0
Emerald	**YOY**	ON-DW	438.3	70.3	117.6	54.8	16.0	29.3	452.3	645.7	20.3	3388.0	480.4	463.2	52.3
Shiner	**YOY**	ON-OB	23.8	1.1	0.0	0.0	0.5	1.2	12.4	1.1	258.3	0.0	27.5	27.6	3.2
	YOY	NY-Fa	94.3	2930.1	62.9	48.5	3.7	150.9	778.5	291.4	7.8	229.7	452.3	194.0	112.4
	YOY	PA-Fa	14.8	NA	NA	1063.0	0.0	81.7	NA	0.5	0.0	1163.4	340.4	264.8	41.0
	YAO	ON-DW	119.2	201.1	30.7	40.1	95.2	149.8	4200.3	139.0	891.2	204.7	620.0	819.0	37.7
	YAO	ON-OB	12.4	16.1	0.0	4.8	3.0	84.3	499.6	0.1	73.8	6.7	70.2	72.0	4.6
	YAO	NY-Fa	93.8	1826.2	20.6	156.4	18.2	84.8	925.5	151.4	284.2	444.5	437.8	290.8	105.4
	YAO	PA-Fa	86.9	NA	NA	1360.3	0.0	4713.1	NA	52.5	0.0	157.6	912.7	710.4	14.5
Spottail	**YOY**	ON-OB	19.1	2.5	3.0	3.7	37.8	35.2	19.8	58.7	43.8	74.1	29.5	119.3	815.9
Shiner	**YOY**	ON-IB	0.0	0.0	0.0	0.0	0.0	0.5	0.1	1.0	0.2	0.4	0.2	0.5	113.9
	YOY	NY-Fa	1.8	0.7	6.5	0.1	0.3	0.1	0.5	0.5	0.1	13.2	2.3	5.6	19.9
	YOY	PA-Fa	0.0	NA	NA	1.1	0.0	0.0	NA	0.0	0.0	0.0	0.2	0.1	4.0
	YAO	ON-OB	1.6	0.5	2.1	3.3	7.5	4.1	10.4	3.2	10.4	5.9	5.9	10.8	74.6
	YAO	ON-IB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.1	2.0
	YAO	NY-Fa	2.0	29.0	10.4	5.1	1.5	0.0	4.1	4.3	2.5	4.8	9.6	6.4	4.0
	YAO	PA-Fa	0.1	NA	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.1	0.1	7.9
Alewife	**YOY**	ON-DW	707.3	2.1	0.9	0.1	2.3	1.0	78.6	0.1	0.3	0.5	12.1	22.5	231.2
	YOY	ON-OB	6.0	6.8	0.0	1.9	11.9	44.6	711.8	11.0	1.5	17.6	81.9	82.1	88.5
	YOY	NY-Fa	183.8	12.4	15.4	0.0	5.6	22.2	30.8	27.7	4.4	3.9	74.0	94.3	52.0
	YOY	PA-Fa	4.6	NA	NA	0.0	0.0	8.0	NA	0.0	0.0	2.5	1.6	1.3	7.7
Gizzard	**YOY**	ON-DW	47.6	18.9	13.3	0.4	86.5	34.6	1.4	1.7	0.2	68.6	22.9	21.3	7.5
Shad	**YOY**	ON-OB	20.0	3.4	3.8	0.0	4.0	22.0	28.7	1.9	1.0	5.1	7.1	7.6	13.4
	YOY	NY-Fa	4.7	15.0	40.9	5.3	10.8	11.7	14.1	3.7	0.6	27.8	13.5	11.9	4.2
	YOY	PA-Fa	1.0	NA	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.1	0.1	0.9
White	**YOY**	ON-DW	0.8	0.0	1.6	0.6	5.4	0.1	0.9	0.1	0.0	16.2	2.5	2.9	1.8
Perch	**YOY**	ON-OB	0.9	0.0	0.0	0.0	2.1	0.7	1.2	0.4	0.2	14.6	1.9	2.8	17.6
	YOY	NY-Fa	18.3	36.5	157.3	20.2	431.5	34.6	91.9	99.8	1.0	37.7	91.7	74.3	29.4
	YOY	PA-Fa	380.0	NA	NA	598.5	0.7	444.6	NA	51.2	0.0	523.9	231.3	256.0	101.1
Trout	**All**	ON-DW	0.0	0.0	0.3	0.8	0.8	0.8	1.1	0.0	1.7	2.7	0.9	0.9	0.6
Perch	**All**	NY-Fa	338.9	654.3	461.6	517.0	996.4	561.2	519.4	1317.3	545.9	1392.6	786.4	826.0	410.0
	All	PA-Fa	52.2	NA	NA	558.8	0.6	156.9	NA	198.5	160.3	256.6	190.2	152.1	50.9
Round	**All**	ON-DW	129.0	125.4	9.7	43.6	452.6	973.2	93.3	66.9	323.8	158.8	237.4	235.9	0.0
Goby	**All**	ON-OB	68.0	103.3	67.6	91.2	63.4	73.9	32.7	28.0	94.4	114.2	82.0	86.9	0.1
	All	ON-IB	80.2	114.6	135.1	280.5	211.8	263.0	34.0	21.0	95.4	28.6	124.0	120.0	0.1
	All	NY-Fa	180.2	165.8	173.3	502.6	466.8	1293.2	846.5	707.0	1094.5	613.4	599.9	651.7	35.9
	All	PA-Fa	31.6	NA	NA	350.1	441.6	2043.8	NA	887.8	927.5	387.3	726.0	1094.6	30.3

"**NA**" denotes that reporting of indices was Not Applicable or that data were Not Available.

Ontario Ministry of Natural Resources Trawl Surveys

ON-DW Trawling is conducted weekly during October at 4 fixed stations in the offshore waters of Outer Long Point Bay using a 10-m trawl with 13-mm mesh cod end liner. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

ON-OB Trawling is conducted weekly during September and October at 3 fixed stations in the nearshore waters of Outer Long Point Bay using a 6.1-m trawl with a 13-mm mes cod end liner. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

ON-IB Trawling is conducted weekly during September and October at 4 fixed stations in Inner Long Point Bay using a 6.1-m trawl with a 13-mm mesh cod end liner. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

New York State Department of Environment Conservation Trawl Survey

NY-Fa Trawling is conducted at approximately 30 nearshore (15-30 m) stations during October using a 10-m trawl with a 9.5-mm mesh cod end liner. Indices are reported as NPH; 90's Avg. is for the period 1992 to 1999; 00's Avg. is for the period 2000 to 2009.

Pennsylvania Fish and Boat Commission Trawl Survey

PA-Fa Trawling is conducted at nearshore (< 22 m) and offshore (> 22 m) stations during October using a 10-m trawl with a 6.4-mm mesh cod end liner. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

Table 2.3.1 Relative abundance (arithmetic mean number per hectare) of selected age-0 species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 2002-2012. Ohio West (OH West) is the area of the central basin from Huron, OH, to Fairport Harbor, OH. Ohio East (OH East) is the area of the central basin from Fairport Harbor, OH to the Ohio-Pennsylvania state line. PA is the area of the central basin from the Ohio-Pennsylvania state line to Presque Isle, PA.

		Year											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Species	Survey												
Yellow	OH west	114.6	149.0	8.7	37.8	10.0	167.0	37.3	1.3	41.1	8.7	75.8	57.6
Perch	OH east	13.6	47.5	1.9	156.2	18.9	177.8	52.8	0.5	96.3	14.1	134.4	58.0
	PA	388.4	788.0	2.4	-	-	10.0	863.4	14.2	-	-	487.2	344.4
White	OH west	779.7	310.1	759.7	1002.5	440.4	1381.2	544.9	506.1	254.8	368.3	1896.4	634.8
Perch	OH east	57.6	61.8	108.0	2034.5	46.1	1095.9	91.6	34.6	190.3	84.8	661.9	380.5
	PA	26.6	173.8	2.4	-	-	17.8	199.0	146.5	-	-	370.6	94.3
Rainbow	OH west	2.3	1753.9	352.1	10.7	94.3	98.1	635.2	293.5	776.2	42.4	76.2	405.9
smelt	OH east	0.0	2914.1	388.9	44.4	570.7	702.4	3997.7	0.3	421.6	256.1	319.1	929.6
	PA	377.4	177.6	20.9	-	-	35.1	552.2	23.4	-	-	8.5	197.8
Round	OH west	43.9	22.6	13.9	37.2	19.0	26.9	17.4	25.9	28.4	102.8	19.8	33.8
Goby	OH east	39.6	57.5	173.9	148.1	46.3	273.1	26.3	1.0	41.8	258.9	53.9	106.7
	PA	1577.8	75.3	1011.3	-	-	227.8	227.1	72.2	-	-	2.4	531.9
Emerald	OH west	50.5	477.6	7.0	567.1	587.2	52.6	36.3	6.1	8.8	414.5	1144.7	220.8
Shiner	OH east	2.2	903.1	0.8	279.8	1115.1	63.7	20.2	1.7	234.9	105.4	2188.5	272.7
	PA	8.5	81.8	0.0	-	-	0.8	0.0	303.2	-	-	0.0	65.7
Spottail	OH west	5.9	0.0	0.0	0.2	0.0	3.1	3.7	0.6	0.0	0.6	0.0	1.4
Shiner	OH east	0.7	0.5	0.0	1.1	0.2	0.5	0.2	0.0	0.0	0.4	0.0	0.4
	PA	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Alewife	OH west	50.8	0.1	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	5.5
	OH east	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.1	0.4
	PA	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	2.8	0.0
Gizzard	OH west	60.3	402.6	0.6	12.3	32.7	195.0	35.7	50.9	2.6	770.3	119.1	156.3
Shad	OH east	1.8	20.4	0.3	15.7	30.7	15.5	63.1	3.9	8.5	4.0	28.7	16.4
	PA	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Trout-	OH west	2.0	2.0	20.3	0.1	0.2	0.8	0.3	0.3	0.7	1.6	0.0	2.8
perch	OH east	0.0	1.4	1.4	1.6	0.1	5.4	0.1	0.2	1.4	2.7	0.2	1.4
	PA	7.8	78.0	6.7	-	-	10.9	126.1	28.1	-	-	0.0	43.0

- The Pennsylvania Fish and Boat Commission was unable to sample in 2005, 2006, 2010 and 2011.

Table 2.3.2 Relative abundance (arithmetic mean number per hectare) of selected yearling-and-older species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 2002-2012. Ohio West (OH West) is the area of the central basin from Huron, OH, to Fairport Harbor, OH. Ohio East (OH East) is the area of the central basin from Fairport Harbor, OH to the Pennsylvania state line. PA is the area of the central basin from the Ohio-Pennsylvania state line to Presque Isle, PA.

		Year											
Species	Survey	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Yellow	OH west	5.7	3.2	216.5	18.3	4.2	19.8	56.6	20.7	11.9	5.5	8.5	36.2
Perch	OH east	0.4	1.2	45.2	132.3	12.5	37.0	26.4	139.4	12.4	50.5	23.3	45.7
	PA	41.3	75.6	18.3	-	-	27.4	76.4	120.9	-	-	100.1	60.0
White	OH west	21.7	28.2	83.9	34.1	32.4	27.1	76.5	42.0	32.6	25.0	58.9	40.4
Perch	OH east	0.4	12.0	27.0	20.1	38.5	16.8	36.6	282.3	44.8	45.1	7.7	52.4
	PA	2.4	28.6	6.2	-	-	0.8	4.2	63.3	-	-	6.8	17.6
Rainbow	OH west	55.6	29.4	320.5	89.8	8.9	40.4	9.6	419.4	18.0	35.8	15.3	102.7
Smelt	OH east	3.3	370.3	1360.2	30.8	17.3	532.4	64.9	109.1	56.9	176.0	143.1	272.1
	PA	0.0	22.1	9.9	-	-	10.7	3.5	408.0	-	-	20.0	75.7
Round	OH west	54.8	25.4	27.0	33.6	20.4	26.3	57.9	58.0	44.0	63.7	13.2	41.1
Goby	OH east	88.4	127.1	148.8	263.0	78.9	185.6	167.8	19.3	36.0	123.8	27.0	123.9
	PA	55.2	59.1	767.0	-	-	361.1	326.6	75.9	-	-	71.4	274.2
Emerald	OH west	106.3	54.9	1.5	233.6	162.7	418.7	495.0	99.5	51.5	171.6	1128.6	179.5
Shiner	OH east	0.7	432.0	0.4	479.6	451.1	27.8	1159.4	167.8	375.1	145.2	433.2	323.9
	PA	0.0	217.5	0.0	-	-	769.5	28.0	171.5	-	-	9.0	197.7
Spottail	OH west	3.5	1.6	5.3	0.3	1.2	2.3	2.3	3.1	0.0	23.5	0.0	4.3
Shiner	OH east	1.1	1.0	0.2	3.8	0.7	0.6	2.9	0.0	0.0	4.1	3.0	1.4
	PA	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Trout-	OH west	3.2	12.2	14.0	13.5	3.3	5.5	4.8	0.8	0.7	3.9	1.6	6.2
perch	OH east	2.2	2.9	7.7	76.2	4.8	6.7	8.4	1.5	5.0	8.9	11.7	12.4
	PA	0.6	50.9	5.2	-	-	16.0	61.7	127.3	-	-	30.4	43.6

\- The Pennsylvania Fish and Boat Commission was unable to sample in 2005, 2006, 2010 and 2011.

Table 2.4.1. Mean catch-per-unit-effort (CPUE) and fishing power correction factors (FPC) by vessel-species-age group combinations. All FPCs are calculated relative to the R.V. Keenosay.

Vessel	Species	Age group	Trawl Hauls	Mean CPUE (#/ha)	FPC	95% CI	Apply rule [a]
R.V. Explorer	Gizzard shad	Age 0	22	11.81	2.362	-1.26-5.99	Y
	Emerald shiner	Age 0+	50	67.76	1.494	0.23-2.76	Y
	Troutperch	Age 0+	51	113.20	0.704	0.49-0.91 z	Y
	White perch	Age 0	51	477.15	1.121	1.01-1.23 z	Y
	White bass	Age 0	50	11.73	3.203	0.81-5.60	Y
	Yellow perch	Age 0	51	1012.15	0.933	0.62-1.24	N
	Yellow perch	Age 1+	51	119.62	1.008	0.72-1.30	N
	Walleye	Age 0	51	113.70	1.561	1.25-1.87 z	Y
	Round goby	Age 0+	51	200.27	0.423	0.22-0.63 z	Y
	Freshwater drum	Age 1+	51	249.14	0.598	0.43-0.76 z	Y
R.V. Gibraltar	Gizzard shad	Age 0	29	14.22	1.216	-0.40-2.83	Y
	Emerald shiner	Age 0+	43	51.30	2.170	0.48-3.85	Y
	Troutperch	Age 0+	45	82.11	1.000	0.65-1.34	N
	White perch	Age 0	45	513.53	0.959	0.62-1.30	N
	White bass	Age 0	45	21.88	1.644	0.00-3.28	Y
	Yellow perch	Age 0	45	739.24	1.321	0.99-1.65	Y
	Yellow perch	Age 1+	45	94.56	1.185	0.79-1.58	Y
	Walleye	Age 0	45	119.17	1.520	1.17-1.87 z	Y
	Round goby	Age 0+	45	77.36	0.992	0.41-1.57	N
	Freshwater drum	Age 1+	45	105.21	1.505	1.10-1.91 z	Y
R.V. Grandon	Gizzard shad	Age 0	29	70.87	0.233	-0.06-0.53 z	Y
	Emerald shiner	Age 0+	34	205.43	0.656	-0.04-1.35	Y
	Troutperch	Age 0+	35	135.93	0.620	0.42-0.82 z	Y
	White perch	Age 0	36	771.40	0.699	0.44-0.96 z	Y
	White bass	Age 0	36	34.92	0.679	0.43-0.93 z	Y
	Yellow perch	Age 0	36	1231.63	0.829	0.58-1.08	Y
	Yellow perch	Age 1+	36	123.35	0.907	0.58-1.23	Y
	Walleye	Age 0	36	208.59	0.920	0.72-1.12	Y
	Round goby	Age 0+	36	161.78	0.501	0.08-0.92 z	Y
	Freshwater drum	Age 1+	36	58.82	2.352	1.51-3.19 z	Y
R.V. Musky II	Gizzard shad	Age 0	24	8.80	1.885	-1.50-5.26	Y
	Emerald shiner	Age 0+	47	32.29	3.073	0.36-5.79	Y
	Troutperch	Age 0+	50	62.35	1.277	0.94-1.62	Y
	White perch	Age 0	50	255.71	2.091	1.37-2.81 z	Y
	White bass	Age 0	46	8.35	4.411	0.90-7.92	Y
	Yellow perch	Age 0	50	934.03	1.012	0.77-1.26	N
	Yellow perch	Age 1+	50	34.94	3.452	1.23-5.67 z	Y
	Walleye	Age 0	50	63.70	2.785	2.24-3.33 z	Y
	Round goby	Age 0+	49	66.87	1.266	0.39-2.14	Y
	Freshwater drum	Age 1+	49	1.60	93.326	48.39-138.26 z	Y

z - Indicates statistically significant difference from 1.0 (α=0.05); [a] Y means decision rule indicated FPC application was warranted; , N means decision rule indicated FPC application was not warranted

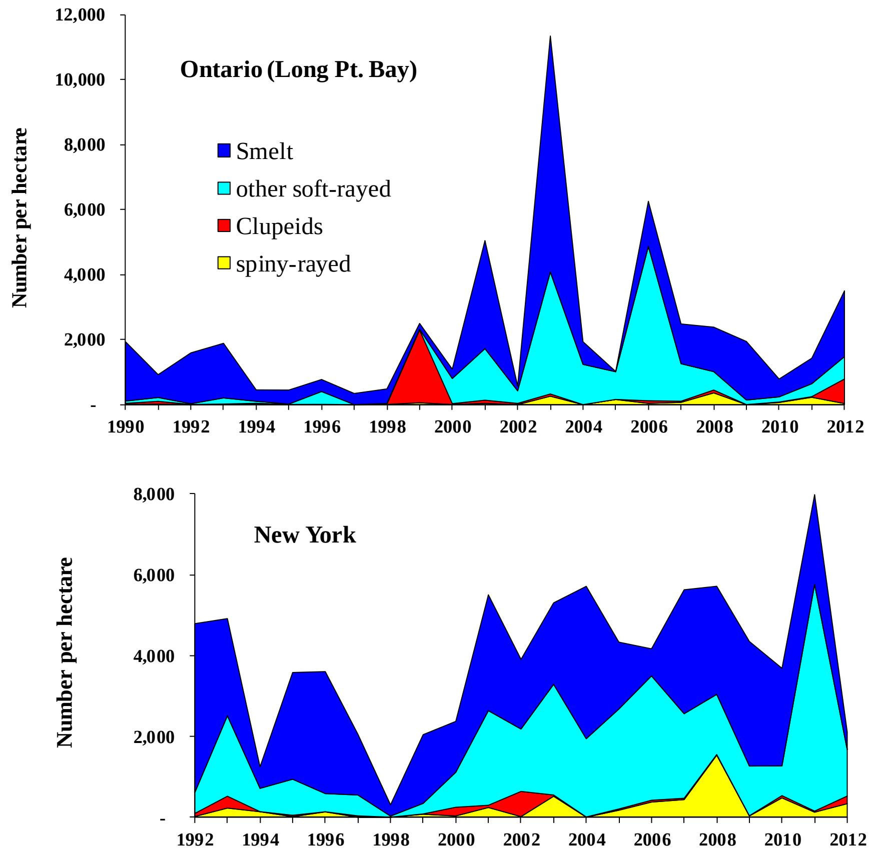


Figure 2.2.1 Mean density of prey fish (no./ha) by functional group in the Ontario and New York waters of the eastern basin, Lake Erie, 1990-2012.

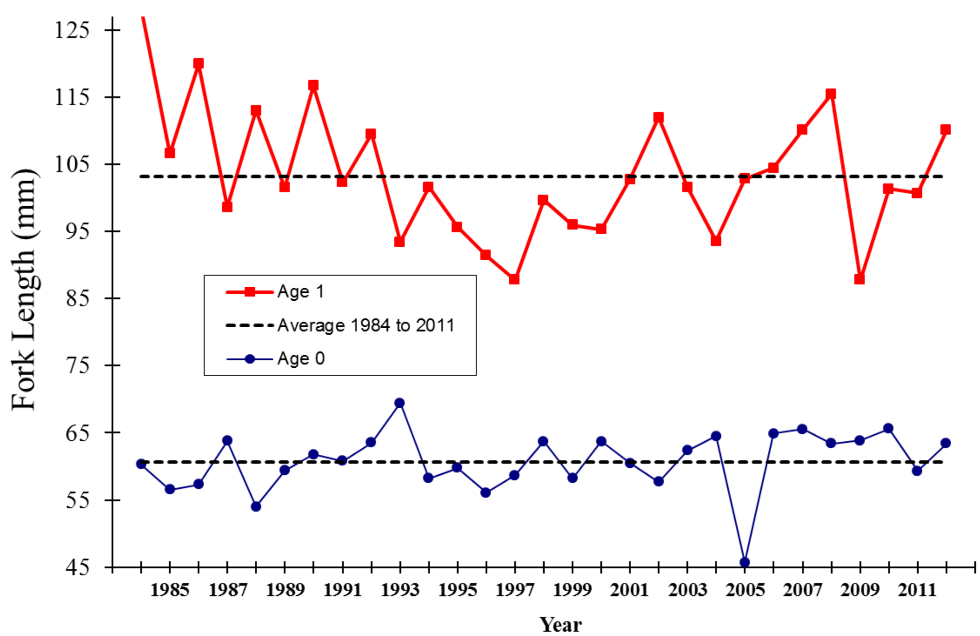


Figure 2.2.2 Mean fork length of age 0 and 1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 2012.

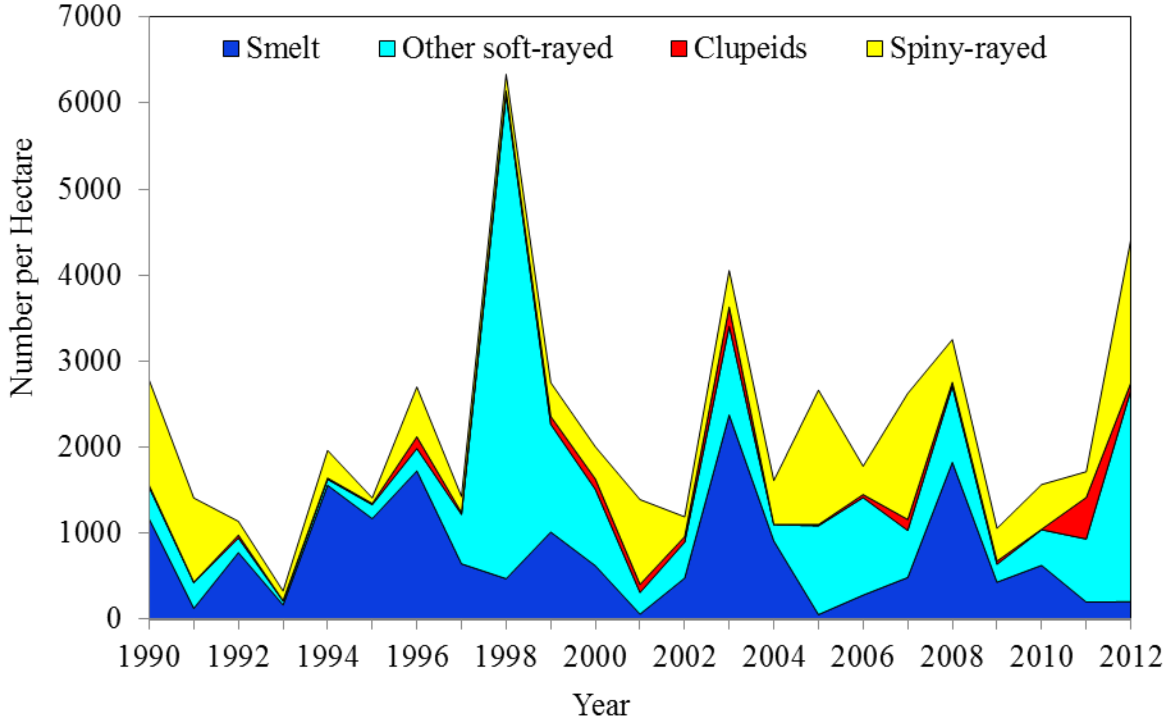


Figure 2.3.1 Mean density of prey fish (no./ha) by functional group in the Ohio waters of the central basin, Lake Erie, 1990-2012.

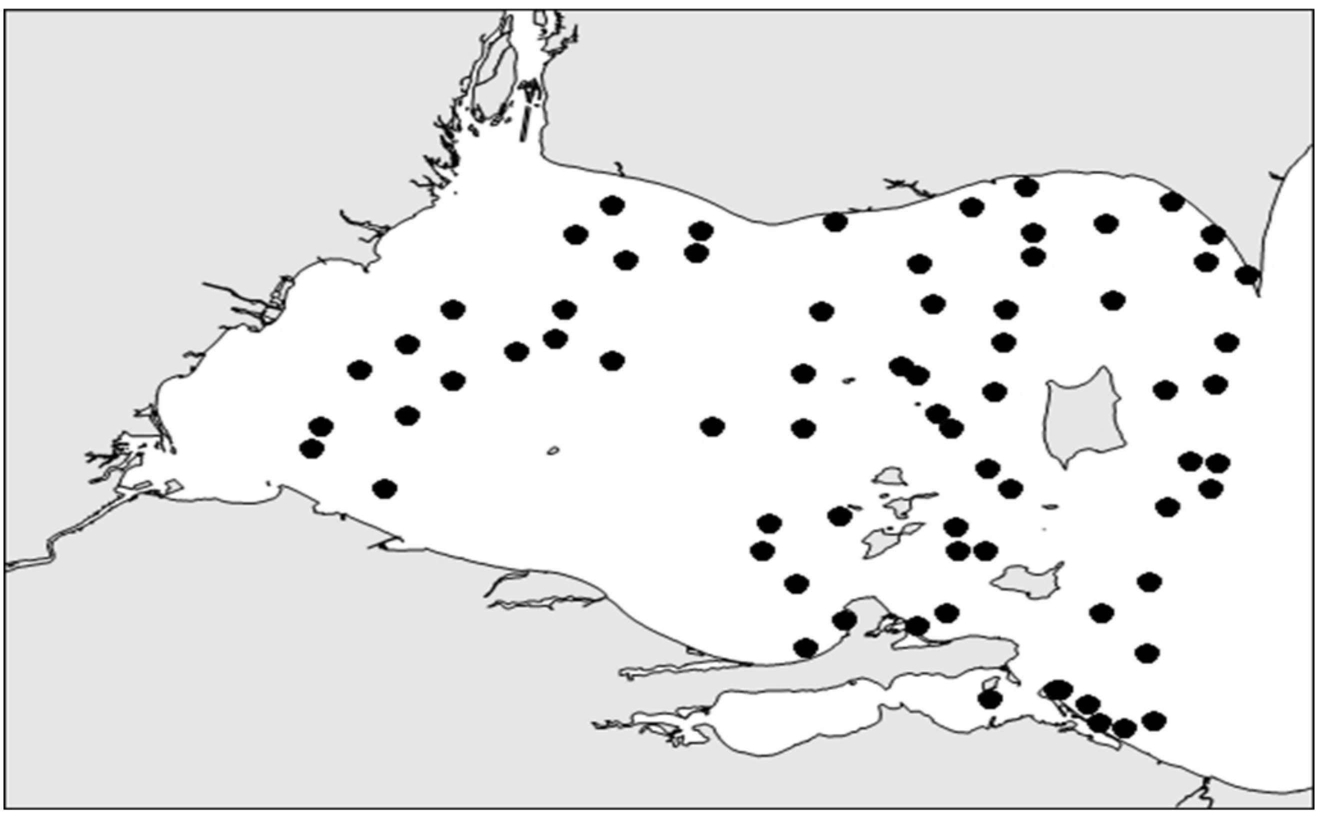


Figure 2.4.1. Trawl locations for the western basin interagency bottom trawl survey, August 2012.

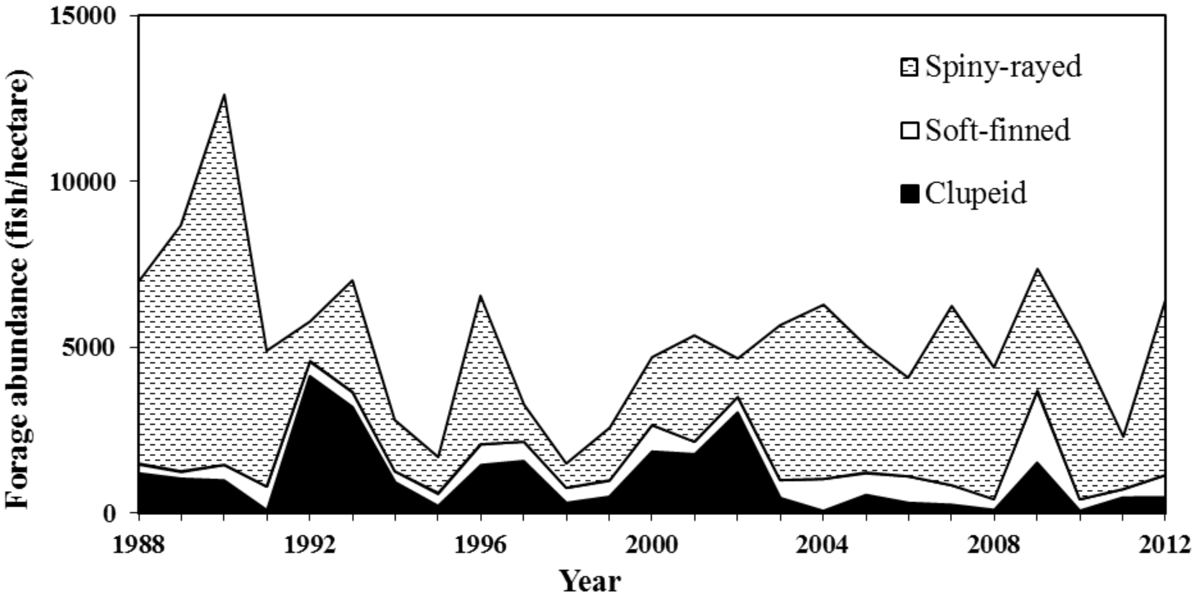


Figure 2.4.2. Mean density (no. / ha) of prey fish by functional group in western Lake Erie, August 1988-2012.

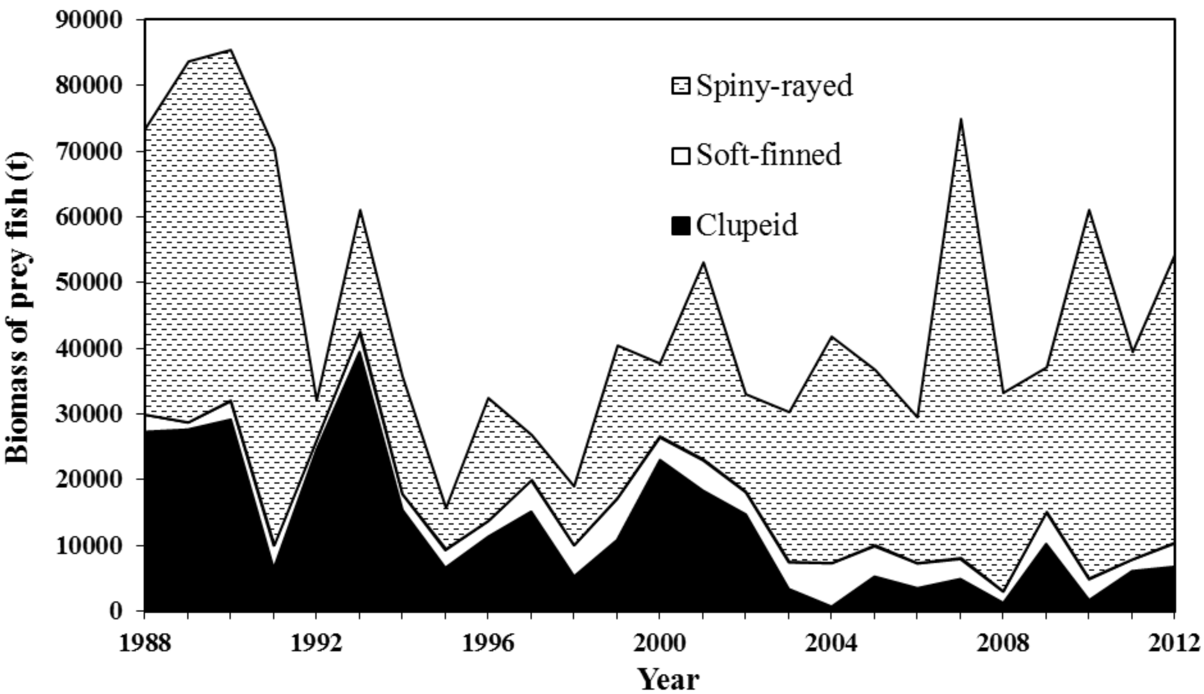


Figure 2.4.3. Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2012.

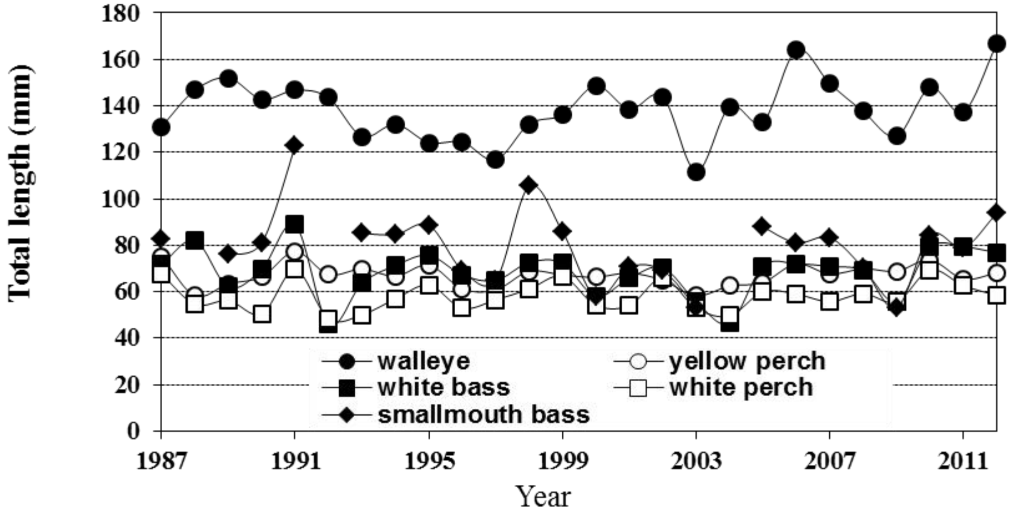


Figure 2.4.4. Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2012.

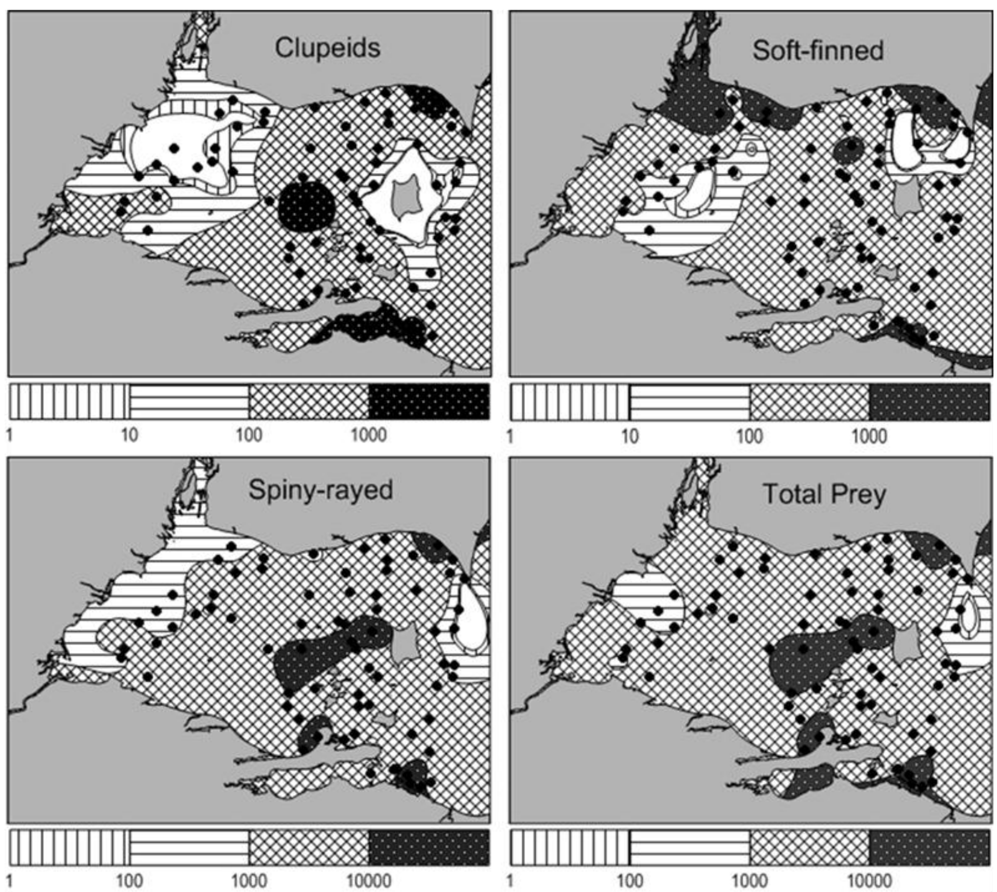


Figure 2.4.5. Spatial distribution of clupeids, soft-finned, spiny-rayed, and total forage abundance (individuals per hectare) in western Lake Erie, 2012. Black dots are trawl sites, white areas are estimates of zero abundance, and contour levels vary with the each functional fish group.

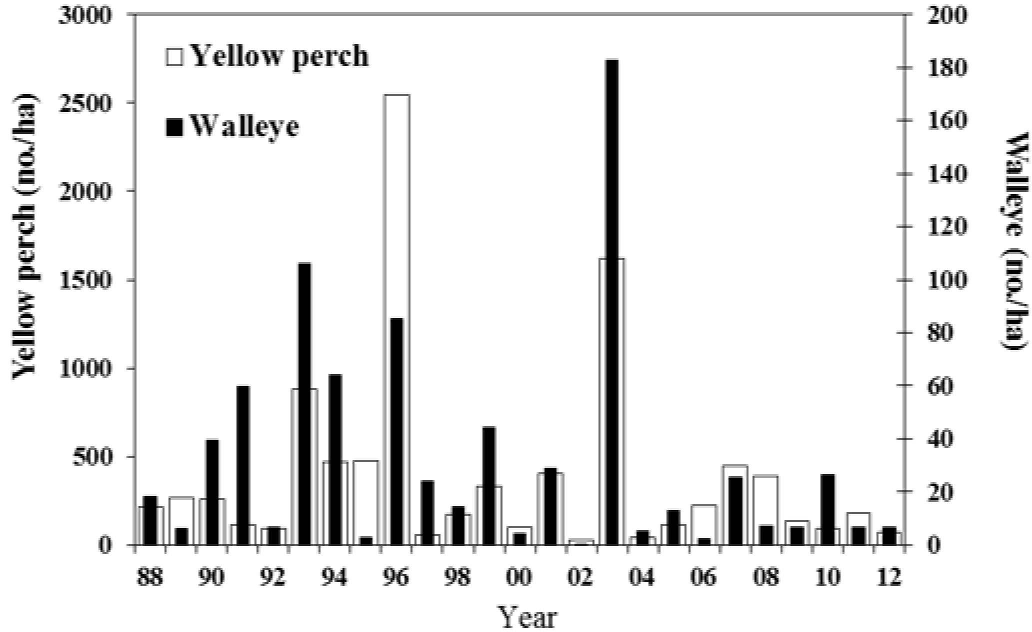


Figure 2.4.6. Density of age-0 yellow perch and walleye in the western basin of Lake Erie, August 1988-2012.

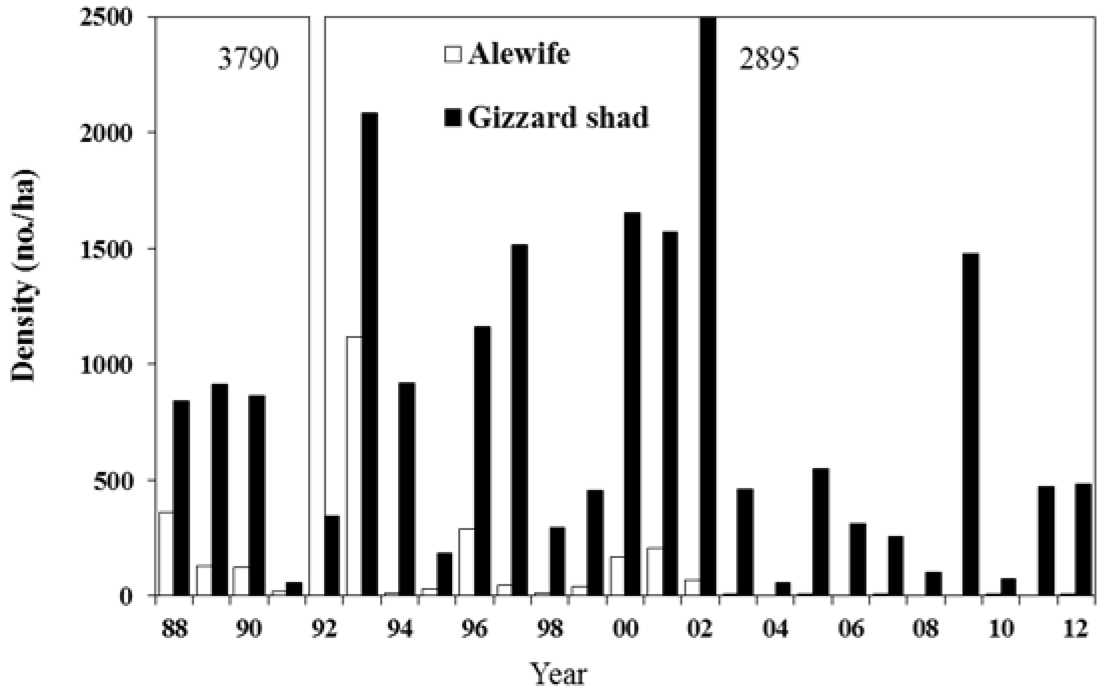


Figure 2.4.7. Density of age-0 alewife and gizzard shad in the western basin of Lake Erie, August 1988-2012.

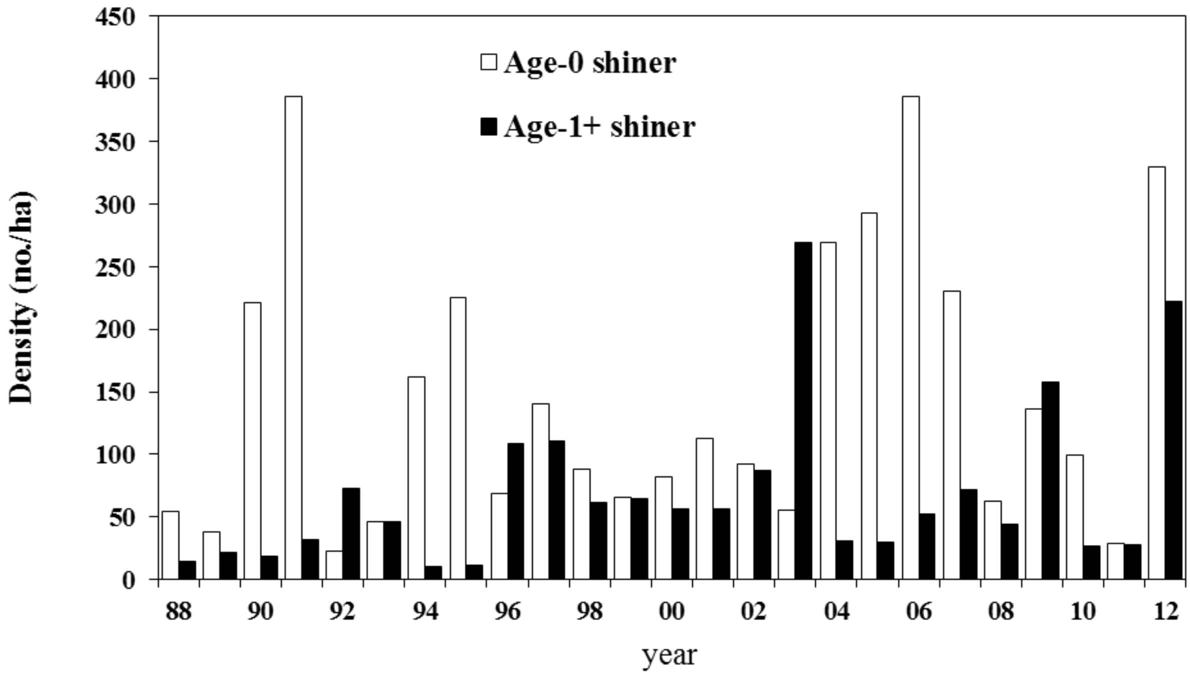


Figure 2.4.8. Density of age-0 and age-1+ shiners (*Notropis* spp.) in the western basin of Lake Erie, August 1988-2012.

3.0 Interagency Trawling Program

An ad-hoc Interagency Index Trawl Group was formed in 1992 to examine the interagency index trawl program in western Lake Erie and recommend standardized trawling methods for assessing fish community indices; and second, to lead the agencies in calibration of index trawling gear using SCANMAR acoustical instrumentation. Before dissolving in March 1993, the ITG recommended the Forage Task Group continue the work on interagency trawling issues. Progress on these charges is reported below.

3.1 Summary of Species CPUE Statistics

The FTG has been estimating basin-wide abundance of forage fish in the western basin using information from SCANMAR trials, trawling effort distance, and catches from the August interagency trawling program since 1988. The latest improvement to the survey incorporated the FPC factors that were developed from the trawl comparison exercise conducted in 2003 (Tyson et al. 2006). The August interagency survey was adopted by western basin agencies as the standard assessment for basin-wide fish community abundance. Data from the interagency survey is now incorporated into the western basin, *Status and Trends of Forage Fish Species*, Section 2.4.

3.3 Trawl Comparison Exercise (R. Kraus)

In 2003, a west basin trawl calibration exercise occurred that applied fishing power corrections to all trawling vessels in the western basin (Tyson et al. 2006). This exercise allowed western basin agencies the ability to compile all their trawling data together on an even scale, thus giving managers an entire view of forage fishes across the basin and an enhanced percid recruitment index.

In 2012, the USGS-Lake Erie Biological Station (USGS-LEBS) launched a new vessel, the *R/V Muskie*. During August 7-8, a trawl comparison exercise was conducted to examine the stability of fishing power correction (FPC) factors from 2003 to 2012 and develop new FPC values for the *R/V Muskie*. The vessels participating in the west basin exercise were the *R/V Explorer* (ODNR-DOW), *R/V Gibraltar* (Ohio State University), *R/V Muskie* (USGS-LEBS), *R/V Musky II* (USGS-LEBS), and *R/V Keenosay* (OMNR). Side scan and vertical scan images of each vessel's trawl were collected during the exercise to measure net geometry. Initial results indicated that the standard gears for Ohio and Ontario agencies have similar catch rates. There was little change from 2003 in the gear comparisons, despite order of magnitude differences in abundance for some species (such as white perch). The new USGS vessel tended to capture more pelagic species (emerald shiner and gizzard shad) and fewer benthic species (trout-perch and round goby) than the Ohio and Ontario gears. Sample size was determined to be a significant limitation in the 2012 data, and Monro's (1998) decision rule indicated that application of FPC's from these data would tend to inflate variance and should not be applied. Future efforts will include size selectivity analysis of catches from the 2012 data set, and all agencies involved in this work agreed to look for opportunities to augment comparison trawl data with additional sampling.

4.0 Hydroacoustic Survey Program

4.1 East Basin Acoustic Survey (L. Witzel and D. Einhouse)

Introduction

Beginning in 1993, a midsummer East Basin fisheries acoustic survey was implemented to provide a more comprehensive evaluation of the distribution and abundance of rainbow smelt. This initiative has been pursued under the auspices of the Lake Erie Committee's Forage Task Group (FTG), and is a collaboration of the Ministry of Natural Resources (OMNR, Port Dover, ON), New York State Department of Environmental Conservation (NYSDEC, Dunkirk, NY) and Cornell University's Warmwater Fisheries Unit through coordinated management efforts facilitated by the Great Lakes Fishery Commission (GLFC).

One of the more prominent advancements in the development of an acoustic survey program was achieved when Lake Erie's FTG was successful in being awarded a grant to purchase a modern signal processing and data management system for inter-agency fisheries acoustic surveys on Lake Erie (Einhouse and Witzel 2003). The new data processing system (Echoview) arrived in 2002. In 2003, Lake Erie representatives from NYSDEC and OMNR also attended a training workshop to attain proficiency in this new software. The newly trained biologists then hosted a second workshop to introduce this signal processing system to the Lake Erie FTG. During 2005 FTG members upgraded the Lake Erie acoustic hardware system through the purchase of a Simrad EY60 GPT/transducer. In 2008, 2009, and 2010 several members of Lake Erie's FTG participated in an ongoing series of workshops, devoted to the development of Standard Operating Procedures (SOP) for hydroacoustic surveys in the Great Lakes region (Parker-Stetter et al. 2009, Rudstam et al. 2009). Completion of the 2008 workshop represented a benchmark event toward implementation of the SOP's in Lake Erie basin acoustic surveys, and specifically for the East Basin, then proceeding to re-processing an acoustic data series beginning in 1997 and applying new standards. A primary focus of the 2009 workshop was to compare present-day acoustic methods used in various acoustic assessments across the Great Lakes with results from following the SOP, and further publications by the principal investigators within this study group are anticipated (Kocovsky et al. in review). Additional GLFC funds were awarded to the Great Lake Acoustic Study Group to convene a workshop that will begin the development of standard protocols for conducting acoustic assessment-based ground-truth trawling operations. This latest workshop was successfully completed at the Lake Erie Biological Station USGS Great Lakes Science Centre, Sandusky, Ohio during September 27 – October 1, 2010.

Survey Methods and Acoustic Series Standardized Analysis

Procedures for the east basin acoustic survey have now been completed largely through the support of GLFC sponsored project "Study group on fisheries acoustics in the Great Lakes". At this time the principal investigators for Lake Erie's east basin survey are incorporating the new SOP for each survey year, and then re-computing fish densities based on these new standards. Among these standard data processing elements is the use of the N_v index (Sawada et al. 1993), a type of data quality control filter to remove possible bias associated with overestimates of in-situ target strength that can occur at high fish densities if multiple echoes (superimposed) are falsely detected as single targets (Rudstam et al. 2003). Additionally, a standard objective method has now been developed to ascribe passive noise thresholds for each survey transect. Documentation of our data collection and processing methods is long overdue and progress continues along with accompanying results for the entire split-beam time series of the Eastern Lake Erie Acoustic Survey (since 1997).

At this writing, the acoustic data series from 1998 to 2003 and from 2007 to 2012 has been re-processed and analyzed using our new survey standards. We previously reported results for the 1999 to 2003 survey years in the 2009 Forage Task Group annual report (Forage Task Group 2009). In this report we highlight results for the six most recent east basin survey years 2007 to 2012.

In general, standard survey procedures have been in-place for offshore transect sampling of eastern Lake Erie since 1993. This midsummer, mobile nighttime survey is implemented as an interagency program involving multiple vessels to collect acoustic signals of pelagic fish density and distribution, with an accompanying mid-water trawling effort to characterize fish species composition.

In 2012, the east basin acoustic team upgraded both of their two Echoview software licenses (from version 3.45 to 5.1).

The 2012 Survey

In most years since 1997, the east basin survey has been accomplished as a two-agency endeavour. Acoustic data acquisition to determine fish densities and distribution were measured with a modern scientific echosounder. The current system consists of a Simrad EY60 120 kHz split-beam GPT, with a 7-degree beam transducer mounted on a fixed pole in a down facing orientation approximately 1 m below the water surface on the starboard side of OMNR's research vessel, *RV Erie Explorer*. Acoustic data were collected at 300 watts power output, 256 µsec pulse duration, and 2 per second ping rate. Precise navigation of randomly selected acoustic transects was accomplished through an interface of the vessel's GPS system to a personal computer (PC) running marine navigation software (Nobeltec Navigation Suite ver7) and the ship's autopilot. The same GPS unit was also connected to a second PC running the Simrad ER60 software controlling the EY60 echosounder. Geo-referenced raw acoustic data were logged to 10-megabyte size files on the host PC.

The 2012 survey was completed in five nights from July 15 to 25; acoustic sampling was suspended due to poor weather on four nights during this period (Figure 4.1.1). A full complement of twelve acoustic transects were sampled totaling 325 kilometers. Approximately 999,200 KB of raw acoustic data were recorded including about 47,000 KB of stationary sampling at the ends of some transects to assess target strength (TS) variability of individual fish tracks. A total of 30 water temperature-depth profiles were sampled across all transects in 2012. Companion mid-water trawl collections to obtain representative samples of the pelagic forage fish community for apportioning of acoustic targets was limited to a one-night effort on July 18(PM)-19(AM). NYSDEC staff aboard R/V ARGO, completed four mid-water trawl tows in the southern half of transects 58864 and 58923 (Figure 4.1.1).

Acoustic data were processed using the Myriax Echoview 5.1 software. Acoustic echograms were partitioned into two depth strata, epilimnion and meta-hypolimnion, based on an approximate depth of the 18-Celsius isotherm (from TD profiles) and from a pre-analysis of the relative proportion of Age-0-size rainbow smelt (-70 to -59 dB) to ALL-size smelt (age-0 + YAO: -70 to -40 dB) by 1-m depth layers for each sample interval (800-m horizontal segments). This pre-analysis of TS distributions was accomplished within a specialized SAS (SAS 2006) program that scanned 1-m depth layers in each sample interval within a specified depth range in a downward progression and selected the first occurrence where the proportion of Age-0- to ALL-size smelt targets was less than 40%. The lower bound of this 1-m depth layer established a preliminary depth for defining the boundary between the two thermal strata (epilimnion and meta-hypolimnion). The SAS-derived Epi-Meta strata boundary was then formatted as a line-definition file and imported into Echoview. This line was then visually examined in the various echogram types (S_v, TS, single target detections) to see how well it spatially delineated Age-0 rainbow smelt located primarily in the epilimnion from YAO smelt located primarily in the metalimnion and hypolimnion. If necessary, and with knowledge of the thermal structure, the line was adjusted to better delineate the two smelt size groups. The final epi-meta boundary line was then referenced to create the two thermal strata across all sample intervals within acoustic transects exhibiting thermal stratification. If coldwater habitat was not apparent the sample interval was considered to be entirely epilimnion.

We applied a -80 dB minimum threshold to the raw ping volume back scattering variable (S_v). Mean S_v data and *in situ* single target detection distributions by analysis cell (thermal strata by 800-m sample interval) were exported to external text delimited files and then imported into a SAS program for computation of fish densities for YOY and YAO smelt-size acoustic targets. We used Sawada et al.'s (1993) N_v index to detect for potential bias from the inclusion of multiple echoes in the *in situ* TS distributions in all analysis cells. If an N_v index for an individual analysis cell exceeded the N_v threshold of 0.1, we replaced the mean backscattering cross section value, sigma (σ_{bs}) for that cell with an average mean sigma calculated from strata cells that had good N_v's (<0.1) as recommended in the SOP (Rudstam et al. 2009). Estimates of basin-wide mean fish density and absolute abundance for YAO smelt-size targets was achieved using a one-stage Cluster Analysis in SAS (Proc Surveymeans; SAS 2004).

Acoustic Series Results 2007–2012

Basin-wide acoustic estimates of total pelagic forage fish density for the acoustic size range of YAO rainbow smelt (-59 to -40 dB) in warm- and cold-water habitat was highest in 2012 (17,182 fish/ha) and lowest in 2007 (5,015 fish/ha) for the most recent six-year period (Figure 4.1.2). The mean density of total forage fish in all thermal habitats increased by 83% in 2012 (from 9,398 fish/ha in 2011).

Maps of pelagic forage fish densities by 800-m sample intervals for the last four years (Figure 4.1.3) and for earlier reported years (Forage Task Group 2009, 2011) indicate ongoing assessment efforts have consistently achieved full spatial coverage of the east basin acoustic survey area. These figures also demonstrate that the spatial distribution of pelagic forage fish abundance can markedly differ across years. In 2012, YAO-smelt size forage fish (all species in warm- and cold-water habitat) were abundant throughout the eastern basin with highest densities occurring near the tip and south of Long Point. A total of 401 800-m horizontal intervals were sampled across 12 transects in 2012 with an average bottom depth of 31 m. Forage fish density estimates (YAO smelt-size) ranged from 173 to 94,176 fish/ha with 19 or <5% of the sample intervals yielding density estimates >50,000 fish/ha (Figure 4.1.3). These very high density observations (>50k fish/ha) were distributed across eight different transects of which 58504 accounted for nearly half (9 of 19). The maximum density observation in the 2012 survey was observed on transect 58621 approximately 5 km from the south end, and was largely attributable to fish concentrated in the warm epilimnion (Figure 4.1.3). Non-smelt fish species likely contributed significantly to this and other high density observations in the 2012 survey, but this cannot be confirmed in the absence of mid-water trawl collections.

The mid-basin region between Port Maitland, ON and Dunkirk, NY exhibited high forage fish densities in 2011, 2010, and 2009 (Figure 4.1.3). In 2008, YAO smelt-size forage fish densities were greatest in a region south of Long Point (Forage Task Group 2011). In 2007, YAO-size smelt densities were comparatively much lower and evenly distributed throughout the east basin (Forage Task Group 2011). This improved knowledge that the East Basin Lake Erie pelagic fish resource can differ spatially across years reinforces the added value of this broad inter-agency approach to forage fish assessment relative to the unilateral efforts of independent trawling programs conducted by three east basin jurisdictions.

4.2 Central Basin Acoustic Survey (J. Deller and P. Kocovsky)

The Ontario Ministry of Natural Resources (OMNR), Ohio Department of Natural Resources (ODNR) and the U.S. Geological Survey (USGS) have collaborated to conduct joint hydroacoustic and midwater trawl surveys in central Lake Erie since 2004. The 2012 central basin acoustic survey was planned according to the protocol and sample design established at the hydroacoustic workshop held in Port Dover, Ontario in December 2003 (Forage Task Group 2005). That survey design calls for eight cross-basin transects on which both hydroacoustic and trawl data are collected. Beginning in 2008 all hydroacoustic data were collected and analyzed following recommendations in the Standard Operating Procedures for Fisheries Acoustics Surveys in the Great Lakes (GLSOP; Parker-Stetter et al. 2009). The primary purpose of this effort is to estimate densities of rainbow smelt and emerald shiner, which are the primary pelagic forage species in the central basin.

Hydroacoustics

Hydroacoustic data were collected from the USGS *R/V Muskie* and the ODNR-DOW *R/V Grandon*. Acoustic transects corresponding to Loran-C TD lines were sampled from one half hour after sunset (approximately 2130) to no later than one half hour before sunrise (approximately 0530), depending on length of the transect and vessel speed. Sampling started and ended at the 10-m contour. Starting location of sampling alternated from the northern shore to the southern shore on alternating nights.

Hydroacoustics data from both vessels were collected with BioSonics DTX® echosounders and BioSonics Visual Acquisition (release 5.1) software. Data from the *R/V Muskie* were collected using a 120-kHz, 8.2-degree, split-beam transducer mounted inside a through hull transducer tube at a depth of 1.5 m below the water surface. Data from the *R/V Grandon* were collected with a 122-kHz, 7.6-degree, split-beam transducer mounted to the starboard hull on a moveable bracket, roughly equidistant between the bow and stern with the transducer 1.3 meters below the surface. Starting with the 2010 survey, we altered our protocol to collect data at multiple pulse durations to facilitate a sensitivity analysis of single target detection parameters at the various pulse durations to determine optimal pulse duration when fish aggregations are dense. Shorter pulse durations can better discern individual targets in dense fish layers (Parker-Stetter et al. 2009), which are common near the thermocline in central Lake Erie. Longer pulse durations can result in biased *in situ* TS estimates, which further result in biased density estimates.

Sound was transmitted at 4 pulses per second (pps) at alternating pulse durations of 0.1 milliseconds (ms), 0.2 ms, 0.3 ms, and 0.4 ms (i.e., every second one pulse lasting 0.1 ms, one pulse lasting 0.2 ms, one pulse lasting 0.3 ms, and one pulse lasting 0.4 ms was transmitted). In surveys prior to 2010 sound was transmitted at 4 pps and 0.4 ms. For this report we use only data collected at 0.4 ms to remain comparable with past practice. We will calculate densities at each pulse duration to determine if shorter pulse durations result in reduced bias in *in situ* target strength estimates and use those results to inform future data collection. Global Positioning Systems (GPS) coordinates from the *R/V Muskie* were collected using a Garmin ® GPSMAP 76Cx, and from the *R/V Grandon,* a Garmin 17HVS. Both vessels interfaced GPS coordinates with the echosounders to obtain simultaneous latitude and longitude coordinates. Thermal profiles were taken on each transect for calculating the speed of sound in water for use in data analysis. We used the temperature just above the thermocline because the largest proportion of fish occurred nearest this depth in the water column. Because temperature is not uniform from surface to bottom this necessarily results in slight error in estimated depth of fish targets. Selecting temperature nearest the thermocline where fish were densest results in the least cumulative error in depth of fish targets. Prior to data collection we used a standard tungsten-carbide calibration sphere designed specifically for 120 kHz transducers to calculate a calibration offset for calculating target strengths. Background noise was estimated by integrating total sound from passive listening data collected just prior to acoustic sampling from the *R/V Musky II*. Background noise from *R/V Grandon* data was estimated from integrating Sv data below the first bottom echo in areas where no fish targets were present.

Analysis of hydroacoustic data was conducted following guidelines established in the GLSOP (Parker-Stetter et al. 2009) using Echoview ® version 4.9 software or version 5.1. Proportionate area backscattering coefficient and single targets identified using Single Target Detection Method 2 (Parker-Stetter et al. 2009) were used to generate density estimates for distance intervals. Distance intervals for each transect were 500 m. Depth strata were established based on similarity of distributions of single target strength. Settings for pulse length determination level, minimum and maximum normalized pulse length, maximum beam compensation, and maximum standard deviation of major and minor axes followed Parker-Stetter et al. (2009). Minimum target threshold was -75 dB. This value permitted inclusion of all targets at least -69 dB within the half-power beam angle. We used -69 dB as the lowest target of interest based on distribution of *in situ* target strength and theoretical values for rainbow smelt of the lengths captured in midwater trawls (Horppila et al. 1996, Rudstam et al. 2003). The Nv statistic, a measure of the probability of observing more than one fish within the sampling volume (Sawada et al. 1993), which will result in overlapping echoes, was calculated for each interval-by-depth stratum cell to monitor the quality of *in situ* single target data. If Nv for an interval-by-depth stratum cell was >0.1, the mean TS of the entire stratum within a transect where Nv values were <0.1 was used (Rudstam et al. 2009).

Density estimates for age-0 and YAO rainbow smelt and emerald shiner were estimated by multiplying acoustic density estimates within each cell by proportions calculated from trawls. For each cell we used proportions of each species and age group from the trawl sample from the same water stratum and from a similar total water depth that was nearest the cell.

Trawling

The *R/V Keenosay* conducted up to eight 20-minute trawls on four transects in Ontario waters concurrent with the *R/V Muskie* acoustic data collection. The R/V Grandon conducted up to three 20 minute midwater trawls in Ohio waters on the remaining four transects. Whenever possible, trawl vessels attempted to distribute trawl effort above and below the thermocline to adequately assess species composition throughout the water column. Catch was sorted by species and age group and relative proportions of each species and age group were calculated for each trawl. Age group was determined based on age-length keys and length distributions. Age group classifications consisted of young-of-year (age-0) for all species and yearling-and-older (age-1+) for forage species and age-2-or-older (2+) for predator species. Total lengths were measured from a subsample of individuals from each species and age group.

Results

Five cross-lake transects were sampled between July 16 and 22, 2012 with hydroacoustics and midwater trawls (Figure 4.2.1). The three remaining transects were not completed due to weather and vessel commitments to other projects.

A total of 32 midwater trawls were completed on the five acoustic transects. Rainbow smelt and emerald shiner were the primary species caught in most midwater trawls (Table 4.2.1). Freshwater drum and yellow perch were the only species other than emerald shiners and rainbow smelt that comprised the majority of an individual trawl catch. Other species caught in midwater trawls included sea lamprey, alewife, gizzard shad, rainbow trout, white perch, white bass, walleye and round goby.

Acoustic TS distributions by depth showed differences in TS across depth strata. The depth of the change in TS distribution varied considerably within and across transects. Three transects were divided into two depth layers with the depth of the break ranging from 11 to 16 m. Two transects were divided into four layers with the depth of the breaks at 6, 12, and 18 m (Table 4.2.2). Highest acoustic densities occurred in the upper depth layers relative to the deepest layer of each transect. Species and age group composition by depth layer overlapped considerably in 2012. The highest densities of both YOY and YAO emerald shiners and rainbow smelt occurred in the middle and upper layers compared to the deepest layers of transects.

Spatial distribution across transects varied by species and age group. Young-of-the-year emerald shiner densities were highest off Erieau, Ontario and on the western transects compared to the east (Figure 4.2.2). High densities of YAO emerald shiner were encountered on all transects and spread throughout the basin (Figure 4.2.3). Young-of-the-year rainbow smelt densities were highest along the north and south shore lines and western transects compared to the east (Figure 4.2.4). Yearling-and-older rainbow smelt densities were highest on transects furthest east and west, transects 57455 and 58100 respectively (Figure 4.2.5).

Discussion

As in previous years, YAO emerald shiners were located primarily in the upper layers of the water column. The highest densities of YAO emerald shiners were similar to densities found in 2011, however, they were distributed throughout the basin in 2012 compared to select portions of transects as in 2011 (Forage Task Group 2012). Estimates of YAO emerald shiner density have increased since 2010 (Forage Task Group 2011, 2012).

Age-0 emerald shiners are usually too small to be recruited to midwater trawls and are not usually included in the central basin hydroacoustic survey. In 2012, spring water temperatures were well above average and likely contributed to earlier spawning and faster growth rates compared to what normally occurs in the central basin. Also, due to the moon phase, the acoustic survey was run the third week of July, compared to the first or second week in previous years. Because of the warm spring and later sampling date, age-0 emerald shiners were larger and susceptible to midwater trawl gear, and were included in hydroacoustic analysis in 2012. Young-of-the-year densities ranged from 10-35% of the total in the upper layers (<12m) where they were present (all transects except 58100).

In 2012, there appeared to be a change in the pattern of species and age group distributions by depth compared to previous years. Typically, YOY rainbow smelt and YAO emerald shiners are found in the warmer, upper layers of the water column while YAO rainbow smelt occupy the deeper, cooler layer of the water column below the thermocline. In 2012, both age groups of emerald shiner and rainbow smelt were found in the middle and upper layers of the water column, generally above the thermocline. Also in 2012, YAO freshwater drum and yellow perch comprised a larger proportion of the midwater trawl catch than what was seen in 2010 or 2011(Forage Task Group 2011, 2012).

Temperature and dissolved oxygen profiles collected from the *R/V Keenosay* and *R/V Grandon* found areas of low dissolved oxygen (<3.5mg/L) on 4 of 5 transects. Profiles were not collected on transect 57455 due to equipment malfunction. Most of the areas of low dissolved oxygen occurred on the shallower ends of transects (<19m) relative to the middle of transects. Where profiles showed low dissolved oxygen levels, there were multiple depth layers based on the acoustic size at depth, or lower densities of fish/targets in the deeper layers relative to the shallower layers. The changes in species and age group distributions within the water column and the large catches of YAO freshwater drum and yellow perch may have resulted from the low dissolved oxygen levels. The low dissolved oxygen levels in the deepest layers may have displaced YAO rainbow smelt, causing them to relocate to shallower depth layers. The low dissolved oxygen may have also caused YAO yellow perch and freshwater drum to move off the bottom, where they would be more accessible to midwater trawls.

Hydroacoustic data have been collected at pulse durations less than 0.4 ms since 2010. We report only those density estimates from data collected at 0.4 ms pulse duration so data are comparable to past years. The data we collected at shorter pulse durations will be analyzed to determine if bias of target strength estimates can be further reduced. We will also assess how density estimates are affected by collecting data at different pulse durations.

4.3 West Basin Acoustic Survey (E. Weimer)

A standardized inter-agency fishery acoustics program has been used to assess forage community abundance and distribution in the eastern basin of Lake Erie since 1993. The acoustic survey was expanded to the central basin in 2000 (Forage Task Group 2004). In 1997, a pilot program was conducted by Sandusky Fisheries Research Unit staff adjacent to Sheldon’s Marsh in July to assess the feasibility of using acoustic technology in the shallow waters of the western basin. The pilot study showed much promise and results indicated an offshore to nearshore gradient in forage-sized fish abundance. In 2004 a pilot western basin acoustic survey was initiated to explore the utility of using down-looking sonar for assessing pelagic forage fish abundance in the west basin. These data were used to develop a standardized acoustic sampling program for the west basin of Lake Erie that complements the ongoing acoustic surveys in the central and eastern basins and facilitates an annual lake snapshot of pelagic forage fish abundance and biomass.

Equipment issues have plagued the western basin acoustic survey since 2007. Prior to the 2007 survey, a BioSonics DT-X echosounder was purchased for the Ohio Department of Natural Resources

Lake Erie Fisheries Unit in Sandusky. During first transect of the 2007 survey, the new Lake Erie unit malfunctioned and was unusable. The remainder of the 2007 survey was completed with a loaner DT-X unit from BioSonics while the Lake Erie system was returned for repairs. In 2008 the Lake Erie system malfunctioned again, and the survey was completed using DT-X unit from the Ohio DNR Inland Fisheries Research Unit. Equipment setup and potential vessel-related issues were discussed and investigated, but the Lake Erie DT-X was not returned to BioSonics for repairs prior to the 2009 survey. That unit malfunctioned again in 2009 after completing one transect, and was returned for repairs a second time. In 2010, the Lake Erie unit failed again, but no unit was available to borrow, leading to no data being collected. The Lake Erie unit was returned and repairs were made to the transducers (BioSonics could not diagnose any issues with the unit when it was returned in 2007 and 2009). In 2011, the unit functioned during most of the survey, although a portion of the eastern transect was lost due to malfunctions. Following the 2011 survey, the surface unit was replaced by BioSonics. Despite this, the unit malfunctioned again in 2012, and the survey was not completed. Insufficient data were collected to report fish density or biomass in 2012.

Table 4.2.1. Percent composition of fish captured in trawl samples collected by the *R/V Keenosay*, and *R/V Grandon* in the central basin Lake Erie in July, 2012. *R/V Keenosay* trawl ID numbers are 1001-3009. *R/V Grandon* trawl ID numbers are 730-735.

Transect	Trawl Depth	Trawl ID	Latitude	longitude	Rainbow Smelt age-0	Rainbow Smelt YAO	Emerald shiner age-0	Emerald shiner YAO	Yellow Perch age-0	Yellow Perch YAO	Freshwater drum YAO	other
57455	3	732	41.7352	-81.8262	0	0	10	73	1	0	0	16
57455	10	731	41.7983	-81.8595	2	2	0	44	2	0	8	41
57455	14	730	41.8677	-81.8923	17	37	8	23	12	0	2	1
57600	4	3008	42.2578	-81.8285	1	0	41	55	1	0	0	1
57600	8	3009	42.2472	-81.8075	15	1	9	5	66	0	3	1
57600	10	3006	42.2280	-81.8118	5	0	83	6	0	0	1	4
57600	12	3007	42.2120	-81.8020	4	0	53	11	5	0	17	9
57600	13	3001	42.0702	-81.7462	59	0	0	12	6	0	24	0
57600	14	3002	42.0542	-81.7395	25	6	0	31	0	0	38	0
57600	14	3005	42.2150	-81.8100	69	0	9	1	18	0	1	1
57600	16	3004	42.0582	-81.7363	30	10	0	50	0	0	10	0
57600	21	3003	42.0733	-81.7425	37	48	0	5	9	0	1	0
57725	5	735	41.9373	-81.4460	0	31	0	65	0	0	0	4
57725	9	733	41.8518	-81.4047	43	4	29	0	7	0	14	4
57725	17	734	41.8987	-81.4257	0	2	0	0	1	93	2	2
57850	5	2001	42.5562	-81.4742	6	0	0	91	0	0	0	2
57850	6	2003	42.4877	-81.4418	47	0	16	36	0	1	0	0
57850	7	2002	42.5528	-81.4720	87	1	0	10	1	0	1	0
57850	9	2008	42.3105	-81.3693	0	0	4	84	6	0	0	6
57850	10	2004	42.4815	-81.4493	0	0	24	29	0	0	35	12
57850	12	2007	42.3300	-81.3752	8	0	4	71	1	0	2	14
57850	14	2005	42.4775	-81.4495	26	21	11	11	5	0	16	11
57850	16	2006	42.3330	-81.3873	44	0	0	42	4	0	4	5
58100	6	1009	42.6172	-81.0245	0	0	0	100	0	0	0	0
58100	8	1007	42.5363	-80.9832	7	0	0	88	4	0	0	0
58100	9	1004	42.3935	-80.9442	0	0	0	95	4	2	0	0
58100	11	1006	42.5363	-80.9845	72	1	0	26	1	0	0	0
58100	11	1008	42.6183	-81.0233	3	0	0	97	0	0	0	0
58100	13	1001	42.3873	-80.9217	10	50	0	40	0	0	0	0
58100	13	1002	42.3915	-80.9380	61	28	0	7	0	1	2	0
58100	13	1005	42.5333	-80.9710	93	0	0	4	3	0	1	0
58100	15	1003	42.3863	-80.9378	13	80	0	6	1	0	1	0

Table 4.2.2. Density (number per hectare) of key species by age class and depth layer for hydroacoustic transects in central basin Lake Erie, July 2012. Transect numbers refer to Loran-TD lines. Depth layers were determined by differences in acoustic target strength (TS) across depth strata within each transect. Species were applied from midwater trawl catch by nearest distance within depth layer.

		Transect														
		57455 Depth layer (m)		57600 Depth layer (m)				57725 Depth layer (m)		57850 Depth layer (m)				58100 Depth layer (m)	
		1-11 [a]	>11 [a]	1-6	6-12	12-18	>18	1-11 [b]	>11 [b]	1-6	6-12	12-18	>18	1-15	>15
YOY	Rainbow Smelt	5720	476	48	7696	2419	450	2324	77	7273	1310	2057	15	1702	1236
	Emerald Shiner	3290	12	3518	3995	278	0	2187	0	2543	1834	38	0	0	0
	Yellow Perch	2921	50	104	1396	507	107	245	22	140	396	219	10	0	130
YAO	Rainbow Smelt	6906	235	0	111	604	581	340	107	43	100	76	33	8510	8
	Emerald Shiner	9162	472	6672	1930	1322	57	4041	10	6348	4550	1919	2	6808	1186
	Freshwater Drum	508	94	31	3789	842	9	836	11	22	1714	257	17	0	136
	Yellow Perch	0	1	0	0	0	42	0	462	0	0	0	836	0	496

[a] varied from 1-11 m to 1-15 m along the transect
[b] varied from 1-11 m to 1-16 m along the transect

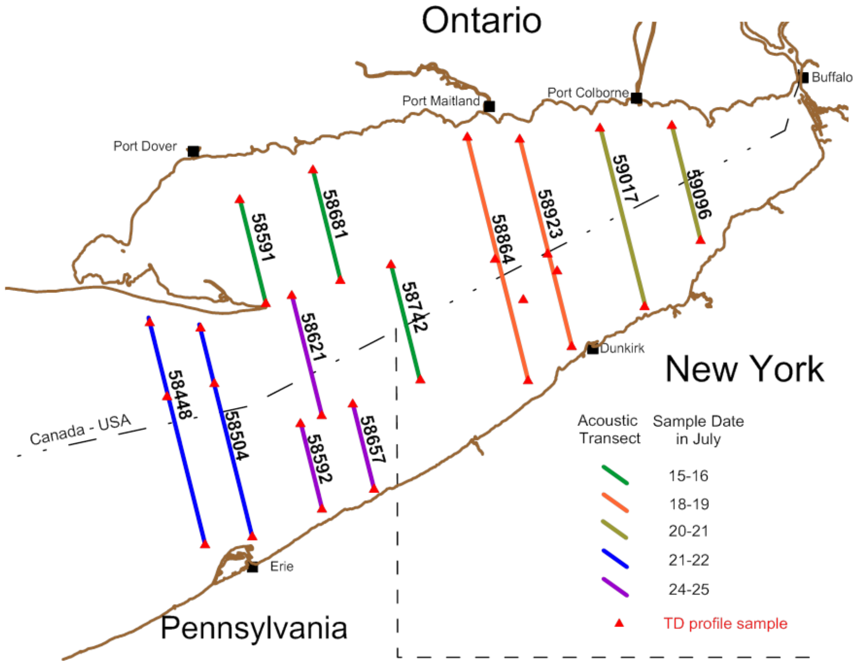


Figure 4.1.1. July 2012 eastern basin Lake Erie inter-agency acoustic survey transects, mid-water trawl and temperature profile sites sampled by the Ontario Ministry of Natural Resources (OMNR) research vessel, *RV Erie Explorer* .

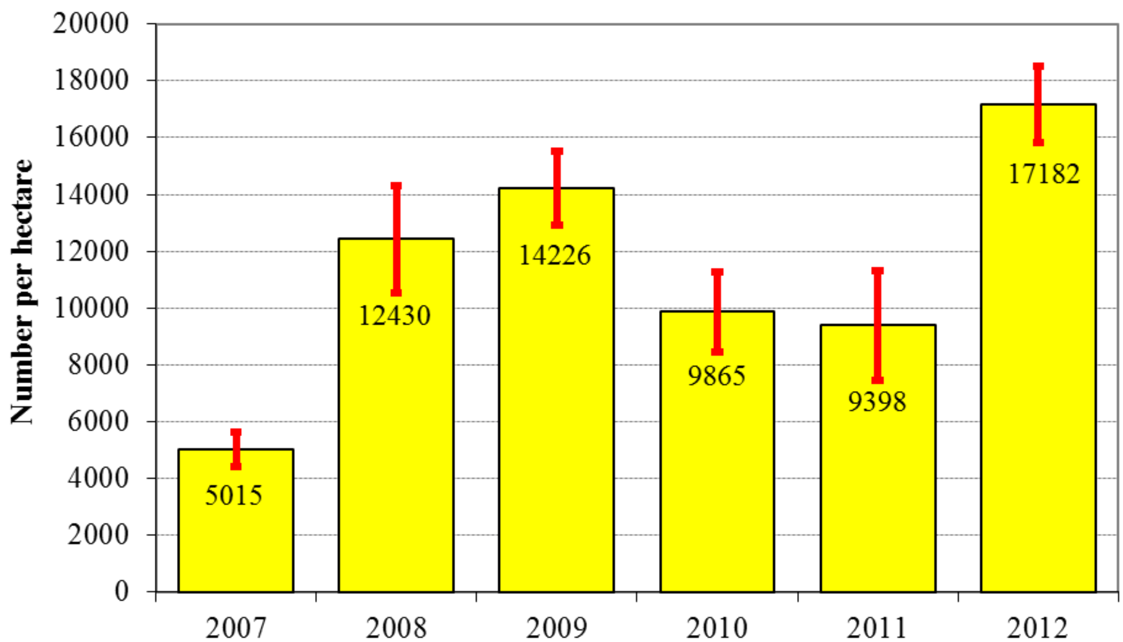


Figure 4.1.2. Mean density (Number per hectare) estimates of pelagic YAO rainbow smelt-sized forage fish sampled with a 120-kHz split-beam echosounder during July fisheries hydroacoustic assessments of eastern Lake Erie, 2007 - 2012. Density estimates were derived from a spatially stratified cluster analysis of acoustic transects comprised of 800-m length sample units. Standard error (of mean) bars shown.

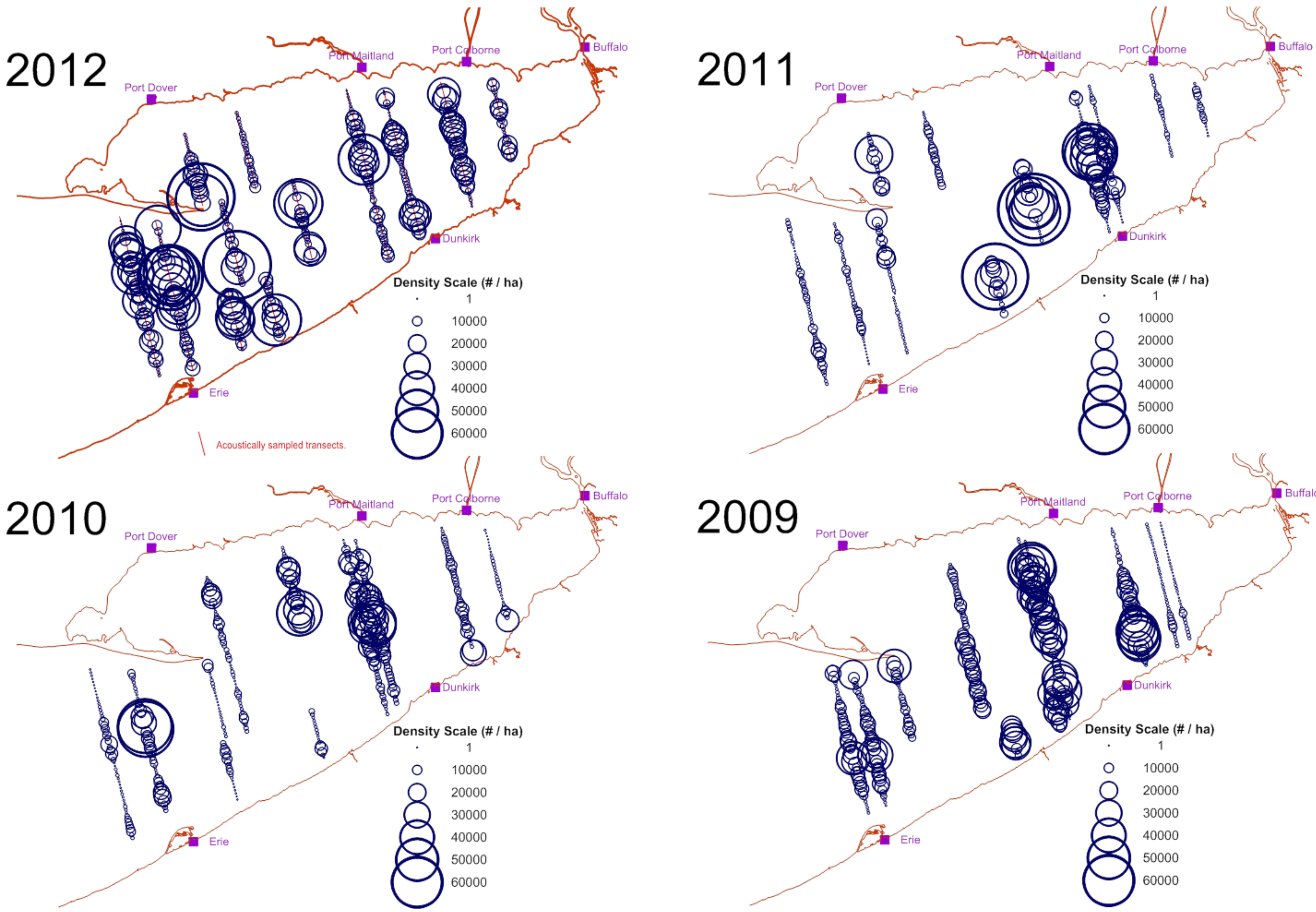


Figure 4.1.3. Relative density (Number per hectare) of pelagic, YAO rainbow smelt-sized forage fish per 800-m interval along transects sampled with a 120-kHz split-beam echosounder during July fisheries acoustic surveys in eastern Lake Erie, 2009 to 2012.

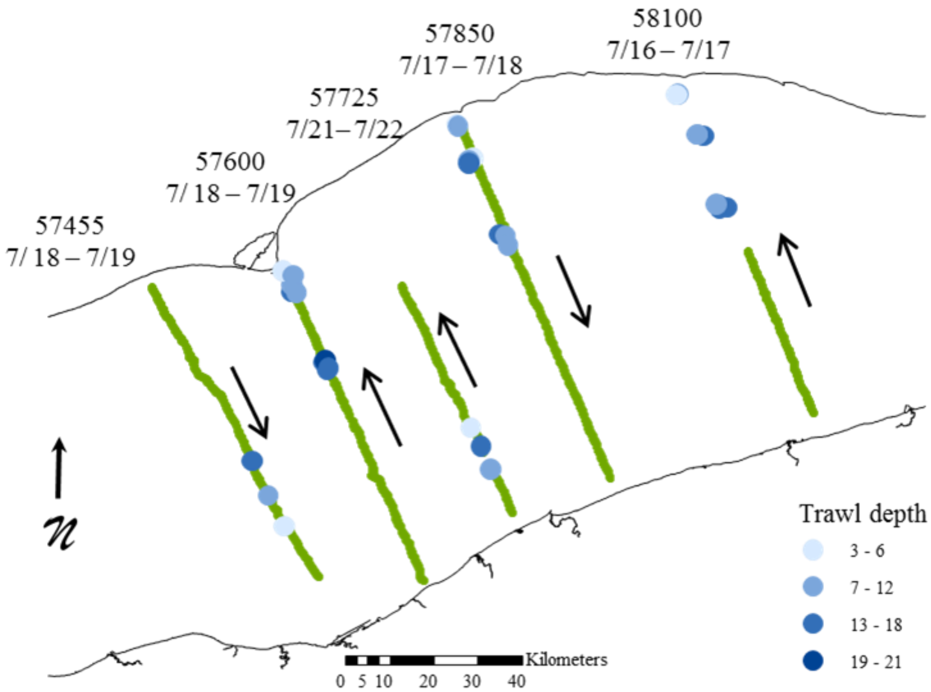


Figure 4.2.1 Hydroacoustic transects and midwater trawling stations in the central basin, Lake Erie, July 16-22, 2012. Transect numbers are Loran-TD lines. Arrows indicate direction of travel.

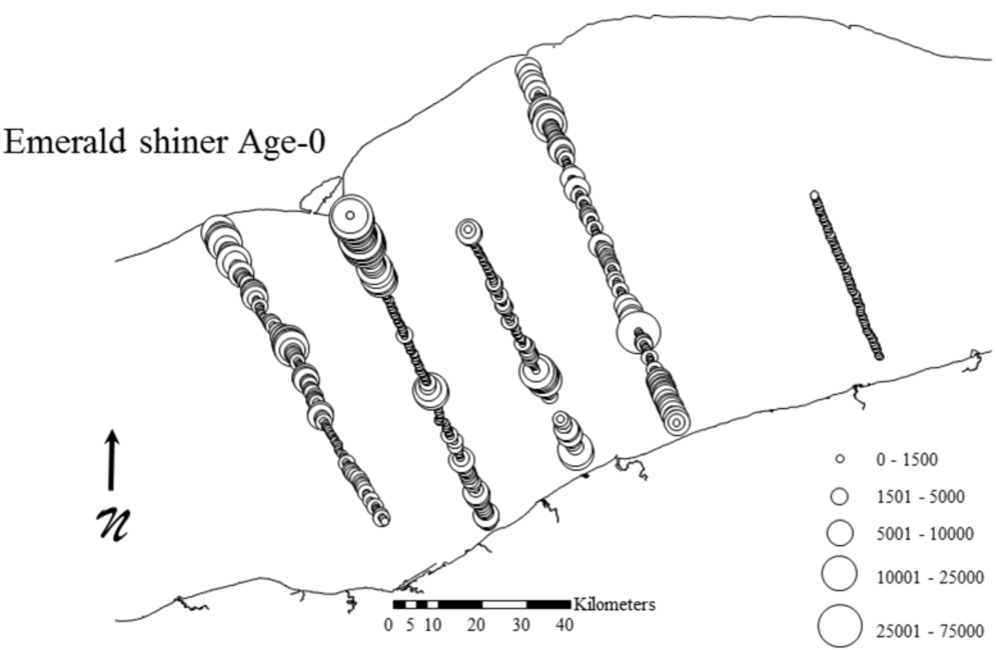


Figure 4.2.2 Density estimates of age-0 emerald shiner (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500-m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2012.

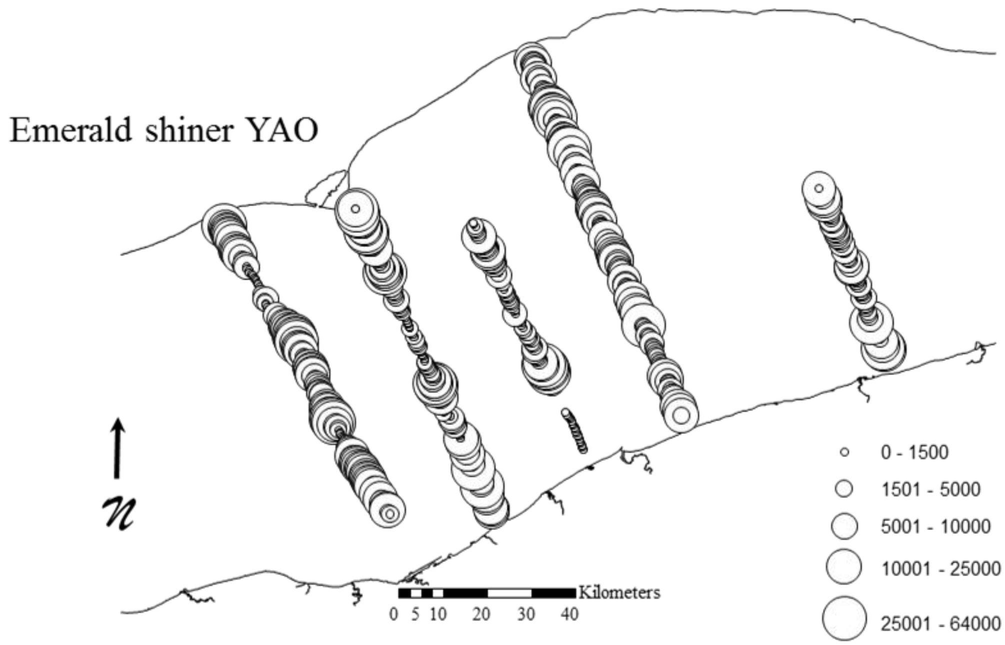


Figure 4.2.3 Density estimates of YAO emerald shiner (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500-m segments to ensure adequate numbers of single targets for i*n-situ* analysis. Transects are Loran-TD lines sampled in 2012.

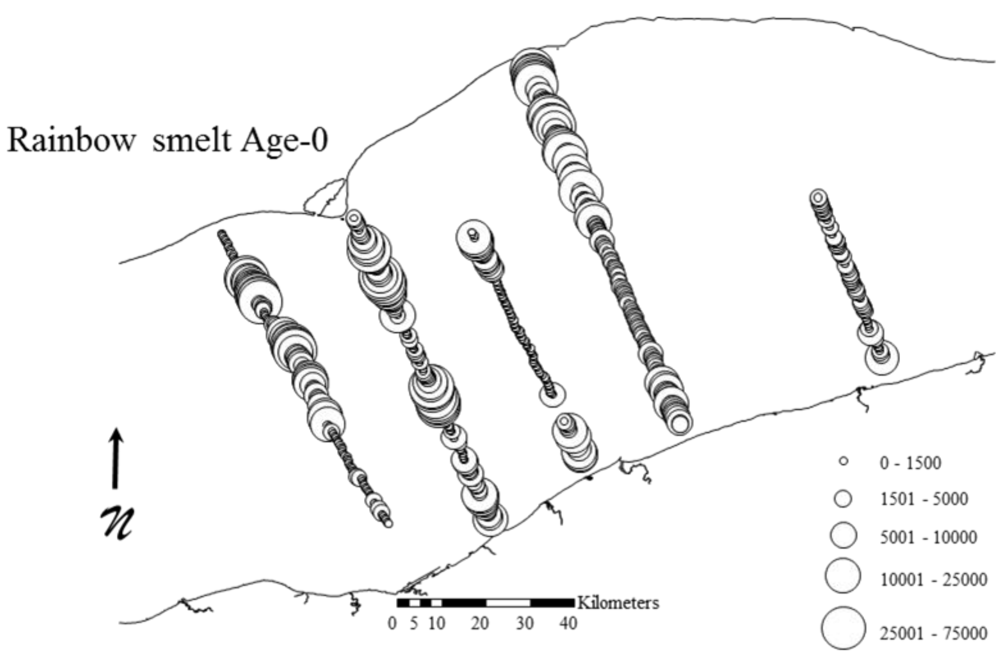


Figure 4.2.4. Density estimates of age-0 rainbow smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500-m segments to ensure adequate numbers of single targets for i*n-situ* analysis. Transects are Loran-TD lines sampled in 2012.

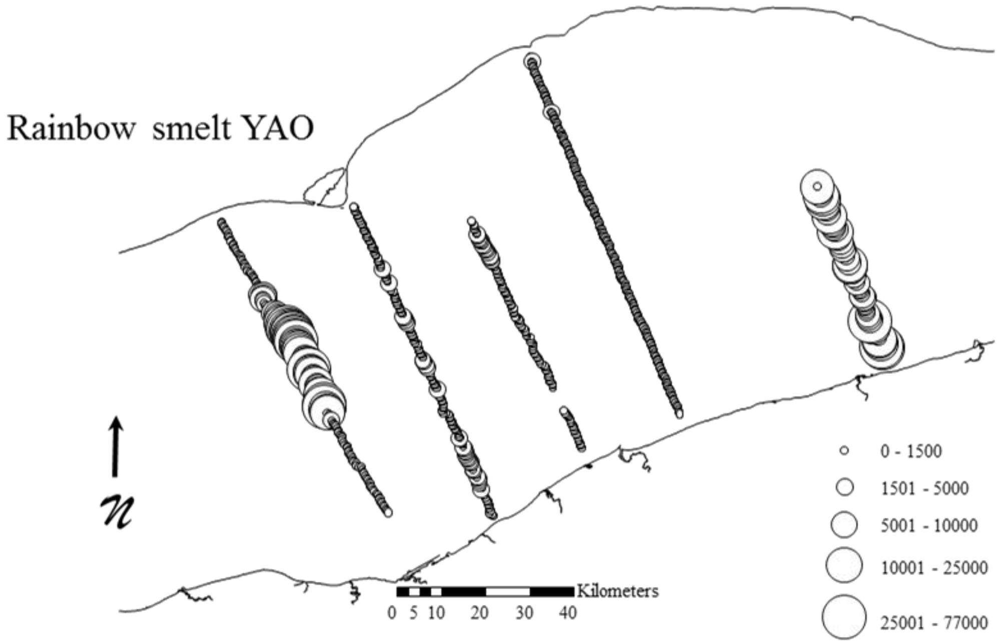


Figure 4.2.5 Density estimates of YAO rainbow smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500-m segments to ensure adequate numbers of single targets for i*n-situ* analysis. Transects are Loran-TD lines sampled in 2012.

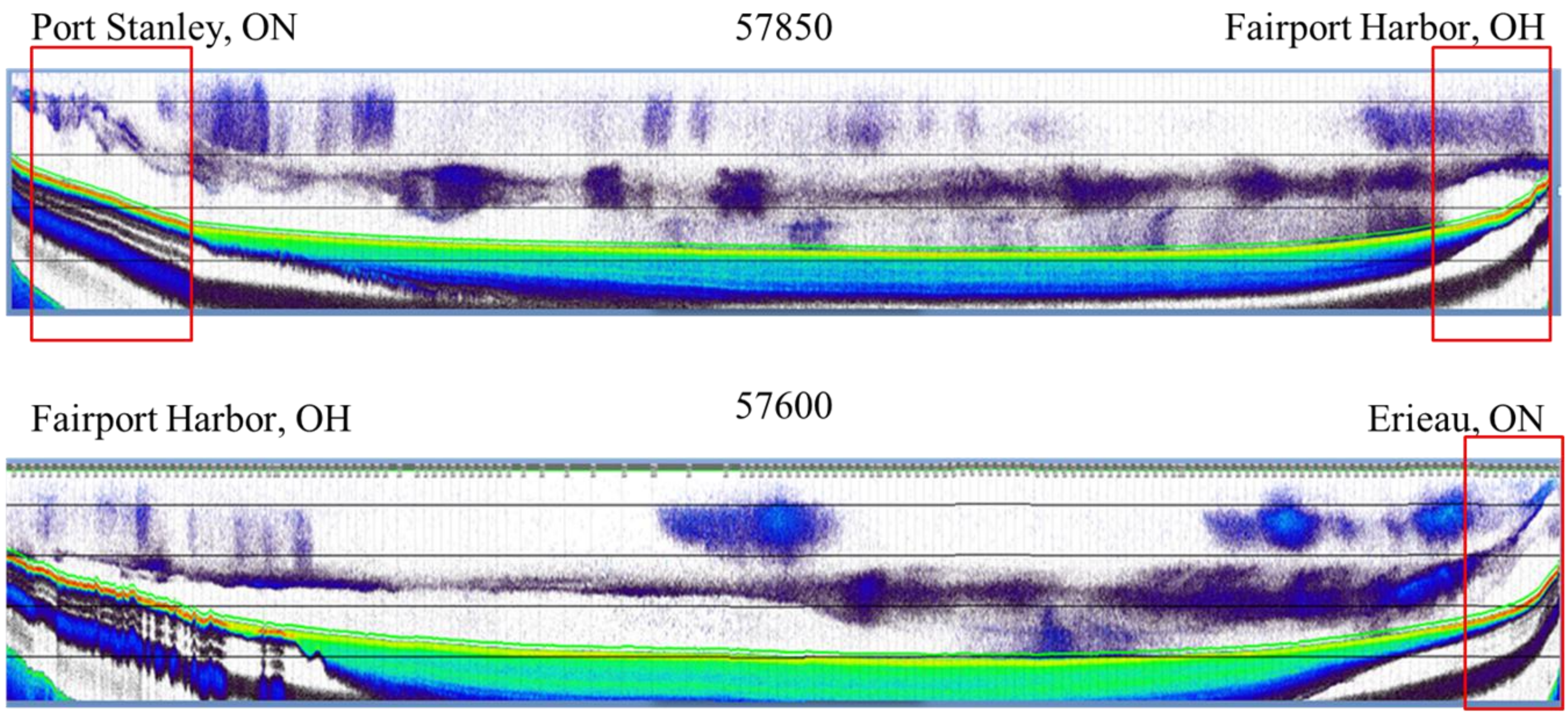


Figure 4.2.6. Echogram files generated from Echoview® software version 4.9 that show acoustic total back scattering (Sv) along tow transects in the central basin, 2012. Red squares indicate areas along transects where low bottom dissolved oxygen (<3.5 mg/l) was measured.

5.0 Interagency Lower Trophic Level Monitoring Program, 1999-2012

(B. Trometer, and J. Markham)

In 1999, the FTG initiated a Lower Trophic Level Assessment program (LTLA) within Lake Erie and Lake St. Clair (Figure 5.0.1). Nine key variables, as identified by a panel of lower trophic level experts, were measured to characterize ecosystem change. These variables included profiles of temperature, dissolved oxygen and light (PAR), water transparency (Secchi), nutrients (total phosphorus), chlorophyll *a*, phytoplankton, zooplankton, and benthos. The protocol called for each station to be visited every two weeks from May through September, totaling 12 sampling periods, with benthos collected on two dates, once in the spring and once in the fall. For this report, we will summarize the last 13 years of data for summer surface temperature, summer bottom dissolved oxygen, chlorophyll *a* concentrations, zooplanktivory, water transparency and total phosphorus. Stations were only included in the analysis if there were at least 3 years each containing 6 or more sampling dates. Stations included in this analysis are stations 3, 4, 5 and 6 from the western basin, stations 7, 8, 9, 10, 11, 12, 13 and 14 from the central basin, and stations 15, 16, 17, 18, 19, 20 and 25 from the eastern basin (Figure 5.0.1). Station 25 (located off Sturgeon Point in 19.5 meters of water) was added in 2009.

The fish community objectives (FCO) for the lower trophic level ecosystem in Lake Erie recommends that mesotrophic conditions favoring percids predominate in the western and central basins and nearshore waters of the eastern basin, and that oligotrophic conditions favoring salmonids exist in the offshore waters of the eastern basin (Ryan *et al.* 2003). Associated with these trophic classes are target ranges for total phosphorus, water transparency, and chlorophyll *a* (Table 5.0.1). For mesotrophic conditions, the total phosphorus range is 9-18 μg/L, summer (June-August) water transparency is 3-6 meters, and chlorophyll *a* concentrations between 2.5-5.0 μg/L (Leach *et al.* 1977). For the offshore waters of the eastern basin, the target ranges for total phosphorus are < 9 μg/L, summer water transparency of > 6 m, and chlorophyll *a* concentrations of < 2.5 μg/L.

Mean Summer Surface Water Temperature

Summer surface water temperature represents the temperature of the water at 0-1 meters depth for offshore stations only. This index should provide a good measure of relative system production and growth rate potential for fishes, assuming prey resources are not limiting. Mean summer surface temperatures are warmest in the western basin (mean=22.8 C) and get progressively cooler moving easterly to the central (mean=21.9 C) and eastern basins (mean=20.6 C) (Figure 5.0.2). Mean summer surface temperatures range from 21.3 C in 2009 to 24.3 C in 2010 in the western basin, 20.5 C in 2009 to 23.7 C in 2005 in the central basin, and 18.5 C (2003) to 22.4 C (2005) in the eastern basin. Above average temperatures were evident across all basins in 2005, 2006, 2010, and 2011; below average temperatures occurred in 2000, 2003, 2004, 2008, and 2009. Increasing trends in summer surface water temperature are not apparent for this 13-year time series. In 2012, the mean summer surface water temperature was above average in all three basins for the third consecutive year. The average water temperature in the west basin was 23.8 C, which was the third highest in the series, 23.6 C in the central basin (second highest in the series) and 21.2 C in the east basin (fifth highest in the series).

Hypolimnetic Dissolved Oxygen

Dissolved oxygen (DO) levels less than 2.0 mg/L are deemed stressful to fish and other aquatic biota (Craig 2012; Eby and Crowder 2002). Low DO can occur near bottom during thermal stratification, which can begin in early June and continue through September in the central and eastern basins. In the western basin, except during prolonged calm periods, the water column remains mixed to the bottom, thus preventing thermal stratification and subsequent development of <2 mg/l DO concentrations (Figure 5.0.3). In 2012, there were no observations where DO was below the 2.0 mg/L threshold in the west basin.

Low DO is more of an issue in the central basin. It happens almost annually at the offshore stations (8, 10, 11 and 13) and occasionally at inshore stations. Dissolved oxygen levels of <2.0 mg/L have been observed as early as mid-June and can persist until late September when fall turnover remixes the water column. In 2012, bottom DO was below 2.0 mg/L threshold in the central basin on two occasions at station 8 (7/16/2012, 1.2 mg/L; 8/30/2012, 0.4 mg/L) (Figure 5.0.3).

Low DO conditions are rare in the eastern basin due to greater water depths, a large hypolimnion and cooler water temperatures. The only occasion when DO was below the 2.0 mg/L threshold was on 14 July and 13 August, 2010 at the new station 25 (Figure 5.0.3). No DO concentrations of less than 7.0 mg/L were recorded in the east basin in 2012.

Chlorophyll *a*

Chlorophyll *a* concentrations indicate biomass of the phytoplankton resource, ultimately representing primary production. For mesotrophic status in the west, central, and nearshore eastern basins, chlorophyll *a* concentrations should range between 2.5-5.0 µg/L, and less than 2.5 µg/L for the offshore eastern basin waters (Table 5.0.1) (Leach *et al*. 1977).

In the west basin, mean chlorophyll *a* concentrations have mainly been above targeted levels in the 14-year time series, falling into eutrophic status rather than mesotrophic status (Figure 5.0.4). Annual variability is also the highest in the west basin. In 2012, the mean chlorophyll *a* concentration was 4.9 µg/L in the west basin, which was within the targeted mesotrophic range for only the third time in the series. In the central basin, chlorophyll *a* concentrations have been less variable and within the targeted mesotrophic range for the entire time series, and that trend continued in 2012 (4.2 µg/L) (Figure 5.0.4). In the eastern basin, chlorophyll *a* concentrations in the nearshore waters have been below the targeted mesotrophic level for the entire time series (Figure 5.0.4). This may be due to high levels of grazing by dreissenids (Nicholls and Hopkins 1993) in the nearshore eastern basin waters where biomass of quagga mussels (*Dreissena bugensis*) remains high (Patterson *et al.* 2005). Conversely, chlorophyll *a* levels in the offshore waters of the eastern basin remain in, or slightly above, the targeted oligotrophic range. In 2012, the mean chlorophyll *a* concentrations were 1.5 µg/L in the nearshore waters of the eastern basin and 2.2 µg/L in the offshore waters.

Total Phosphorus

Total phosphorus levels in the western basin have exceeded FCO targets since the beginning of this monitoring program (Figure 5.0.5). Total phosphorus concentrations in the west basin declined in 2012 to 26.5 µg/L following the dramatic increase in 2011 to 113.0 µg/L, which was a time series high. Total phosphorus measures in 2012 were the lowest in the series but remain well above the target range; the low concentrations in 2012 may have been due in part to dry summer conditions. In the central basin, total phosphorus levels have been on the increase and have exceeded FCO targets since 2006 (Figure 5.0.5). Similar to the west basin, the central basin experienced a decline in total phosphorus in 2012 to 26.5 µg/L compared to the time series high of 47.6 µg/L in 2011. In the nearshore waters of the eastern basin, total phosphorus levels have remained stable and within the targeted mesotrophic range for nearly the entire time series (Figure 5.0.5). A gradual increasing trend was evident from 2006 through 2010, but declines have followed during the last two years. Total phosphorus levels in the offshore waters of the eastern basin show a similar trend to nearshore waters, and have recently risen above the targeted oligotrophic range into the mesotrophic range. In 2012, total phosphorus concentrations in the eastern basin decreased in the nearshore waters (10.7 µg/L) and were within their targeted mesotrophic range, but increased in the offshore waters (10.6 µg/L) and were higher than their targeted oligotrophic range.

Water Transparency

Similar to other fish community ecosystem targets (i.e. chlorophyll *a*, total phosphorus), water transparency has been in the eutrophic range, which is below the FCO target in the western basin, for the entire time series (Figure 5.0.6). Mean summer Secchi depth in the western basin was 2.0 m in 2012, which was identical to the 2011 mean. In contrast, water transparency in the central basin has remained within the targeted mesotrophic range for the entire series, including 2012 (3.9 m) (Figure 5.0.6). Transparency was in the oligotrophic range, which is above FCO targets for the nearshore waters of the eastern basin, from 1999 through 2007, but has been stable and within the FCO targets for the last five years (Figure 5.0.6). In the offshore waters of the eastern basin, water transparency was within the oligotrophic target from 1999 through 2007, but fell into the mesotrophic range in four of the last five years. In 2012, mean summer Secchi depth was 5.4 m in the nearshore waters of the eastern basin, which was within the targeted mesotrophic range, and 5.9 m in the offshore waters, which was below the targeted oligotrophic range.

Zooplanktivory Index and Biomass

Planktivorous fish are size-selective predators, removing larger prey with a resultant decrease in the overall size of the prey community that reflects feeding intensity (Mills *et al.* 1987). Johannsson *et al.* (1999) estimated that a mean zooplankton length of 0.57 mm or less sampled with a 63-µm net reflects a high level of predation by fish. For 1999-2004, predation of zooplankton (zooplanktivory) was high in Lake Erie, as the average size of the community was generally less than the 0.57 mm size metric (Figure 5.0.7). Since 2005 in the western basin and 2006 in the central basin, the mean size of the zooplankton community has been greater than the critical size, indicating low zooplanktivory for all years except 2007. The trend of low feeding intensity continued in 2012 in the western basin; the west basin is showing a trend of decreasing zooplankton size since 2010 while the central basin continues to show an increasing trend since 2008. In the eastern basin, the zooplanktivory index has been the most stable compared to the other two basins and is generally at the critical size level.

Zooplankton biomass varies among basins and years. In the western basin, the 2012 mean biomass was 96.2 mg/m^3, which is above the long term average of 81.7 mg/m^3 (Figure 5.0.8). In the central basin, the 2012 mean zooplankton biomass was the highest in the series at 350.1 mg/m^3 and above the long term average of 127.4 mg/m^3. There was an exceptionally high biomass of *Daphnia* *galeata mendotae* at some stations in the central basin in 2012. Data is not yet available for the eastern basin in 2012, but the 2011 zooplankton biomass was the highest in the series at 99.3 mg/m^3 and above the long term average of 63.9 mg/m^3. From 1999 to 2007, there appeared to be a gradient of zooplankton biomass from west to east, with the highest biomass in the west basin and lowest in the east basin. In addition, cladocerans were more dominant in the west basin than elsewhere. Since 2009, zooplankton biomass has been highest in the central basin, except in 2011, when it was highest in the east basin.

Distribution of New Zooplankters

For this review, data from stations 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18, 19 and 20 were included. *Bythotrephes longimanus* was first collected in Lake Erie in October 1985 (Bur *et al.* 1986). It is consistently present at central and eastern basin stations, but is very rare at western basin stations. Densities ranged from 0.001 to 6,370 individuals/m^3 and were generally higher from July through September.

Cercopagis pengoi was first collected in Lake Ontario in 1998, and by 2001 was also collected in the western basin of Lake Erie (Therriault et al. 2002). They first appeared in this sampling effort at station 5 in July 2001 and station 9 in September 2001. In subsequent years it has also been found at stations 5, 6, 9, 10, 15, 16, 17, 18 and 19. Except for the year 2002, when it was collected at 8 stations, *Cercopagis* is seen less frequently around the lake than *Bythotrephes*. Densities ranged from 0.03 to 876 individuals/m^3.

The first record of *Daphnia lumholtzi* in the Great Lakes was in the western basin of Lake Erie in August 1999 (Muzinic 2000). It was first identified in our seasonal sampling effort in August 2001 at stations 5 and 6, and at station 9 by September 2001. *D. lumholtzi* was collected at stations 5 and 6 in 2002, and at stations 5, 6, 8 and 9 in 2004. Data is not available for these stations from 2005 through 2010, but in 2011 *D.lumholtzi* was found at station 5 and 6 with densities of 91 and 83 individuals/m3, respectively. In 2007 it was found at station 18, the first and only record for the eastern basin. Densities ranged from 0.002 to 91 individuals/m^3.

Fish Community Ecosystem Targets

Measures of lower trophic variables (total phosphorus, transparency, chlorophyll *a*) in 2012 indicate that the western basin is in a eutrophic state. Current conditions favor a centrarchid (bass, sunfish) fish community instead of the targeted percid (walleye, yellow perch) fish community (Table 5.0.2). In the central and nearshore eastern basin, the lower trophic measures in 2012 mainly fell within the targeted mesotrophic range preferred by percids. However, it is worth noting that total phosphorus concentrations in the central basin remain in the eutrophic range in 2012. In the offshore waters of the eastern basin, measures of total phosphorus and transparency indicate a mesotrophic class that favors percids while chlorophyll *a* was within the targeted oligotrophic range favored by salmonids.

Table 5.0.1. Ranges of lower trophic indicators for each trophic class and associated fish community (Leach *et al.* 1977; Ryder and Keer 1978).

Trophic Class	Phosphorus (µg/L)	Chlorophyll a (µg/L)	Transparency (m)	Harmonic Fish Community
Oligotrophic	<9	<2.5	>6	Salmonids
Mesotrophic	9 - 18	2.5 - 5.0	3 - 6	Percids
Eutrophic	18 - 50	5.0 - 15	1 - 3	Centrarchids
Hyper-eutrophic	>50	>15	<1	Cyprinids

Table 5.0.2. Measures of key lower trophic indicators and current trophic class, by basin, from Lake Erie, 2012. The east basin is separated into nearshore and offshore.

Basin	Phosphorus (µg/L)	Chlorophyll a (µg/L)	Transparency (m)	Trophic Class
West	26	4.9	2.0	Eutrophic
Central	26	4.2	3.9	Mesotrophic
East - Nearshore	11	1.5	5.4	Mesotrophic
East - Offshore	11	2.2	5.9	Mesotrophic

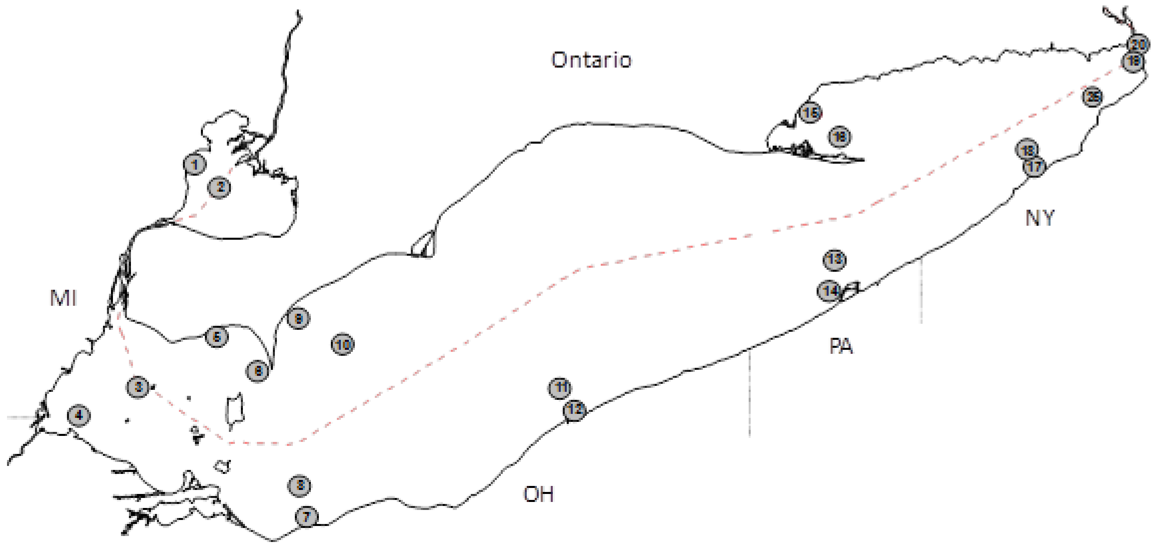


Figure 5.0.1. Lower trophic level sampling stations in Lakes Erie and St. Clair. Station 25 was added in 2009.

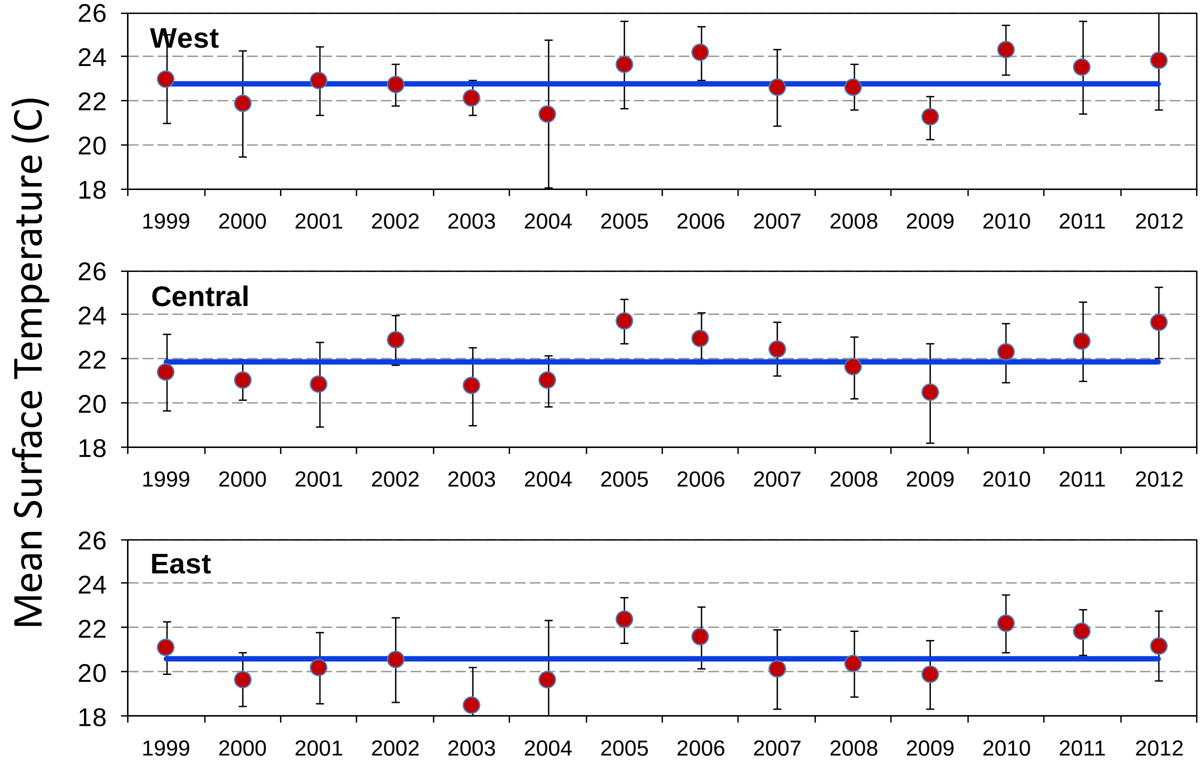


Figure 5.0.2. Mean summer (June-August) surface water temperature (C) at offshore stations, weighted by month, with 95% confidence limits (2 SE's) by basin in Lake Erie, 1999-2012. Dark blue lines represent time series average water temperature. Data included in this analysis by basin and station: West - 3, 6; Central – 8, 10, 11, 13; East – 16, 18, 19, 25.

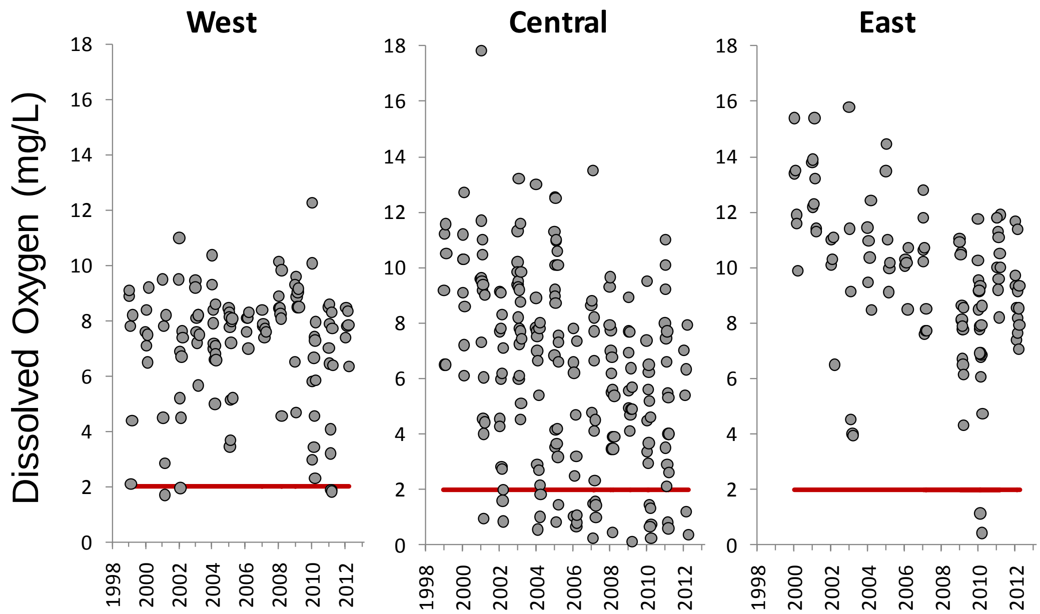


Figure 5.0.3. Summer (June-August) bottom dissolved oxygen (mg/L) concentrations for offshore sites by basin in Lake Erie, 1999-2012. The red horizontal line represents 2 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. Data included in this analysis by basin and station: West - 3, 6; Central – 8, 10, 11, 13; East – 16, 18, 19, 25.

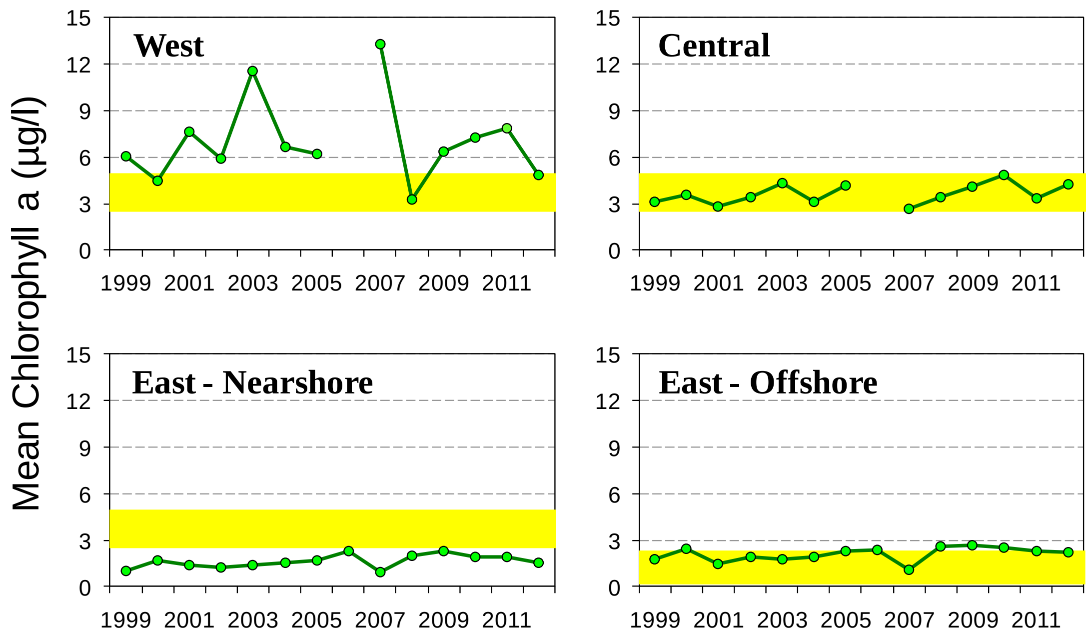


Figure 5.0.4. Mean chlorophyll *a* concentration (ug/L), weighted by month, by basin in Lake Erie, 1999-2011. The east basin is separated into nearshore and offshore. Yellow bars represent targeted trophic class range. For this analysis data from stations 3 through 20 and 25 were included.

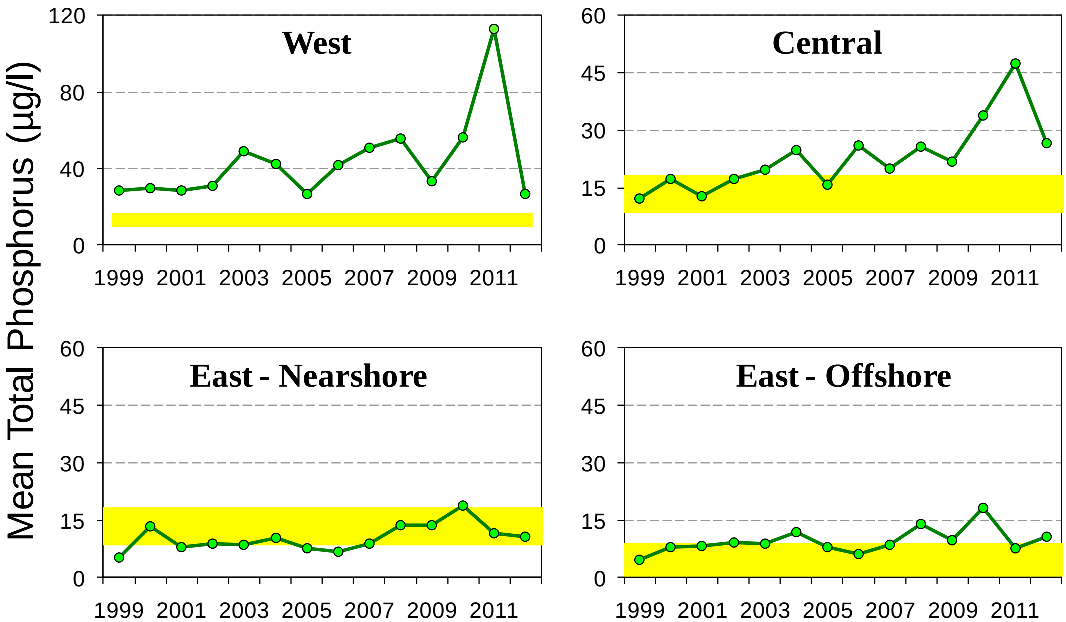


Figure 5.0.5. Mean total phosphorus (µg/L), weighted by month, for offshore sites by basin in Lake Erie, 1999-2012. The east basin is separated into nearshore and offshore. Yellow shaded areas represent the targeted trophic class range. For this analysis data from stations 3 through 20 and 25 were included.

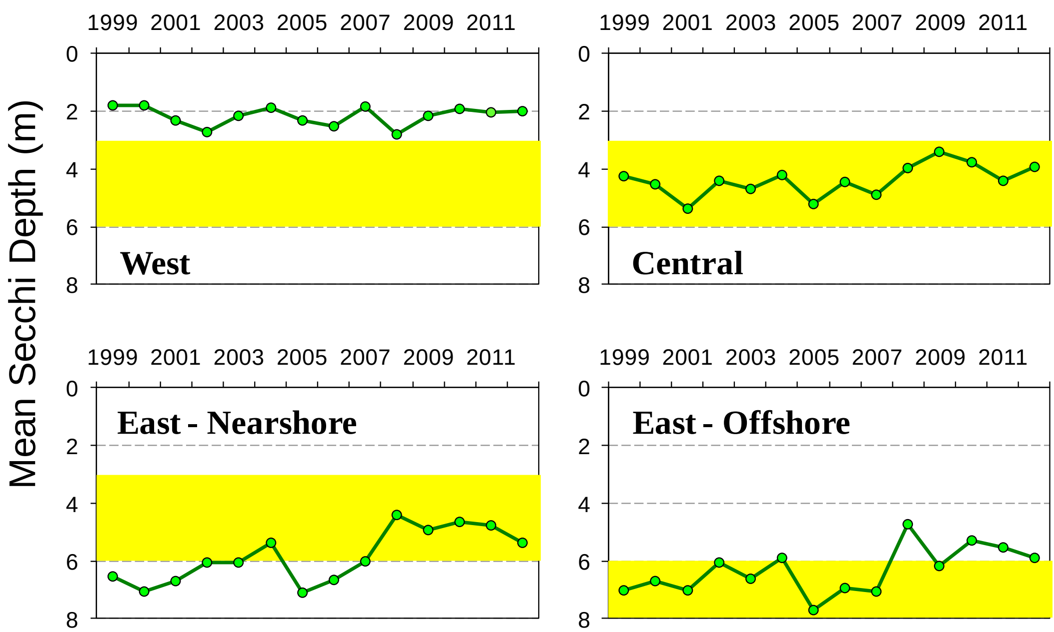


Figure 5.0.6. Mean summer (June-August) Secchi depth (m), weighted by month, by basin in Lake Erie, 1999-2012. The east basin is separated into inshore and offshore. Yellow shaded areas represent the targeted trophic class range. For this analysis data from stations 3 through 20 and 25 were included.

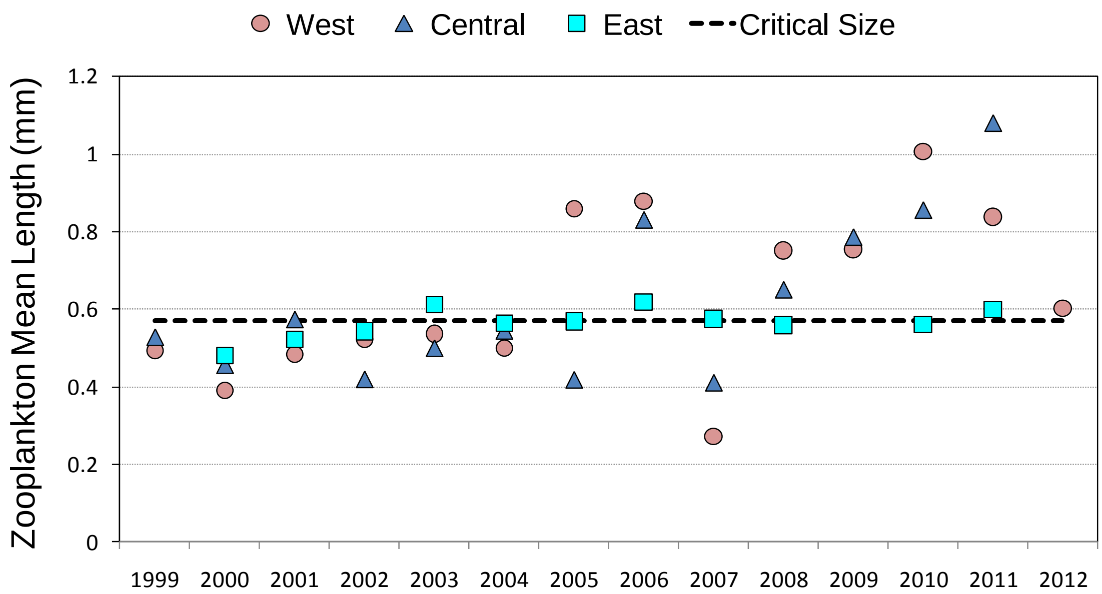


Figure 5.0.7. Mean length of the zooplankton community sampled with a 63 µm plankton net hauled through the epilimnion of each basin of Lake Erie, 1999-2012. The horizontal dashed line depicts 0.57 mm; if the mean size of the zooplankton community is 0.57 mm or less, predation by fish is considered to be intense (Mills *et al*. 1987, Johannsson *et al*. 1999). For this analysis data from stations 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 were included.

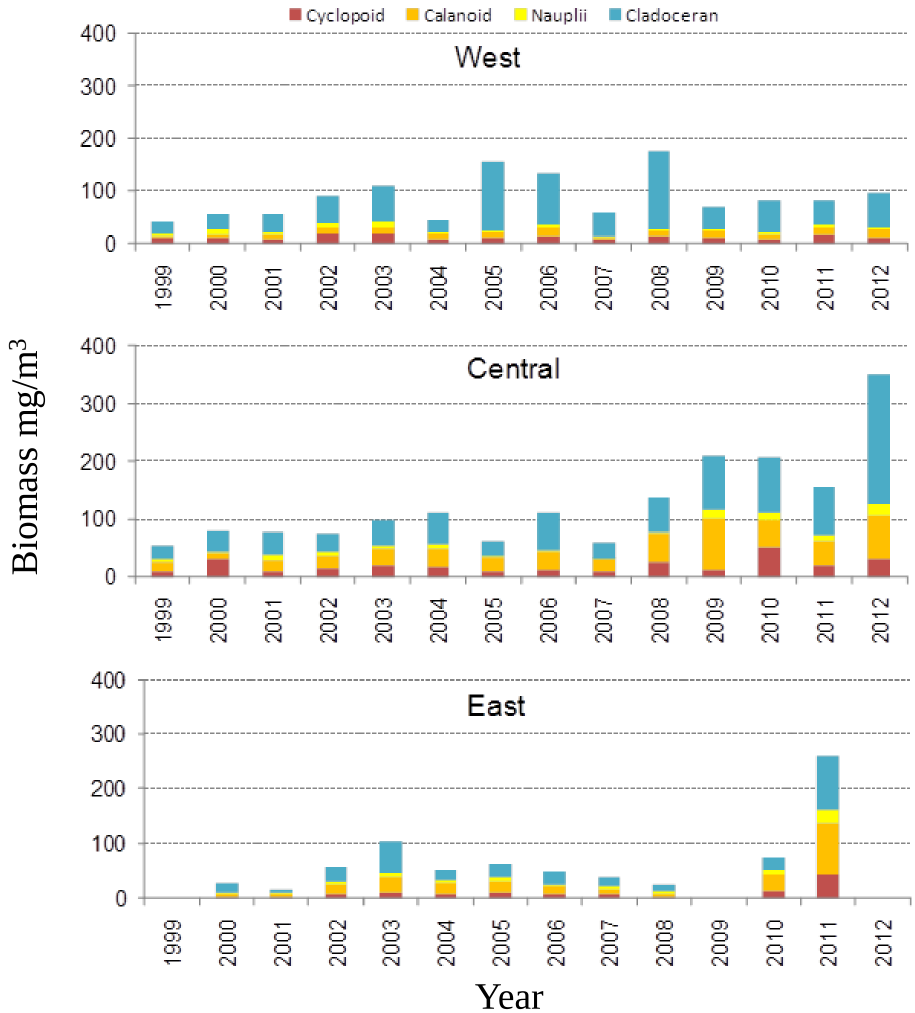


Figure 5.0.8. Mean annual zooplankton biomass (mg/m^3) by major taxonomic group basin, 1999 through 2012. There is no data for 1999, 2009 and 2012 in the eastern basin. West basin includes stations 3, 4, 5, and 6. East basin includes stations 7, 8, 9, 10, 11, 12, 13, and 14. East basin includes stations 15, 16, 17, 18, 19, and 20. Data excludes rotifers, and veligers.

6.0 *Hemimysis anomala* (T. MacDougal)

Hemimysis anomala, commonly called the bloody-red shrimp, is a small shrimp-like mysid crustacean native to European waters, primarily the Black Sea, the Azov Sea, and the Caspian Sea. It was first detected in the Great Lakes in 2006, likely as a result of introduction via ballast water from oceangoing ships. Confirmed observations of *Hemimysis anomala* from disparate geographic locations in 2006 (near Muskegon, MI, along the northeast shoreline of Lake Erie and in Lake Ontario near Oswego, New York) suggest that HA was established and broadly distributed within the Great Lakes at this point. (NOAA- GLERL; *Hemimysis* fact sheet, February 2007).

Occurrence in Fish Diets

Hemimysis anomala have been observed in the diets of a limited number of Lake Erie fish species. First observed in white perch in 2006 in Long Point Bay, they had also been observed in the stomachs of rock bass and, less frequently, yellow perch in the western basin waters by 2009 (Figure 6.0.1). In 2010 they were found for the first time in white bass and walleye (the walleye also contained a rainbow smelt offering a secondary possible source). *H. anomala* can now be reliably collected from harbor piers in the eastern basin of the lake (K. Bowen; DFO-GLLFAS; pers com) however no targeted surveys for *H. anomala* regularly occur. Because they are rarely observed other than in fish stomachs, documentation of *H. anomala* occurrence in fish diets has provided the most reliable method for tracking expansion and persistence of this invasive species in Lake Erie. Although there is no spatially comprehensive, lake-wide analysis of fish diets, at least three surveys allow for the consideration of the consumption of hemimysis by fish in all three basins (Figure 6.0.1). It should be noted that not all fish species are examined in all three surveys and that the number of individual fish examined varies between surveys and years. However, this data gives us a general picture of spatial difference and trend over time (within surveys).

Diet analysis from a gillnet index fishing program in Long Point Bay on the north shore of the eastern basin provides some idea of changes in use by different fish species since 2006. To date, the primary and most consistent consumer of *H. anomala* is white perch, which proportionally increased from 3% in 2006 to 14% in 2009. In 2012, white perch continued to be the primary consumer of *H. anomala* in this survey, they occurring in 10% of white perch examined (up from 7% in 2011; Figure 6.0.2). Rock bass are the second most consistent consumer, with H. anomala annually found in 1-3% of examined fish from 2007-2012 (but not in 2006 or 2010). Two percent of the rock bass in 2012 contained the mysid. *Hemimysis anomala* have not been observed in any yellow perch from Long Point Bay over the same time period, during which 3454 stomachs were examined.

Conversely, yellow perch were the first known consumers of *H. anomala* reported in the central basin (5 fish from ODNR surveys of Ohio waters). In 2010 one yellow perch from the western basin (USGS trawl surveys) was observed to have consumed *H. anomala*. *Hemimysis anomala* has also been found in the stomach of a white perch taken from east of Pelee Island in the western basin in 2009 (USGS surveys), and is the first observation from offshore, western basin waters. This suggests that the islands of the western basin likely also harbor this mysid. In 2011, hemimysis was observed in four yellow perch and one white perch in the western basin at locations including Michigan waters, the most western reports to date. Similarly, USGS and ODNR surveys each reported H. anomala in both white perch and yellow perch in 2012. Occurrences of *H. anomala* in white perch have been observed in all three basins, with proportions of fish consuming *H. anomala* increasing from west (0.40%) to central (0.99%) to east (5.86%). Occurrences of *H. anomala* in yellow perch are confined to the central and west basins.

White bass were first observed to utilize *H. anomala* in Long Point Bay in 2010 (1% of fish examined). Absent in 2011, they were observed in three percent of the white bass from the same area in 2012. The first and only observation of use by white bass west of this was from one individual captured by the ODNR near Fairport OH, in 2011.

By way of comparison, *H. anomala* in Lake Ontario have been shown to be utilized by rock bass (August) and yellow perch (October) to some degree (33% and 2%; respectively) but are predominantly utilized by alewives (69%-100%) in August, September, and October (Lantry et al. 2010). No Lake Ontario white perch consumed *H. anomala*, although the number examined was small (n=4).

Occurrence in Other Surveys

Outside of fish diets, *H. anomala* can be difficult to locate because the species is nocturnal, preferring to hide in rocky cracks and crevices near the bottom along the shoreline during daylight. It sometimes exhibits swarming behavior, especially in late summer, forming small dense reddish-tinged clouds containing thousands of individuals concentrated in one location and visible just below the surface of the water in a shallow zone (NOAA- GLERL; Hemimysis fact sheet, February 2007). Their preference for rocky substrate is also apparent from catches in survey gill nets from Long Point Bay (Figure 6.0.3).

In 2007, one free-swimming individual was detected in waters associated with the NRG Energy Steam Station in Dunkirk, NY and underwater video of the lakebed near Hoover Point, Ontario revealed multiple swarms of what appear to be *H. anomala* in 7m depths associated with rocky areas. In November 2008, lake trout egg traps captured 58 individuals on Brocton Shoal, a historic lake trout spawning area just west of Dunkirk. These samples were collected at depths of 13.7-18.9 m. *Hemimysis anomala* were also collected in egg traps in this same area during 2009 but in lesser numbers. Targeted sampling for *H. anomala*, conducted by the Canadian Department of Fisheries and Oceans (DFO-GLLFAS), along the north shore during 2007 and 2008, regularly found *H. anomala* in large numbers in all three lake basins (K. Bowen, Dept. of Fisheries and Oceans, GLLFAS, pers. comm.). Few (n=2) were caught during a much more intensive deployment of the traps in 2010 . In April of 2011, a single individual *H. anomala* was caught in a zooplankton net in School House Bay, Middle Bass Island (Darren Bade, Kent State University, pers. comm.). Swarms of *H. anomala* were recorded 6.5 km offshore during underwater video surveillance of Nanticoke Shoal in the fall of 2012; the first noted occurrence beyond the nearshore of the eastern basin (Figure 6.0.1).

The impact of this species on Lake Erie and the other Great Lakes is still unknown, but based on its history of invasion across Europe, significant impacts are possible. If integrated into the current lake ecosystem, this species has the potential to alter foodwebs by serving as both a food source and as a consumer of zooplankton resources. In its native waters, its main prey item is zooplankton, primarily cladocerans, rotifers, and ostracods. Laboratory studies using *Daphnia* have shown that *H. anomala* consumes preferentially small and medium-size zooplankton (0.7-1.5 mm), although it can attack larger prey, and also consumes small amounts of algae (Pérez-Fuentetaja personal observation). This species has the ability to reduce zooplankton biomass where it is abundant. Due to its lipid content, *H. anomala* is considered a high-energy food source and has the potential to increase the growth of planktivores (Kipp and Ricciardi 2007).

The Forage Task Group will continue to monitor and document the progression of this species and consider its impact on the Lake Erie ecosystem.

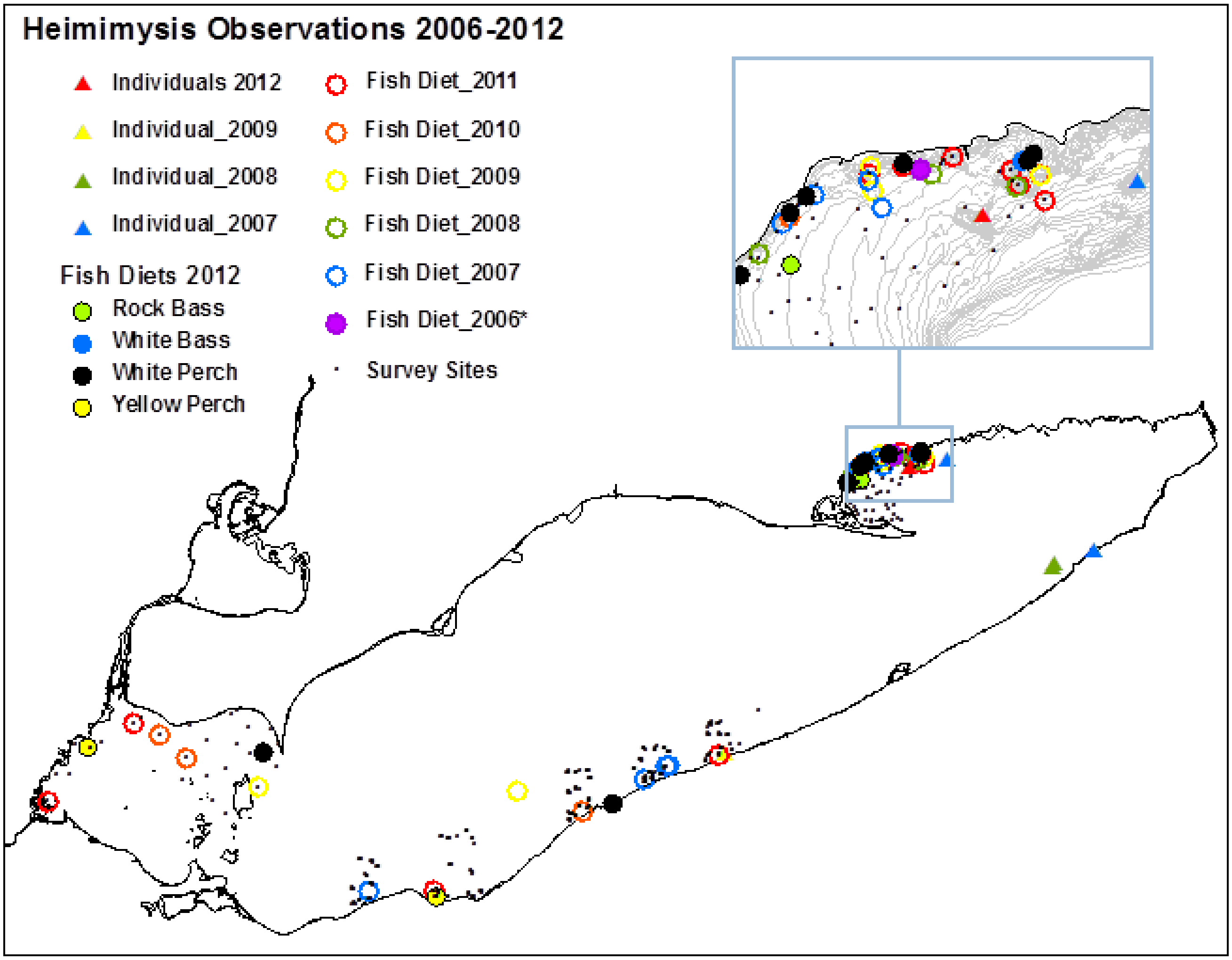


Figure 6.0.1. Distribution of *Hemimysis anomala* observations in Lake Erie, 2006-2012. The general areas where fish are collected for diet analyses are indicated with 2011 gillnet locations.

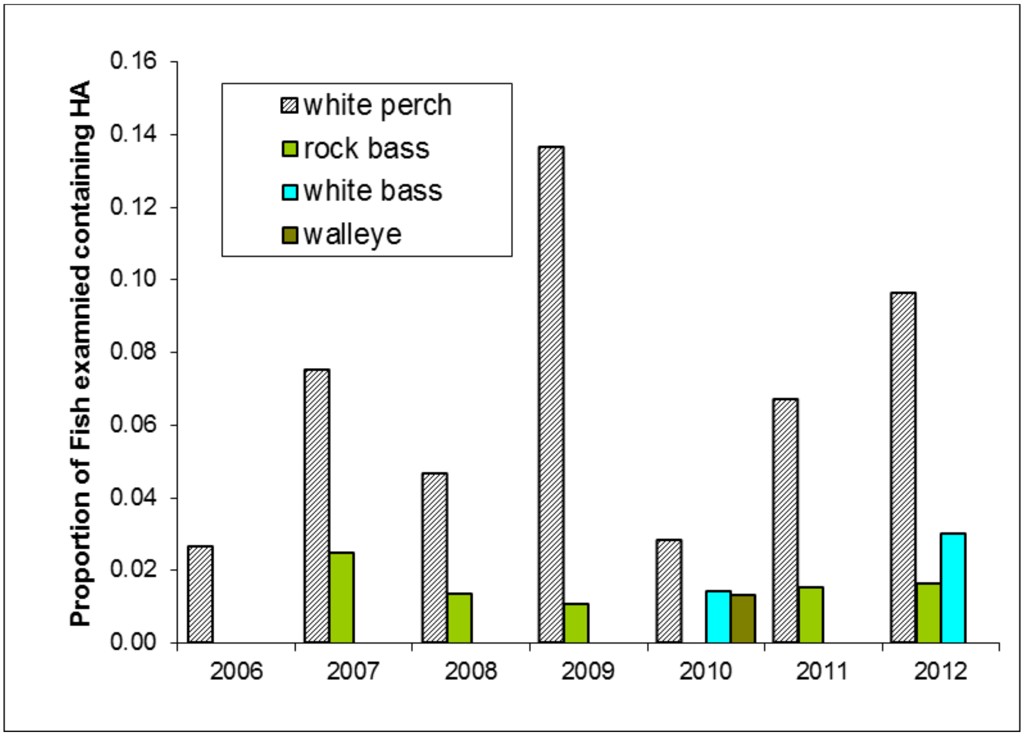


Figure 6.0.2 Occurrence of *Hemimysis anomala* in the diets of four fish species (proportion of fish stomachs examined) captured by gillnet in Long Point Bay, Ontario, 2006 – 2012.

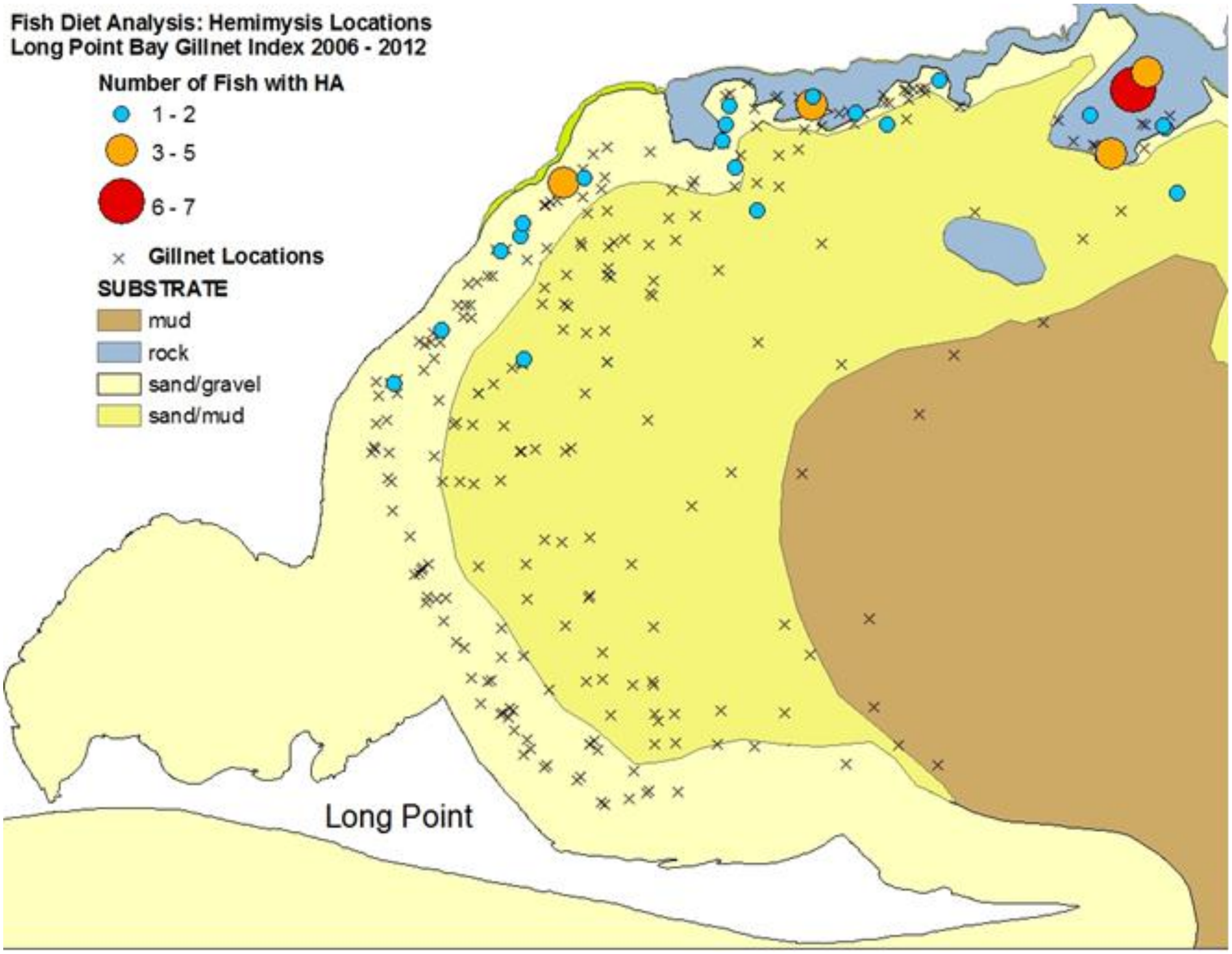


Figure 6.0.3. Distribution and occurrence of *Hemimysis anomala* observed in fish diets in a gillnet survey in Long Point Bay, Lake Erie, 2006 – 2012.

7.0 Protocol for Use of Forage Task Group Data and Reports

- The Forage Task Group (FTG) has standardized methods, equipment, and protocols as much as possible; however, data are not identical across agencies, management units, or basins. The data are based on surveys that have limitations due to gear, depth, time and weather constraints that vary from year to year. Any results, conclusions, or abundance information must be treated with respect to these limitations. Caution should be exercised by outside researchers not familiar with each agency's collection and analysis methods to avoid misinterpretation.

- The FTG strongly encourages outside researchers to contact and involve the FTG in the use of any specific data contained in this report. Coordination with the FTG can only enhance the final output or publication and benefit all parties involved.

- Any data intended for publication should be reviewed by the FTG and written permission obtained from the agency responsible for the data collection.

Citation:

Forage Task Group. 2013. Report of the Lake Erie Forage Task Group, March 2013. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission, Ann Arbor, Michigan, USA.

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