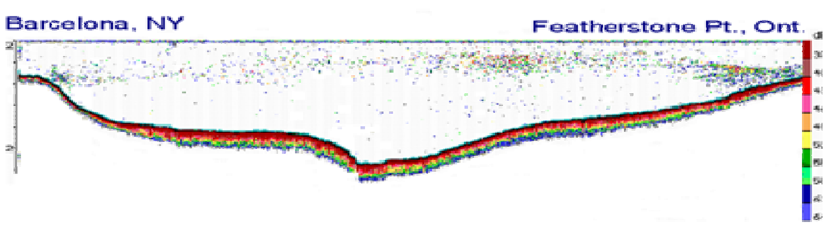
Report of the Lake Erie Forage Task Group

March 2011



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Eric Weimer	- Ohio Department of Natural Resources, (ODNR) {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)
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Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

Table of Contents

1.0 Charges to the Forage Task Group in 2010-2011

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 2010 Forage Status and Trends

General Patterns

- Relative forage abundance was low to moderate in 2010
- Age-0 rainbow smelt increased in the East, decreased in the West.
- Gizzard shad increased in East, decreased in the West
- Alewife have declined from early 2000's
- Predator growth was above average in all basins
- Phosphorus levels are increasing in all basins, and are at or above Fish Community Objectives.

Eastern Basin

- Forage fish abundance during 2010 was low (Ontario) to moderate (New York)
- Age-0 rainbow smelt abundance increased basin-wide; 2010 year class was weak (ON) to moderate (NY)
- YAO rainbow smelt abundance decreased basin wide; below average (ON) to above average (NY) abundance
- Age-0 yellow perch abundance increased; 2010 year class strength ranked as average (ON) to above average (NY)
- Age-0 alewife abundance increased but remained below average
- Age-0 gizzard shad increased; highest numeric density (NY), 4th highest biomass CPE (ON)
- Age-0 emerald shiners increased; Yearling-and-older (YAO) decreased, all age groups below average abundance
- Spottail shiner remain at low densities throughout basin
- Round goby densities decreased basin-wide
- Average length of age-0 and age-1 smelt increased
- Predator diets were diverse, dominated by fish species, primarily rainbow smelt and round goby
- Predator growth remains good; age-2 to age-6 smallmouth bass remain at or near record long length-at-age in Long Pt. Bay, ON, and age-2 and age-3 bass cohorts in NY near maximum mean lengths
- Lake trout growth remains high and stable

Central Basin

- Low to moderate forage fish abundance throughout the basin in 2010
- Age-0 recruitment increased from 2009, but was below average
- Yearling-and-older decreased from 2009, well below average
- Age-0 rainbow smelt increased in western Ohio, above average
- Age-0 and YAO emerald shiner increased in eastern Ohio
- Age-0 alewife have not been caught in the last three years in central basin surveys
- Round goby abundance is below average in eastern Ohio and slightly above average in western Ohio
- Mean size of forage species remains at or above average
- Mean size of walleye and white bass above average for fish up to age-3
- Predator diets were predominantly rainbow smelt, gizzard shad and emerald shiners

West Basin

- Age-0 gizzard shad catches decreased dramatically from 2009 to the third lowest level in time series (1988)
- Age-0 and YAO rainbow smelt catches decreased dramatically from 2009
- Age-0 and YAO emerald shiner decreased from 2009 and both below long-term mean
- Age-0 white perch increased 31% from 2009, well above the long-term mean
- Round gobies decreased for the third consecutive year, and lowest since first year of invasion (1997)
- Age-0 yellow perch 5th lowest in time series; walleye recruitment up from 2009 but below long-term mean; white bass recruitment down slightly but still above long-term mean; age-0 smallmouth bass 4th highest in time series
- Size of age-0 walleye, yellow perch, white bass, white perch, and smallmouth bass all above long term means
- Fall walleye diets show reliance on gizzard shad and emerald shiners

2.2 Eastern Basin (L. Witzel, J. Markham, D. Einhouse, and C. Murray)

Rainbow smelt are the principal forage fish species of piscivores in the offshore waters of eastern Lake Erie. In 2010, rainbow smelt once again was the most abundant forage species captured in fall index bottom trawl surveys in Ontario (OMNR) and New York (NYS DEC); the PFBC did not perform any bottom trawl assessment in Pennsylvania waters of the east basin during 2010 (Table 2.2.1). Yearling-and-older (YAO) rainbow smelt abundance was average in New York and below average in Ontario with approximately 50% of YAO-members from the 2008 year class (age-2). Age-0 rainbow smelt abundance was higher in New York compared to Ontario; 2010 density estimates were near average in New York, but only about one-third of the long-term average for Ontario's trawl time series. The mean length of age-0 (66 mm FL) rainbow smelt increased slightly in 2010 (Figure 2.2.1). The mean length of age-1 (101 mm FL) smelt increased considerably from record small size in 2009 (88 mm FL), but were still smaller than average (1984-2009 avg. = 103 mm).

The contribution of non-smelt fish species to the forage fish community of eastern Lake Erie was dominated in 2010 by emerald shiner and round goby in Ontario and by trout perch, age-0 yellow perch, round goby and age-0 white perch in New York (Table 2.2.1). Emerald shiner remained below average abundance throughout most regions of eastern Lake Erie in 2010 following record high catches in 2006. Spottail shiner abundance remained low throughout all eastern basin regions in 2010. (Table 2.2.1). Episodic high catches of age-0 alewife have been observed in agency trawl assessments, but not in recent years (2000, 2002 in NY, 1999 in ON). Age-0 alewife abundance was below the long-term average for all surveyed areas in 2010. Age-0 gizzard shad abundance increased in 2010, reaching a record high numeric density in New York and was the fourth highest biomass index observed in Ontario.

Round goby emerged as a new species among the eastern basin forage fish community during the late 1990s. Round gobies continued to increase in density 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 during the current decade have been variable in an increasing trend with peak densities occurring about ever third year in 2001, 2004 and most recently in 2007. Round goby densities have decreased since 2007 and the 2010 estimate ranks as the lowest index observed in Ontario and the second lowest in New York since 2000, the year after this invader was first captured in these east basin jurisdictions (Table 2.2.1).

During 2010, NYS DEC and OMNR continued to participate in the eastern basin component of the lake-wide inter-agency Lower Trophic Level Assessment (LTLA) program coordinated through the Forage Task Group. Pennsylvania (PFBC) did not participate in this sampling program in 2010. Last year's data have been or are in the process of being incorporated in the Forage Task Group's LTLA database. Selected elements of 2010 LTLA results for the east basin and other regions of Lake Erie are reported in Section 5.0.

Rainbow smelt have remained 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 about 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 2006, a year of low YAO rainbow smelt abundance, round goby became prominent in the diets of both Lean and Klondike strain lake trout, occurring in 53% and 68% respectively of stomach samples containing food. Since 2007, rainbow smelt once again were the most frequently observed food item of both Lean and Klondike strain lake trout. In 2010, the decrease in the smelt population was once again evident in lake trout diets. Smelt were the most prevalent diet item (61%) in Lean strain lake trout, but round goby were the most common diet item in Klondike strain lake trout (57%). Round goby occurred more frequently in the diets of Klondike than Lean strain lake trout during all six years since 2005 that Klondike trout have been collected in coldwater assessment gear.

Decreased abundance of YAO rainbow smelt in the eastern basin of Lake Erie in 2010 was also evident in the diet of burbot. The occurrence of rainbow smelt in burbot stomachs containing food decreased to 37% from a 2009 high of 60% and was coincident with an increase in occurrence of round goby from 36 to 65%. This was the second highest percentage of round goby observed in burbot diets since 2000. For the first time ever, a stocked yearling lake trout was found in a burbot stomach in 2009.

Mean length of age-2 and age-3 smallmouth bass cohorts sampled in 2010 autumn gill net collections (New York) equaled the highest observations spanning the 30-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 2010, length-at-age for each of age-2 to age-6 smallmouth bass cohorts remained at or near maximum values observed during the 25-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 near long term average sizes. Mean size-at-age (length and weight) of lake trout in 2010 were consistent with the recent 10-year average (2000 – 2009) and k condition coefficients 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 C. Murray)

Overall forage abundance in the central basin was below average for 2010. Yearling-and-older forage indices decreased from 2009 and were the second lowest abundance indices in the 10-year time series. Age-0 trawl indices generally increased from 2009, especially in eastern Ohio, but were below average (Tables 2.3.1 and 2.3.2).

Age-0 trawl indices for yellow perch, rainbow smelt, emerald shiner and trout-perch increased from 2009 in both eastern and western Ohio waters. In eastern Ohio, only yellow perch and trout-perch indices were above the long-term average. Rainbow smelt was the only age-0 index above the long-term average in western Ohio. Abundances of gizzard shad and white perch increased in eastern Ohio, but decreased in western Ohio relative to 2009. Both gizzard shad and white perch indices were well below long-term averages. Alewife has not been caught in the central basin since 2007, despite being regularly encountered in western Ohio prior to 2004. Spottail shiner were also absent from Ohio surveys. While abundance of spottail shiners has traditionally been low in the central basin, a catch of zero is unusual.

Emerald shiner and trout-perch YAO abundance indices increased in eastern Ohio relative to 2009. All other YAO forage indices, except for round goby in eastern Ohio, decreased from 2009. Emerald shiner abundance was slightly above the long-term average in eastern Ohio, and except for round goby in western Ohio, all other YAO indices were below the long-term average. The basin wide decrease in YAO abundance is most likely due to the poor 2009 year class.

Over the last decade, round goby abundance has tended to be more stable and consistent in the west compared to the east for both age-0 and YAO. In 2010, age-0 round goby abundance was similar to 2009 in western OH, while abundance of age-0 increased in eastern OH. Yearling-and-older round goby abundance decreased slightly in western OH, and increased in eastern OH. Abundance of both age-0 and YAO round goby were slightly above average in western Ohio and below average in eastern Ohio.

Central basin diets of walleye and white bass from the fall gillnet survey in Ohio continue to be comprised of gizzard shad, rainbow smelt and emerald shiners. Adult walleye diets were similar between western and eastern Ohio. Gizzard shad and emerald shiners, when combined, contributed 92% of the diets in western Ohio and 77% of the diets in eastern Ohio. Rainbow smelt comprised the remaining proportion of the diet in both areas (2011 ODW). Yearling walleye diets were almost exclusively emerald shiner (93%). Gizzard shad comprised the remaining diet of age-1 walleye. Adult white bass diets in western Ohio were comprised of emerald shiner (67%) gizzard shad (20%), and rainbow smelt (11%). Eastern Ohio white bass diets contained primarily emerald shiners (58%) and rainbow smelt (31%), with a small contribution from gizzard shad (4.2%). Smallmouth bass diets collected in fall gillnet surveys continue to be primarily round goby throughout the central basin (65% western Ohio, 66% eastern Ohio), followed by emerald shiner (19% western Ohio, 21% eastern Ohio). Gizzard shad comprised the remaining smallmouth bass diet in western Ohio. Smallmouth bass in eastern Ohio consumed a wider variety of prey items including small amounts of rainbow smelt, crayfish and other fish.

Mean size at age of walleye and white bass collected during 2010 were above average for fish up to age-3. Walleye growth up to age-3 in the central basin has been above average since 2007. Mean size of most forage species also remains at or above average for the ten year time series.

During 2010, Lower Trophic Level Assessment samples were collected from May through September in the central basin. These data are included in the Forage Task Group's LTLA database.

2.4 West Basin (E. Weimer, P. Kocovsky, and A. Stoneman)

Long periods of warm, stable weather typified the summer of 2010, reducing mixing and establishing areas of reduced dissolved oxygen. Low levels of dissolved oxygen at the bottom of the water column during the August trawling surveys likely reduced catches at some sites, particularly in the deeper waters near the boundary between the west and central basins. Ten of the 32 Ohio sites and 3 of the 39 Ontario sites surveyed in August had extremely low bottom dissolved oxygen levels. In Ohio, these sites were among the deepest in the survey, and the layer of deoxygenated water extended up to 2 m off the bottom, thus reducing the likelihood that fish would be collected in bottom trawls. In response to low dissolved oxygen, these sites were removed from analyses, leaving 58 remaining sites in 2010.

Indices of western basin recruitment and forage abundance declined in 2010 for most species. Recruitment of age-0 yellow perch (95.4/ha) decreased relative to 2009, while age-0 walleye (26.2/ha) increased (Figure 2.4.1); both remain well below long-term means. Age-0 white perch (4051.8/ha) increased dramatically to the sixth highest index since 1988. Age-0 white bass (215.9/ha) decreased, yet remain above long term means, while age-0 smallmouth bass (2.06/ha) increased to the fourth highest index since 1988. Age-0 and yearling-and-older (YAO) rainbow smelt decreased sharply in 2010 (0.04/ha and 0.11/ha, respectively) relative to the high catches in 2009. Age-0 gizzard shad (74.7/ha) also decreased dramatically to the third lowest index since 1988, while alewife remain missing (Figure 2.4.2). Catches of age-0 emerald shiners (62/ha) and YAO emerald shiners (18.3/ha) decreased in 2010. Catches of round gobies (30.1/ha) decreased to the lowest levels since their discovery in 1997. Catches of age-0 and YAO logperch, and yearling and adult yellow perch decreased in 2010, while age-0 and YAO trout-perch, age-0 freshwater drum, and age-0 and YAO spottail shiners all increased. Overall, catches of age-0 and YAO shiners declined in 2010 (Figure 2.4.3). Lengths of age-0 walleye, yellow perch, white bass, white perch, and smallmouth bass all increased in 2010 relative to 2009.

Adult walleye diets taken from fall gillnet catches were dominated by gizzard shad (65%) and emerald shiner (31%) in the western basin. Yearling walleye relied on emerald shiner (85%) and gizzard shad (13%). In 2010, spring and autumn diet analysis of age-2 and older yellow perch showed most of the stomachs contained benthic invertebrates (87.9 and 88.7% respectively), primarily *Hexagenia sp*., Chironomidae, and *Dreissena sp.* Zooplankton, primarily *Daphnia retrocurva*, occurred in a higher percentage of stomachs during spring (70.3%) than in autumn (26.8%). Trends indicate that benthic prey always made up an important component of the diet, occurring in >50% of yellow perch stomachs regardless of season. Yellow perch have a greater percentage of stomachs containing fish prey in autumn samples than in spring samples.

Water temperatures were generally higher in 2010 than the previous year, with peak surface temperature (28.4°C) recorded on July 26. Spring warming rate (May 10 to June 3) was 0.33°C per day, higher than 2009. Seasonally averaged basin wide Secchi depth remained similar to 2009, averaging 1.7 m [range 0.3m (May 24) to 4.9m (July 14)]. Western basin bottom dissolved oxygen levels averaged 7.5 mg/l [range 1.6 (July 14) to 11.0mg/l (May 20)], lower than the previous year. Ecological indices useful in interpreting the state of the western basin resource are discussed in Section 5.0 (“Interagency lower trophic level monitoring”).

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 three most recent completed decades. Agency trawl surveys are described below. Pennsylvania FBC (PA-Fa) did not conduct a fall index trawl survey in 2006 and 2010, and the 2008 survey was a reduced effort of four tows sampled in a single day.

Species	Age Group	Trawl Survey	Year 2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	Long-term Average by decade 2000's	1990's	1980's
Smelt	**YOY**	ON-DW	326.9	148.2	1293.0	991.3	1256.0	0.9	132.2	7058.1	142.5	2633.3	1391.5	485.6	1382.9
	YOY	NY-Fa	1416.6	64.9	2128.9	2889.6	507.9	1259.6	1146.1	1733.4	1606.6	2727.7	1524.9	1450.9	NA
	YOY	PA-Fa	NA	47.7	15.1	260.2	NA	47.9	12.3	592.2	98.0	34.6	138.2	550.8	7058.1
	YAO	ON-DW	222.7	1654.3	77.3	232.8	136.2	7.6	567.5	209.8	5.9	741.5	366.2	404.7	969.0
	YAO	NY-Fa	997.8	3016.6	546.5	176.9	162.9	395.2	2624.1	282.1	117.0	138.3	753.4	581.6	NA
	YAO	PA-Fa	NA	407.2	1.8	1006.3	NA	0.0	12.3	32.4	6.5	13.9	164.5	378.0	2408.6
Emerald Shiner	**YOY**	ON-DW	117.6	54.8	16.0	29.3	452.3	645.7	20.3	3388.0	9.5	12.7	463.2	54.8	20.5
	YOY	ON-OB	0.0	1.3	1.6	76.9	64.8	1.1	405.2	160.3	20.0	28.6	78.1	119.4	152.3
	YOY	NY-Fa	62.9	48.5	3.7	150.9	778.5	291.4	7.8	229.7	19.5	366.7	194.0	112.4	NA
	YOY	PA-Fa	NA	1063.0	0.0	81.7	NA	0.5	0.0	1163.4	74.4	0.0	264.8	41.0	118.3
	YAO	ON-DW	30.7	40.1	95.2	149.8	4200.3	139.0	891.2	204.7	247.8	1503.7	819.0	46.4	38.1
	YAO	ON-OB	0.0	3.0	5.1	56.3	318.4	0.1	60.0	21.3	19.3	21.8	52.6	49.9	133.5
	YAO	NY-Fa	20.6	156.4	18.2	84.8	925.5	151.4	284.2	444.5	466.4	333.8	290.8	105.4	NA
	YAO	PA-Fa	NA	1360.3	0.0	4713.1	NA	52.5	0.0	157.6	105.6	4.6	710.4	14.5	45.6
Spottail Shiner	**YOY**	ON-OB	2.2	2.8	23.9	12.3	12.5	58.7	43.2	40.0	12.6	50.4	137.5	696.6	249.0
	YOY	ON-IB	0.0	0.0	0.0	0.3	0.1	1.0	1.9	0.3	0.0	10.7	1.7	111.6	291.3
	YOY	NY-Fa	6.5	0.1	0.3	0.1	0.5	0.5	0.1	13.2	1.0	40.6	5.6	19.9	NA
	YOY	PA-Fa	NA	1.1	0.0	0.0	NA	0.0	0.0	0.0	0.0	0.0	0.1	4.0	2.0
	YAO	ON-OB	1.6	2.0	4.7	0.0	6.5	3.2	7.9	4.8	12.1	8.4	10.3	52.3	21.3
	YAO	ON-IB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	2.0	0.4	2.0	9.4
	YAO	NY-Fa	10.4	5.1	1.5	0.0	4.1	4.3	2.5	4.8	34.2	7.5	6.4	4.0	NA
	YAO	PA-Fa	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.8	0.0	0.1	7.9	12.4
Alewife	**YOY**	ON-DW	0.9	0.1	2.3	1.0	78.6	0.1	0.3	0.5	35.3	81.1	22.5	234.1	21.4
	YOY	ON-OB	0.2	1.1	11.4	25.5	459.4	11.0	3.2	8.9	13.0	0.3	55.1	61.0	51.5
	YOY	NY-Fa	15.4	0.0	5.6	22.2	30.8	27.7	4.4	3.9	617.6	16.2	94.3	52.0	NA
	YOY	PA-Fa	NA	0.0	0.0	8.0	NA	0.0	0.0	2.5	0.8	0.0	1.3	7.7	16.6
Gizzard Shad	**YOY**	ON-DW	13.3	0.4	86.5	34.6	1.4	1.7	0.2	68.6	3.2	16.0	21.3	7.5	15.3
	YOY	ON-OB	2.7	1.1	2.6	12.3	19.0	1.9	3.6	3.1	1.5	6.3	5.7	9.6	24.1
	YOY	NY-Fa	40.9	5.3	10.8	11.7	14.1	3.7	0.6	27.8	5.5	39.7	11.9	4.2	NA
	YOY	PA-Fa	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	0.8	0.0	0.1	0.9	74.3
White Perch	**YOY**	ON-DW	1.6	0.6	5.4	0.1	0.9	0.1	0.0	16.2	0.0	6.1	2.9	2.2	5.6
	YOY	ON-OB	0.0	0.0	1.3	0.4	0.8	0.4	0.1	8.6	0.0	3.9	2.1	14.2	28.7
	YOY	NY-Fa	157.3	20.2	431.5	34.6	91.9	99.8	1.0	37.7	6.2	19.3	74.3	29.4	NA
	YOY	PA-Fa	NA	598.5	0.7	444.6	NA	51.2	0.0	523.9	0.0	677.4	256.0	101.1	NA
Trout Perch	**All**	ON-DW	0.3	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.1	0.1	0.5
	All	NY-Fa	461.6	517.0	996.4	561.2	519.4	1317.3	545.9	1392.6	886.0	1015.3	826.0	410.0	NA
	All	PA-Fa	NA	558.8	0.6	156.9	NA	198.5	160.3	256.6	0.0	27.6	152.1	50.9	NA
Round Goby	**All**	ON-DW	9.7	43.6	452.6	973.2	93.3	66.9	323.8	158.8	127.0	69.0	235.9	0.0	0.0
	All	ON-OB	48.5	52.1	44.2	59.8	20.8	28.0	69.1	61.6	97.2	129.9	58.2	0.1	0.0
	All	ON-IB	100.5	164.0	137.9	185.1	21.4	21.0	66.9	20.4	46.6	122.6	80.2	0.0	0.0
	All	NY-Fa	173.3	502.6	466.8	1293.2	846.5	707.0	1094.5	613.4	135.9	575.4	651.7	35.9	0.0
	All	PA-Fa	NA	350.1	441.6	2043.8	NA	887.8	927.5	387.3	43.9	3419.1	1094.6	30.3	0.0

"**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; 80's Avg. is for the period 1984 to 1989; 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 mesh cod end liner. Indices are reported as NPH; 80's Avg. is for the period 1984 to 1989; 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; 80's Avg. is for the period 1984 to 1989; 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; 80's Avg. is for the period 1984 to 1989; 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 2000-2010. 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											
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
Species	Survey												
Yellow	OH west	21.9	114.6	6.0	149.0	8.7	37.8	10.0	167.0	37.3	1.3	41.1	55.4
Perch	OH east	1.3	13.6	2.5	47.5	1.9	156.2	18.9	177.8	52.8	0.5	96.3	47.3
	PA	15.7	388.4	11.9	788.0	2.4	-	-	10.0	863.4	14.2	-	261.7
White	OH west	581.3	779.7	293.0	310.1	759.7	1002.5	440.4	1381.2	544.9	506.1	254.8	659.9
Perch	OH east	4.9	57.6	5.9	61.8	108.0	2034.5	46.1	1095.9	91.6	34.6	190.3	354.1
	PA	75.9	26.6	80.7	173.8	2.4	-	-	17.8	199.0	146.5	-	90.3
Rainbow	OH west	150.1	2.3	274.7	1753.9	352.1	10.7	94.3	98.1	635.2	293.5	776.2	366.5
melt	OH east	1070.3	0.0	218.1	2914.1	388.9	44.4	570.7	702.4	3997.7	0.3	421.6	990.7
	PA	15.3	377.4	152.9	177.6	20.9	-	-	35.1	552.2	23.4	-	169.4
Round	OH west	21.7	43.9	37.8	22.6	13.9	37.2	19.0	26.9	17.4	25.9	28.4	26.6
Goby	OH east	158.2	39.6	64.7	57.5	173.9	148.1	46.3	273.1	26.3	1.0	41.8	98.9
	PA	781.1	1577.8	289.3	75.3	1011.3	-	-	227.8	227.1	72.2	-	532.7
Emerald	OH west	127.2	50.5	39.4	477.6	7.0	567.1	587.2	52.6	36.3	6.1	8.8	195.1
Shiner	OH east	500.6	2.2	0.5	903.1	0.8	279.8	1115.1	63.7	20.2	1.7	234.9	288.8
	PA	0.0	8.5	38.1	81.8	0.0	-	-	0.8	0.0	303.2	-	54.0
Spottail	OH west	0.4	5.9	1.6	0.0	0.0	0.2	0.0	3.1	3.7	0.6	0.0	1.6
Shiner	OH east	0.0	0.7	0.2	0.5	0.0	1.1	0.2	0.5	0.2	0.0	0.0	0.3
	PA	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	0.0
Alewife	OH west	62.1	50.8	59.7	0.1	0.0	0.0	4.4	0.0	0.0	0.0	0.0	17.7
	OH east	12.4	0.0	1.1	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	1.7
	PA	0.0	0.0	0.4	0.0	0.0	-	-	0.0	0.0	0.0	-	0.1
Gizzard	OH west	117.1	60.3	24.6	402.6	0.6	12.3	32.7	195.0	35.7	50.9	2.6	93.2
Shad	OH east	27.6	1.8	12.3	20.4	0.3	15.7	30.7	15.5	63.1	3.9	8.5	19.1
	PA	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	0.0
Trout-	OH west	1.0	2.0	1.4	2.0	20.3	0.1	0.2	0.8	0.3	0.3	0.7	2.8
perch	OH east	0.4	0.0	0.3	1.4	1.4	1.6	0.1	5.4	0.1	0.2	1.4	1.1
	PA	23.0	7.8	45.6	78.0	6.7	-	-	10.9	126.1	28.1	-	40.8

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

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 2000-2010. 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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
Yellow	OH west	61.6	5.7	51.7	3.2	216.5	18.3	4.2	19.8	56.6	20.7	11.9	45.8
Perch	OH east	19.3	0.4	38.3	1.2	45.2	132.3	12.5	37.0	26.4	139.4	12.4	45.2
	PA	3.9	41.3	37.5	75.6	18.3	-	-	27.4	76.4	120.9	-	50.2
White	OH west	91.1	21.7	91.5	28.2	83.9	34.1	32.4	27.1	76.5	42.0	32.6	52.9
Perch	OH east	38.6	0.4	176.2	12.0	27.0	20.1	38.5	16.8	36.6	282.3	44.8	64.9
	PA	0.6	2.4	38.5	28.6	6.2	-	-	0.8	4.2	63.3	-	18.1
Rainbow	OH west	65.6	55.6	45.3	29.4	320.5	89.8	8.9	40.4	9.6	419.4	18.0	108.5
Smelt	OH east	150.3	3.3	320.9	370.3	1360.2	30.8	17.3	532.4	64.9	109.1	56.9	296.0
	PA	75.8	0.0	6.2	22.1	9.9	-	-	10.7	3.5	408.0	-	67.0
Round	OH west	27.5	54.8	39.2	25.4	27.0	33.6	20.4	26.3	57.9	58.0	44.0	37.0
Goby	OH east	164.5	88.4	54.3	127.1	148.8	263.0	78.9	185.6	167.8	19.3	36.0	129.8
	PA	126.5	55.2	238.3	59.1	767.0	-	-	361.1	326.6	75.9	-	251.2
Emerald	OH west	109.2	106.3	233.9	54.9	1.5	233.6	162.7	418.7	495.0	99.5	51.5	191.5
Shiner	OH east	830.5	0.7	133.2	432.0	0.4	479.6	451.1	27.8	1159.4	167.8	375.1	368.3
	PA	0.0	0.0	107.4	217.5	0.0	-	-	769.5	28.0	171.5	-	161.7
Spottail	OH west	8.7	3.5	6.6	1.6	5.3	0.3	1.2	2.3	2.3	3.1	0.0	3.5
Shiner	OH east	8.6	1.1	5.9	1.0	0.2	3.8	0.7	0.6	2.9	0.0	0.0	2.5
	PA	0.0	0.0	2.2	0.0	0.0	-	-	0.0	0.0	0.0	-	0.3
Trout-	OH west	17.2	3.2	27.2	12.2	14.0	13.5	3.3	5.5	4.8	0.8	0.7	10.2
perch	OH east	15.3	2.2	8.5	2.9	7.7	76.2	4.8	6.7	8.4	1.5	5.0	13.4
	PA	11.5	0.6	81.2	50.9	5.2	-	-	16.0	61.7	127.3	-	44.3

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

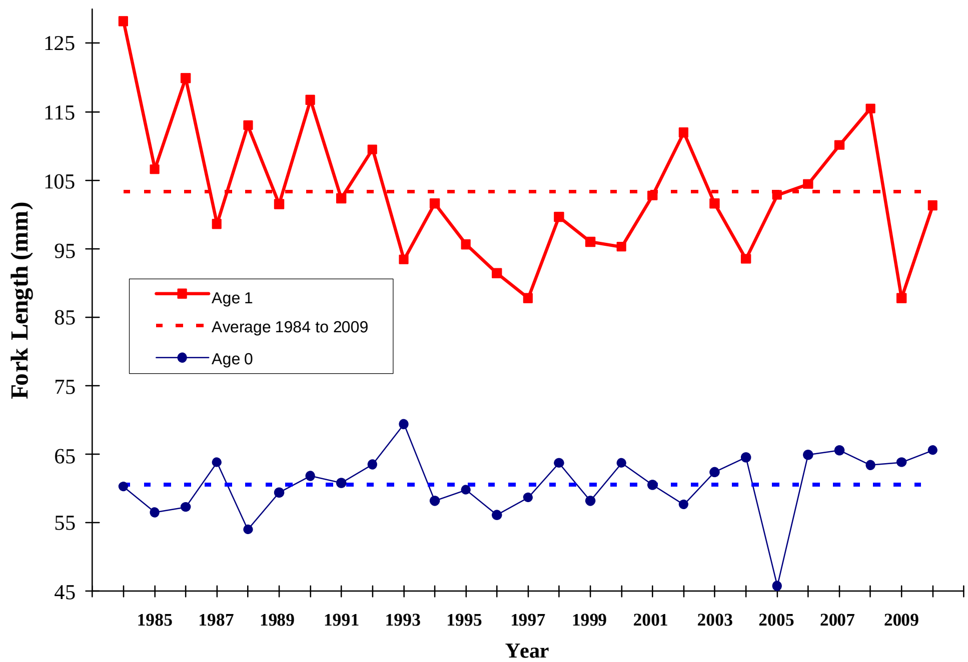

Figure 2.2.1 Mean fork length of age 0 and 1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 2010.

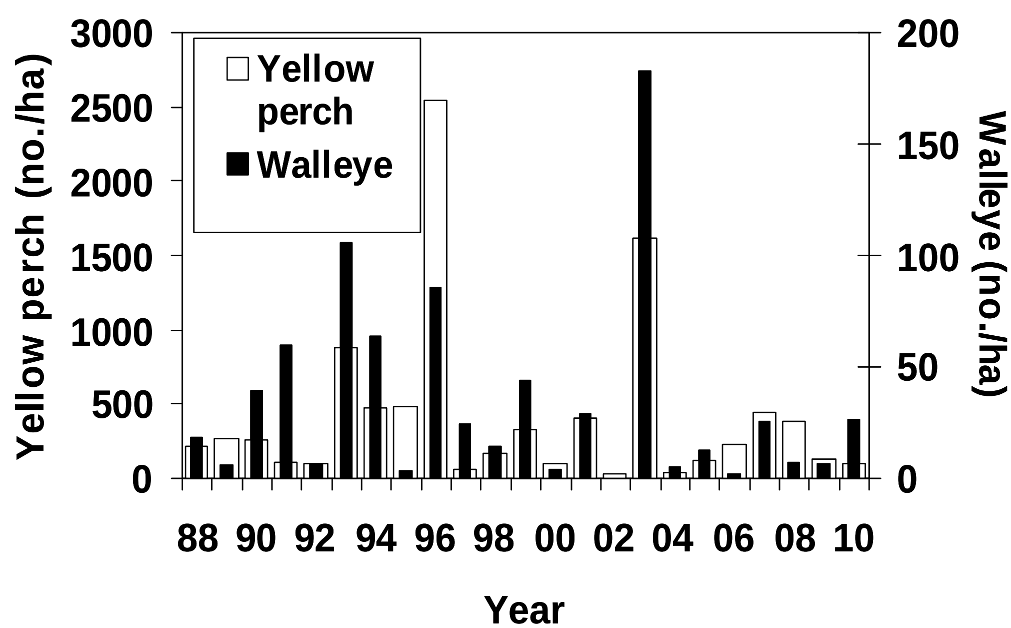

Figure 2.4.1. Density of age-0 yellow perch and walleye in the western basin of Lake Erie, August 1988-2010.

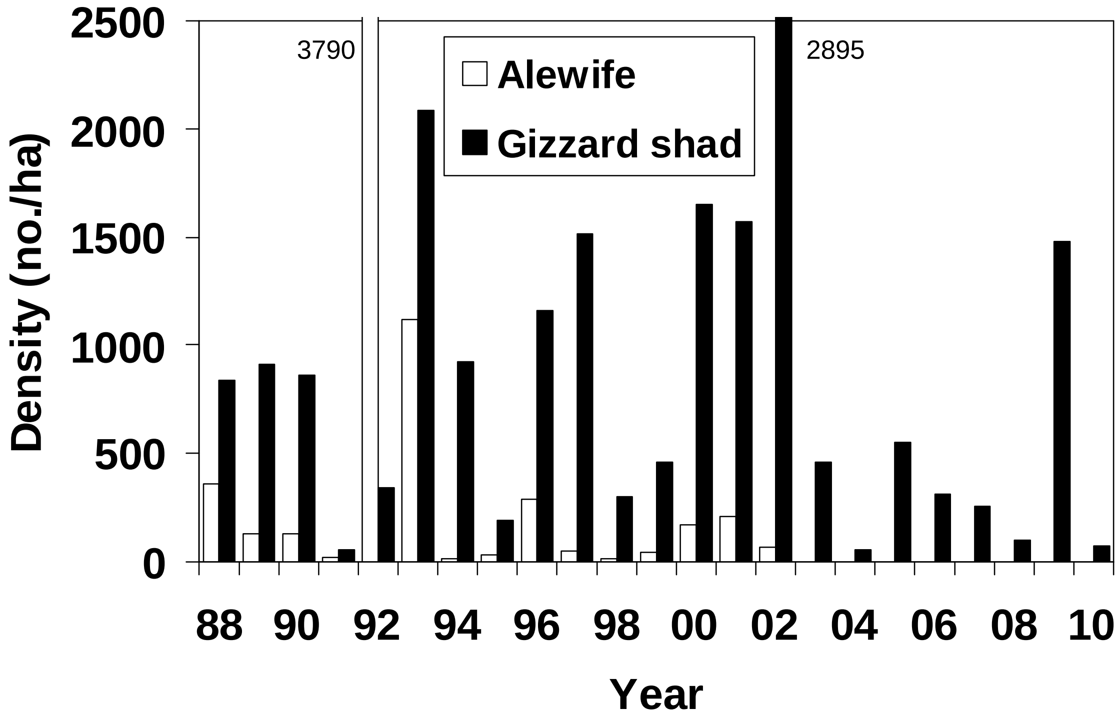

Figure 2.4.2. Density of age-0 alewife and gizzard shad in the western basin of Lake Erie, August 1988-2010.

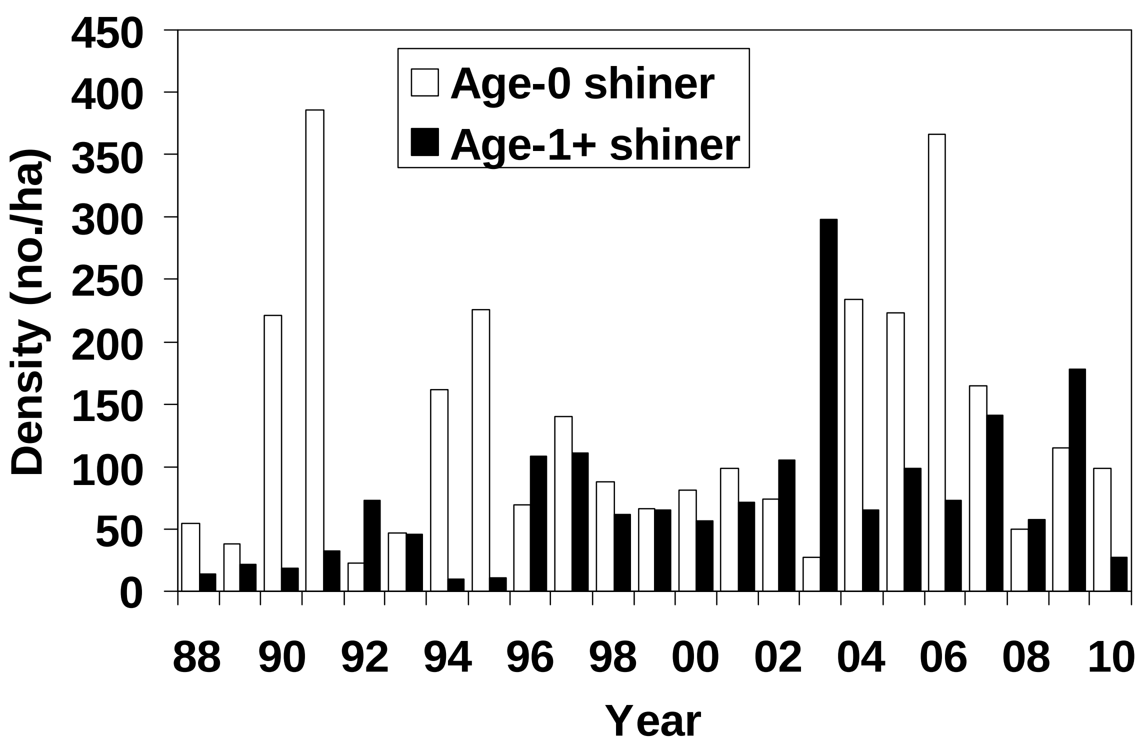

Figure 2.4.3. Density of age-0 and age-1+ shiners (*Notropis* spp.) in the western basin of Lake Erie, August 1988-2010.

3.0 Interagency Trawling Program

An ad-hoc Interagency Index Trawl Group (ITG) was formed in 1992 to first view 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.

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3.1 Summary of Species CPUE Statistics (E. Weimer)

Interagency trawling has been conducted in Ontario and Ohio waters of the western basin of Lake Erie in August of each year since 1987, though missing effort data from 1987 has resulted in the use of only data since 1988. This interagency trawling program was developed to measure basin-wide recruitment of percids. More recently, the interpretation has been expanded to provide basin-wide community abundance indices, including forage fish abundance and growth. Information collected during the surveys includes length and abundance data on all species collected. A total of 62-90 standardized tows conforming to a depth-stratified (0-6m and >6m) random design are conducted annually by OMNR and ODNR throughout the western basin; results from 58 trawls were used in the analyses in 2010 (Figure 3.1.1).

In 1992, the ITG recommended that the 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.

The FTG recognizes the increasing interest in using information from this bottom trawling program to express abundance and distribution of the entire prey fish community of the western basin. Preliminary survey work by OMNR in 1999 demonstrated the potential to underestimate the abundance of pelagic fishes (principally clupeids and cyprinids) when relying solely on bottom trawls. The FTG will continue to recognize the strength of hydroacoustics to describe pelagic fish distribution and abundance, and has developed hydroacoustic programs for the east and central basins of Lake Erie. However, the shallow depths and complex bathymetry of the western basin provide challenges to implementing a hydroacoustic program in this basin, such that other pelagic sampling techniques are also being explored. Results of the *Trawl Comparison Exercise* of 2003 have now been fully analyzed, and Fishing Power Correction (FPC) factors have been applied to the vessels administering the western basin Interagency Trawling Program. All vessel CPUEs were standardized to the *R.V. Keenosay* using correction factors developed during the trawl comparison experiment in 2003 (Table 3.1.1). A manuscript describing justification, methods used, and results has been published in the *North American Journal of Fisheries Management* (Tyson et al. 2006). Information from this experiment will also be used in development of an additional interagency trawling program to examine temporal and spatial patterns in forage abundances in the western basin during June and September administered by ODNR and USGS – Lake Erie Biological Station.

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 (#/ha or #/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).

Total forage abundance decreased 29% in 2010, reaching a level similar to 2005 (Figure 3.1.2). Clupeid and soft-rayed fish decreases (down 95% and 84%, respectively) were responsible for this trend; spiny-rayed fish increased 31% compared to 2009. Because of the composition of the forage fish community in 2010, total forage biomass increased 67%, to levels similar to 1993 (Figure 3.1.3). Relative biomass of clupeid, soft-rayed, and spiny-rayed species was 3%, 5%, and 92%, respectively, and quite different from the respective historic averages of 30%, 8%, and 62%. Walleye show a clear preference for clupeids and soft-rayed fishes over spiny-rayed prey (Knight and Vondracek 1993), and thus decreases in biomass of clupeid and soft-rayed fish may intensify predatory demand in Lake Erie.

Mean length of age-0 fishes in 2010 increased compared to 2009 (Figure 3.1.4). Lengths of select age-0 species include walleye (148 mm), yellow perch (74 mm), white bass (79 mm), white perch (69mm), and smallmouth bass (84 mm). These lengths are well above long-term averages (137 mm, 67 mm, 68 mm, 58 mm, and 79 mm, respectively).

Spatial maps of forage distribution were constructed using FPC-corrected site-specific catches (#/ha) of the functional forage groups (Figure 3.1.5). Abundance contours were generated using kriging contouring techniques to interpolate abundance among trawl locations. Clupeid catches were highest around Middle Sister Island, Sandusky Bay, and Pigeon Bay. Soft-rayed fish were most abundant near the mouth of the Detroit River. Spiny-rayed abundance was highest along the south shore around Sandusky Bay. Relative abundance of the dominant species includes: age-0 white perch (80%), age-0 freshwater drum (5%), and age-0 white bass (4%). Total forage abundance averaged 5,047 fish/ha across the western basin, decreasing 29% from 2009, below the long-term average (5,331 fish/ha). Clupeid density was 75 fish/ha (average 1,109 fish/ha), soft-rayed fish density was 340 fish/ha (average 580 fish/ha), and spiny-rayed fish density was 4,631 fish/ha (average 3,641 fish/ha).

3.3 Trawl Comparison Exercise (J. Deller)

The Forage Task Group is considering continuation of the trawl comparison exercise to include the boats and agencies of the central and eastern basins. This would provide further improvement in coordination and integration of trawl surveys conducted throughout Lake Erie. We are currently trying to coordinate agency sampling schedules and working through travel restrictions. We are planning on conducting the exercise during the summer of 2012 or 2013.

Table 3.1.1. 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 3.1.1. Trawl locations for the western basin interagency bottom trawl survey, August 2010.

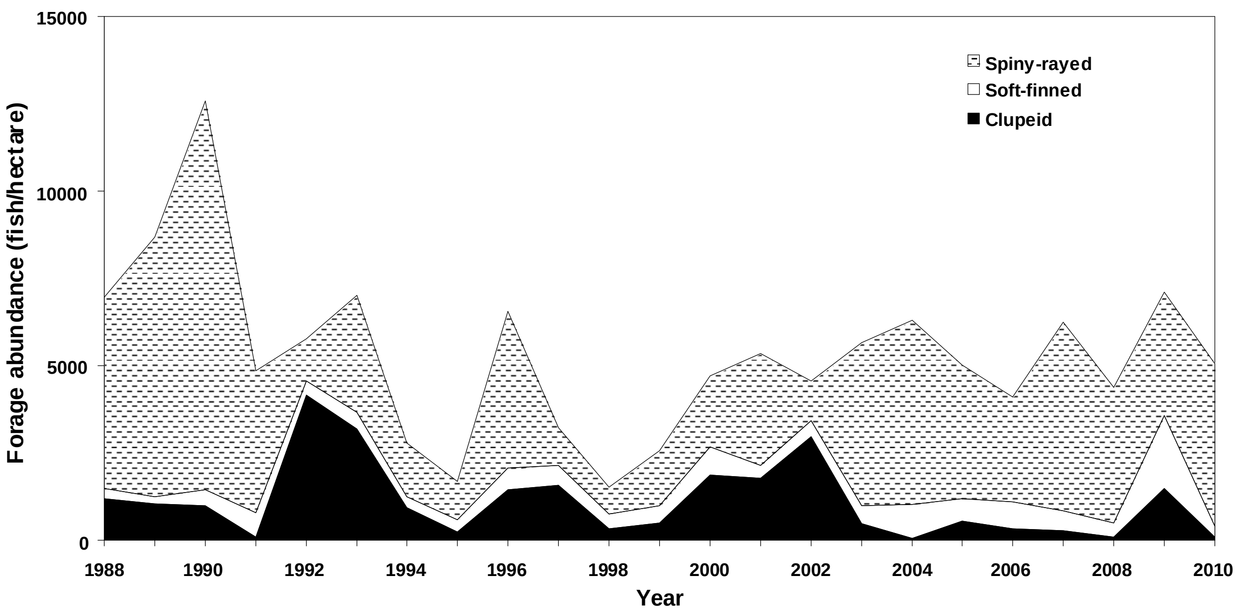


Figure 3.1.2. Mean density (no./ ha) of prey fish by functional group in western Lake Erie, August 1988-2010.

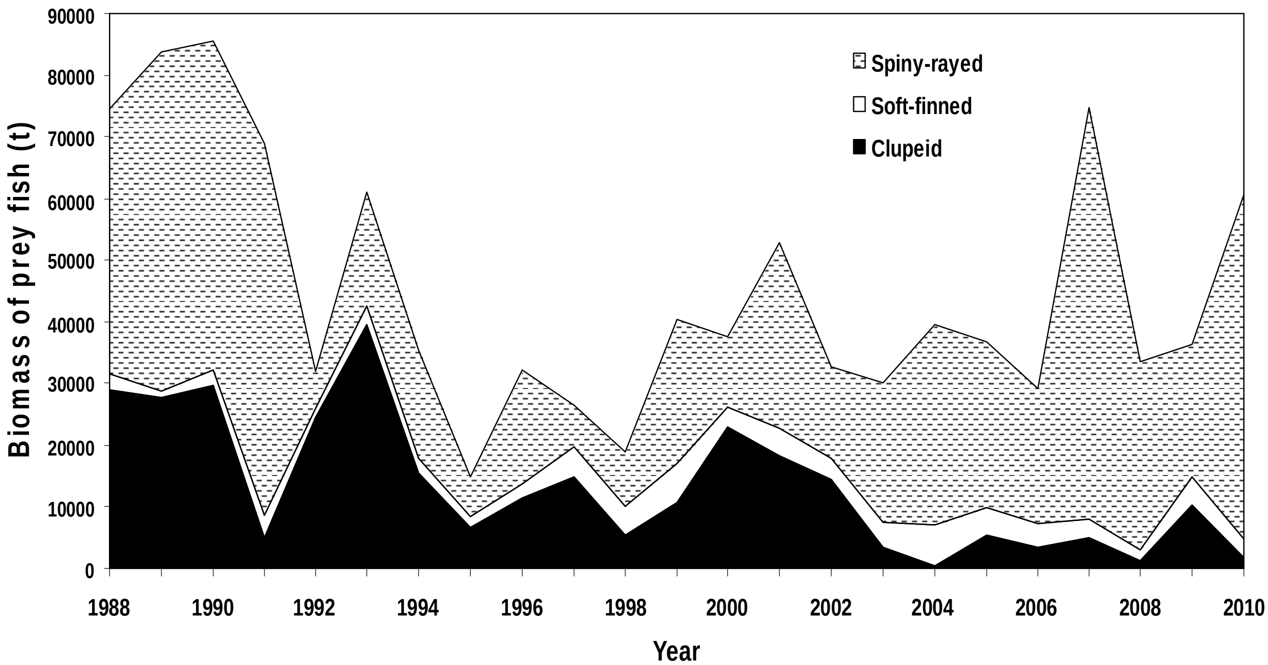


Figure 3.1.3. Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2010.

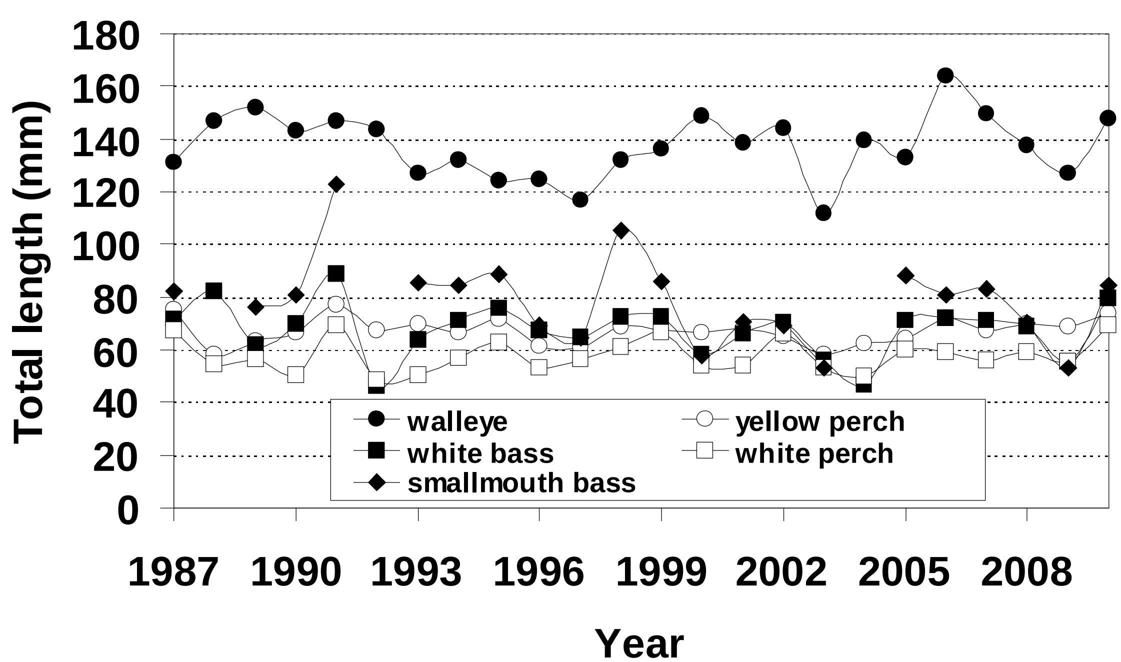


Figure 3.1.4. Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2010.

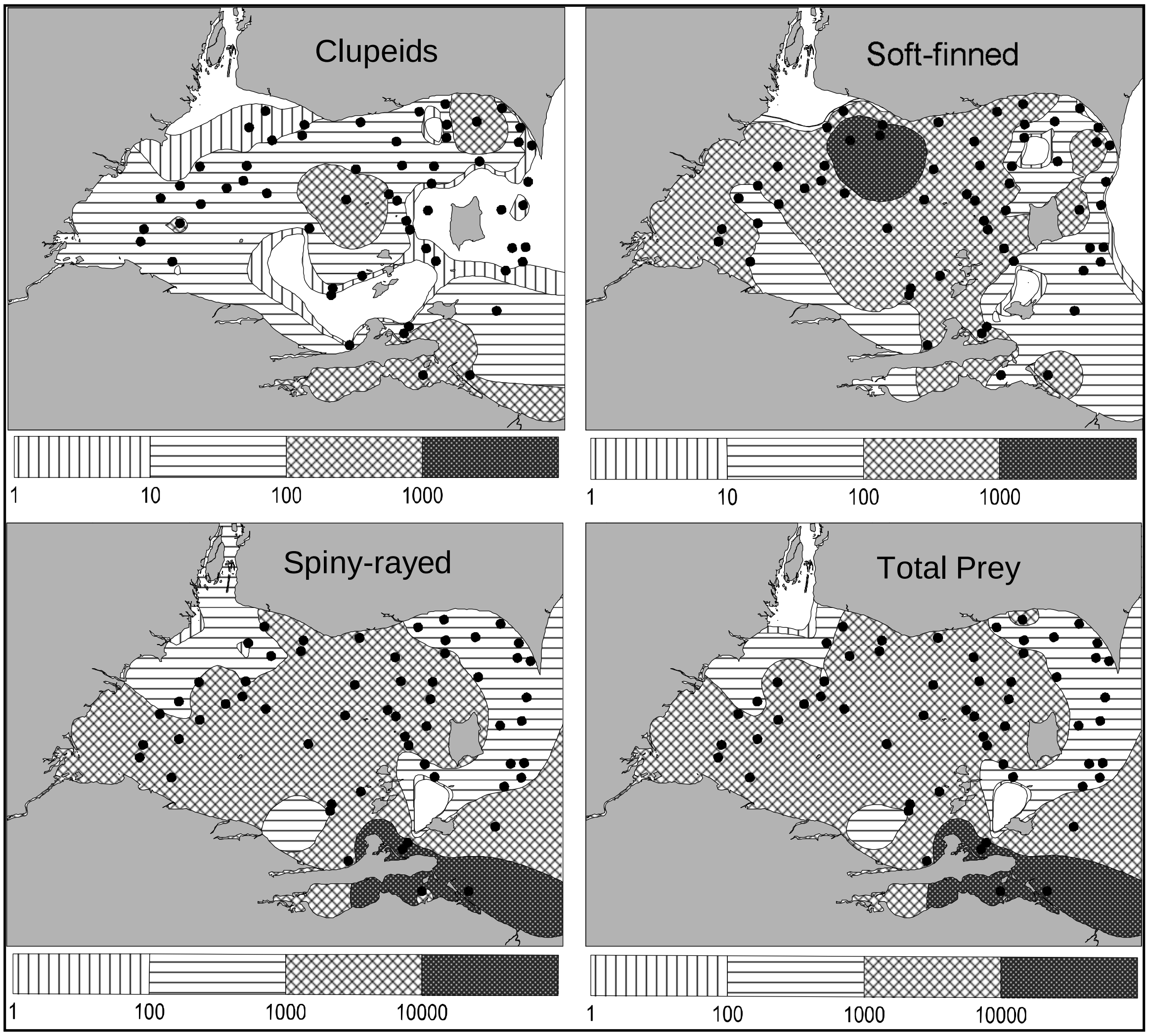


Figure 3.1.5. Spatial distribution of clupeids, soft-finned, spiny-rayed, and total forage abundance (individuals per hectare) in western Lake Erie, 2010. Black dots are locations for trawling and contour levels vary with the each functional fish group.

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 neighboring East Basin Lake Erie jurisdictions and Cornell University's Warmwater Fisheries Unit through coordinated management efforts facilitated by the Great Lakes Fishery Commission (GLFC).

Some of the more recent progress 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 New York State Department of Environmental Conservation and the Ontario Ministry of Natural Resources 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 Center, 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 for examining estimates of fish abundance in densely concentrated areas to diminish possible bias associated with extrapolating abundance based on mean in-situ target strength (Rudstam et al. 2003). Additionally, a standard objective method has now been developed to ascribe passive noise thresholds for each survey transect. A complete description of our data collection and processing methods will be forthcoming in a separate document with accompanying results for the entire split-beam time series of this acoustic survey (since 1997).

At this writing the acoustic data series from 1998 to 2003 and from 2007 to 2010 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 four most recent east basin survey years 2007 to 2010.

A thorough description of survey methodology and comprehensive description of the entire series of acoustic survey results for the eastern basin Lake Erie is being pursued as a separate report expected to be available in the near future. 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 2011, we expect to resume standardized reanalysis of acoustic data for the remaining backlog of survey years 1997 and 2004 through 2006. Upon completion of this overview document, subsequent results will be updated annually in Lake Erie's FTG Report.

The 2010 Survey

In recent years, 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 the Ontario Ministry of Natural Resources (OMNR) 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)-based navigation software program (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 that controlled all operations of the echosounder. Geo-referenced raw acoustic data were logged to 10-megabyte size files on the host PC.

The 2010 survey was completed in six nights from July 7 to 14th (Figure 4.1.1). A full compliment of twelve acoustic transects were sampled totaling 185 nautical miles. Approximately 1,053,000 KB of raw acoustic data were recorded including some 67,000 KB of stationary sampling at the ends of some transects to assess target strength (TS) variability of individual fish tracks. A total of 27 water temperature-depth profiles were sampled across all transects in 2010. Companion mid-water trawl collections to obtain representative samples of the pelagic forage fish community for apportioning of acoustic targets was limited to only four mid-water trawl samples due to mechanical problems with New York State DEC's research vessel, *R/V Argo*. OMNR and NYS DEC participants both remained fully engaged in eastern basin data processing and analysis activities.

Acoustic data were processed using the Myriax Echoview 3.45 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 YOY-size smelt (-70 to -59 dB) to ALL-size smelt (YOY + YAO: -70 to -40 dB) by 1-m depth layers for each 800-m transect interval. This pre-analysis of TS distributions was accomplished within a specialized SAS (SAS 2006) program that scanned each 1-m depth layer within a specified depth range in a downward progression and selected the first occurrence where the proportion of YOY- 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 YOY rainbow smelt, located primarily in the epilimnion from deeper 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 age (size) groups. The final Epi-Meta boundary line was then referenced to create the two thermal strata throughout all intervals of an acoustic transect that exhibited thermal stratification. If coldwater habitat was not apparent the 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 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 2007–2010

Basin-wide acoustic estimates of pelagic YAO rainbow smelt-size density was highest in 2009 (14226/ha) and lowest in 2007 (5015/ha) for the most recent four-year period (Figure 4.1.2). Mean density of YAO-size smelt decreased in 2010 (9865/ha) but was still about twice that observed in 2007. Acoustic survey results using the new SOP to describe trends in densities of pelagic forage fish are shown in Table 4.1.1, along with a series of independent bottom trawl measures of YAO rainbow smelt. The synchrony of year-to-year abundance fluctuations between acoustic pelagic fish densities and independent bottom trawl abundance measures for the dominant pelagic forage species (rainbow smelt) in eastern Lake Erie lend support to the veracity of acoustic assessment estimation techniques for pelagic forage fish. It was very constructive to see good agreement of acoustic densities of YAO pelagic forage fish and our independent trawl measures of YAO rainbow smelt abundance.

The spatial distribution of pelagic fish densities for the YAO acoustic size range is shown in Figure 4.1.3. The distribution of sampled acoustic transects through this 2007 to 2010 period shows consistent full spatial coverage of the east basin survey using our most modern echosounder, a 120 kHz split-beam Simrad EY60 GPT. Also, this figure demonstrates the spatial distribution of pelagic forage fish densities can markedly differ across years. The mid-basin region between Port Maitland, ON and Dunkirk, NY exhibited high densities in 2009 and 2010. In 2008, YAO-size smelt densities were greatest in a region south of Long Point. In 2007, YAO-size smelt densities were comparatively much lower and evenly distributed throughout the east basin. 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.

Perspective

A comprehensive analysis of our full series of acoustic survey findings has been planned for several years, but annual constraints on staff time have repeatedly postponed a complete analysis of acoustic data. However, at this time most of the hurdles related to specialized acoustic processing and analysis methodology have been resolved and the east basin investigators are continuing efforts started in 2008 to analyze and report on 15 years of acoustic survey results. Furthermore, upon completion of these new analyses, Forage Task Group acoustic survey investigators currently pursuing somewhat independent efforts in the eastern, central and western basins expect to eventually integrate their analysis and reporting efforts to produce a lake wide July snapshot of pelagic fish density and distribution for Lake Erie.

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

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 2010 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 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, the most abundant species in the central basin, which is also harvested commercially.

Hydroacoustics

Hydroacoustic data were collected from the USGS *R/V Musky II.* Acoustic transects corresponding to Loran-C TD lines were sampled from one half hour after sunset (around 2130) to no later than one half hour before sunrise, depending on length of the transect and vessel speed. Sampling began at the 10-m contour and continued to the opposite shore until the transect was completed or weather conditions forced cancellation of data collection. Starting location of sampling alternated from the northern shore to the southern shore on alternating nights.

Hydroacoustics data were collected using a 120-kHz, 7.8-degree, split-beam transducer with a BioSonics DTX® echosounder and BioSonics Visual Acquisition (release 5.1) software. The transducer was mounted to the starboard hull roughly equidistant between the bow and stern, 1 m below the water surface. Sound was transmitted at 3 pulses per second (pps) at alternating pulse durations of 0.2 milliseconds (ms), 0.3 ms, and 0.4 ms (i.e., each second one pulse lasting 0.2 ms, one pulse lasting 0.3 ms, and one pulse lasting 0.4 ms was transmitted). In past surveys we transmitted sound at 4 pps and 0.4 ms. We altered our protocol this year to collect data at shorter pulse durations because shorter pulse durations can better discern individual targets in dense fish layers, which are common near the thermocline in central Lake Erie. Longer pulse durations result in biased *in situ* TS estimates, which further result in biased density estimates. 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 coordinates were collected using a Garmin ® GPSMAP 76Cx interfaced with the echosounder to obtain simultaneous latitude and longitude coordinates. Thermal profiles were taken on each transect to calculate 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.

Analysis of hydroacoustic data was conducted following guidelines established in the GLSOP (Parker-Stetter et al. 2009) using EchoView ® version 4.4 software. Proportionate area backscattering coefficient and single targets identified using Single Target Detection Method 2 (recommended by the GLSOP) were used to generate density estimates for 500-m distance intervals in each water depth stratum. 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 the GLSOP. 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 YOY and YAO rainbow smelt and YAO emerald shiner (97% of all species and age groups captured) 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, (OMNR) and *R/V Musky II* (USGS) conducted midwater trawling concurrent with acoustic data collection. The *R/V Musky II* conducted four 10-minute trawls in Ohio waters on one transect, while the *R/V Keenosay* conducted up to eight 20-minute trawls per transect in Ontario waters. Both vessels used trawls of the same design for all trawling. 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

Three cross-lake transects were sampled between 7 July and 15 July 2010 (Figure 4.2.1). Mechanical problems with the R/V Grandon (ODNR) prevented its use, which reduced the number of transects that could be sampled. Trawling was completed by OMNR on all four prescribed transects and by USGS on one transect, two of which were sampled acoustically (Figure 4.2.1). Crew shortages prevented additional trawling aboard the Musky II.

Trawl catches were dominated by rainbow smelt and emerald shiner (Table 4.2.1). Both species' distributions were more varied this year compared to 2009. Species other than rainbow smelt and emerald shiner composed < 4% of the total catch and included unidentified cyprinidae, white perch, walleye, round goby, and freshwater drum.

Young-of-year and YAO rainbow smelt, which typically segregate into clear and distinct layers of the water column with YOY in the epilimnion and YAO in the on the thermocline and in the hypolimnion, were not clearly segregated in 2010. Many trawl samples included comparatively high proportions of both age groups throughout water column (Table 4.2.1). Acoustic target strength distributions by depth showed less distinct differences across depth strata (Figure 4.2.2). Emerald shiner were also more widely distributed with respect to depth. Yearling-and-older emerald shiner made up at least 10% of the total catch in two hypolimnetic trawls on separate transects. Because of this overlap, defining distinct and consistent layers of fish that corresponded with limnetic layers, as has been done in the past, was not possible. For all three transects fish target strength in the 5-10 km closest to each shore was well mixed with no discernible breaks in depth or size distribution. Elsewhere distinct differences in TS distribution were evident, but the depth of the break varied considerably, from as shallow as 9 m to as deep as 18 m. Hence there is no absolute depth separating fish layers and the layers do not necessarily correspond to the epi- and hypolimnia. We refer instead to upper and lower fish layers.

Upper layers were dominated by YOY rainbow smelt and YAO emerald shiner (Table 4.2.2). Relative proportion of emerald shiner was higher this year than past years. Lower layers were dominated by YAO rainbow smelt (Table 4.2.2). Overall, densities were highest for YOY rainbow smelt and lowest for YAO rainbow smelt (Figures 4.2.3, 4.2.4, and 4.2.5).

Discussion

The 2010 hydroacoustics results were quite different from past years in terms of distributions of the two primary species. High hypolimnetic dissolved oxygen (never lower than 4.4 mg/l on three transects sampled by USGS) coupled with low densities of YAO rainbow smelt may have permitted the lack of distinct segregation of age groups and species as in the past. The presence of emerald shiner in hypolimnetic trawl samples was unusual. This may be explained by epilimnetic emerald shiners being captured as the trawl was being deployed or retrieved, but it also may have been a real difference in distribution because biotic and abiotic conditions permitted it. The low abundance of YAO rainbow smelt may have resulted in less predatory pressure against YOY rainbow smelt permitting them to be more mixed than in past. Low abundance of YAO rainbow smelt is attributable to mass mortality of adults, many of them likely from the large 2008 year class, around the time of spawning.

Acoustic density estimates also did not suffer from the potential of biased *in situ* target strength estimates as in past years. Since 2004 up to 85% of in situ target strength estimates have been biased in dense fish layers, which typically were near the thermocline. In 2010 fewer than 14% of analytic cells were biased. Low bias of *in situ* estimates of target strength were likely a result of lower overall fish densities and fish being more widely distributed by depth. The method of data collection did not have an effect. Although we collected data at different pulse durations, we report only those density estimates from data collected at 0.4 ms pulse duration as in 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)

Equipment failures again plagued the western basin survey in 2010. None of the three proposed cross-basin transects were completed. A loss of function with the Lake Erie BioSonics DT-X surface unit again halted the survey, and by the time alternative hydroacoustic equipment became available, the window of opportunity for completing this survey was past. The equipment was returned to the manufacturer in July, and after having faulty transducers repaired was returned in September, 2010. The equipment was used for two days in September to map lake bathymetry, and no failures were experienced during this time. Additional mapping is planned for the spring and summer of 2011, and will ensure the equipment is fully functional prior to the 2011 hydroacoustic survey.

Table 4.1.1. Indices of relative abundance of pelagic forage fish species in eastern Lake Erie from a basin-wide acoustic survey from 2007 to 2010, compared with bottom trawl survey results for rainbow smelt conducted by Ontario, New York and Pennsylvania during the same period. Indices are reported as arithmetic mean number caught per hectare (NPHa) for the yearling-and-older (YAO) age group.

		Number per hectare			
Sampling Method	**East Basin Index Stratum**	**2010**	**2009**	**2008**	**2007**
Btm. Trawl YAO Smelt	**ON-DW**	**223**	**1654**	**77**	**233**
Btm. Trawl YAO Smelt	**NY-Fa**	**998**	**3017**	**546**	**177**
Btm. Trawl YAO Smelt	**PA-Fa**		**407**	**2**	**1006**
Btm. Trawl YAO Smelt	**basin trawl avg (area weighted)**	**438**	**1939**	**214**	**301**
Acoustic YAO-smelt size fish	**East Basin (all thermal strata)**	**9865**	**14226**	**12430**	**5015**

<u>Ontario Ministry of Natural Resources Trawl Survey</u>

ON-DW — Trawling is conducted weekly during Oct. at 4 fixed stations in offshore waters of Outer Long Point Bay using a 10-m trawl.

<u>New York State Department of Environmental Conservation Trawl Survey</u>

NY-Fa — Trawling is conducted at 30 nearshore (15-30 m) stations during Oct. using a 10-m trawl

<u>Pennsylvania Fish and Boat Commission Trawl Survey</u>

PA-Fa — Trawling is conducted at nearshore (<22 m) and offshore (>22 m) stations during Oct. using a 10-m trawl.

<u>Inter-agency East Basin Acoustic Survey</u>

East Basin Acoustic — Acoustic survey encompassing Ontario, Pennsylvania and New York waters with cross-basin transects > 15-m depth contour (Figure 4.1.2).

Table 4.2.1. Percent composition of all fish captured in trawl samples collected by the *R/V Keenosay,* and *R/V Musky II* in the central basin Lake Erie in July, 2010. *R/V Keenosay* trawl ID numbers are 2001-3009. *R/V Musky II* trawl ID numbers are 201-204. Layer was determined from distribution of acoustic target size to depth along each transect. Upper layer refers to target sizes similar to YOY rainbow smelt. Lower layer refers to target sizes similar to YAO rainbow smelt. Layer was assigned to trawl data based on the depth and transect where the trawl was fished. Species composition from trawl data was applied to acoustic data based on layer and transect.

						Emerald shiner	Freshwater drum	Rainbow smelt		Round goby	White perch	Yellow perch		Cyprinidae	Walleye
Transect	Trawl ID	Trawl depth (m)	Latitude	Longitude	Layer	YAO	YAO	YAO	YOY	YAO	YAO	YAO	YOY	YOY	YAO
57850	2001	8	42.5643	-81.4713	Upper	0.0	0.0	99.7	0.1	0.1	0.0	0.0	0.0	0.0	0.1
57850	2002	5	42.5452	-81.4607	Upper	0.0	0.0	1.3	91.0	0.0	0.0	0.0	7.7	0.0	0.0
57850	2003	9	42.4928	-81.4437	Upper	1.8	0.0	87.9	9.4	0.0	0.9	0.0	0.0	0.0	0.0
57850	2004	6	42.4793	-81.4375	Upper	5.2	0.6	5.8	87.7	0.0	0.6	0.0	0.0	0.0	0.0
57850	2005	14	42.4915	-81.4447	Lower	0.0	0.1	99.3	0.6	0.0	0.0	0.1	0.0	0.0	0.0
57850	2006	17	42.3423	-81.3740	Lower	10.3	32.8	19.0	36.2	0.0	1.7	0.0	0.0	0.0	0.0
57850	2007	14	42.3183	-81.3600	Upper	18.4	0.0	2.6	73.7	0.0	0.0	0.0	5.3	0.0	0.0
57850	2008	20	42.3080	-81.3547	Lower	0.4	0.1	98.5	0.4	0.0	0.0	0.6	0.0	0.0	0.0
57600	3001	18	42.0788	-81.7493	Lower	2.2	0.0	97.6	0.0	0.0	0.0	0.1	0.1	0.0	0.1
57600	3002	15	42.0620	-81.7467	Upper	10.0	1.8	0.9	83.6	0.0	0.0	0.0	2.7	0.9	0.0
57600	3003	12	42.0532	-81.7408	Upper	68.3	1.7	0.0	25.0	0.0	0.0	0.0	5.0	0.0	0.0
57600	3004	7	42.0577	-81.7378	Upper	92.3	0.0	1.3	5.1	0.0	1.3	0.0	0.0	0.0	0.0
57600	3005	17	42.2240	-81.8137	Lower	13.3	0.0	86.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57600	3006	9	42.2242	-81.8148	Upper	27.1	0.4	68.7	1.1	0.0	0.0	0.0	2.7	0.0	0.2
57600	3007	6	42.2287	-81.8197	Upper	50.5	0.1	42.6	1.6	0.0	0.1	0.0	5.1	0.0	0.0
57600	3008	9	42.2632	-81.8273	Upper	0.4	0.0	99.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0
57600	3009	6	42.2743	-81.8107	Upper	92.3	0.0	0.4	3.0	0.0	0.0	0.0	4.3	0.0	0.0
57600	201	12	41.9563	-81.6926	Upper	1.1	0.0	2.2	95.6	0.0	0.0	0.0	1.1	0.0	0.0
57600	202	17	41.8848	-81.6589	Lower	1.1	0.0	53.8	44.1	0.0	0.0	0.0	1.1	0.0	0.0
57600	203	16	41.7859	-81.6136	Lower	5.5	0.0	83.4	11.1	0.0	0.0	0.0	0.0	0.0	0.0
57600	204	5	41.6774	-81.5658	Upper	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4.2.2. Mean acoustic density (fish/hectare) by species and age class for hydroacoustic transects in central Lake Erie, July 2010.

		Loran C TD line		
Upper layer	Life stage	57600	57725	57850
Rainbow smelt	YOY	756	3353	3038
Rainbow smelt	YAO	17	725	88
Emerald shiner	YAO	552	2908	505
Other[1]		37	190	97
Lower layer				
Rainbow smelt	YOY	104	758	193
Rainbow smelt	YAO	780	2050	935
Emerald shiner	YAO	51	98	56
Other[1]		9	79	251

1 Other species include: YOY freshwater drum, YOY yellow perch, round goby, walleye, and white perch.

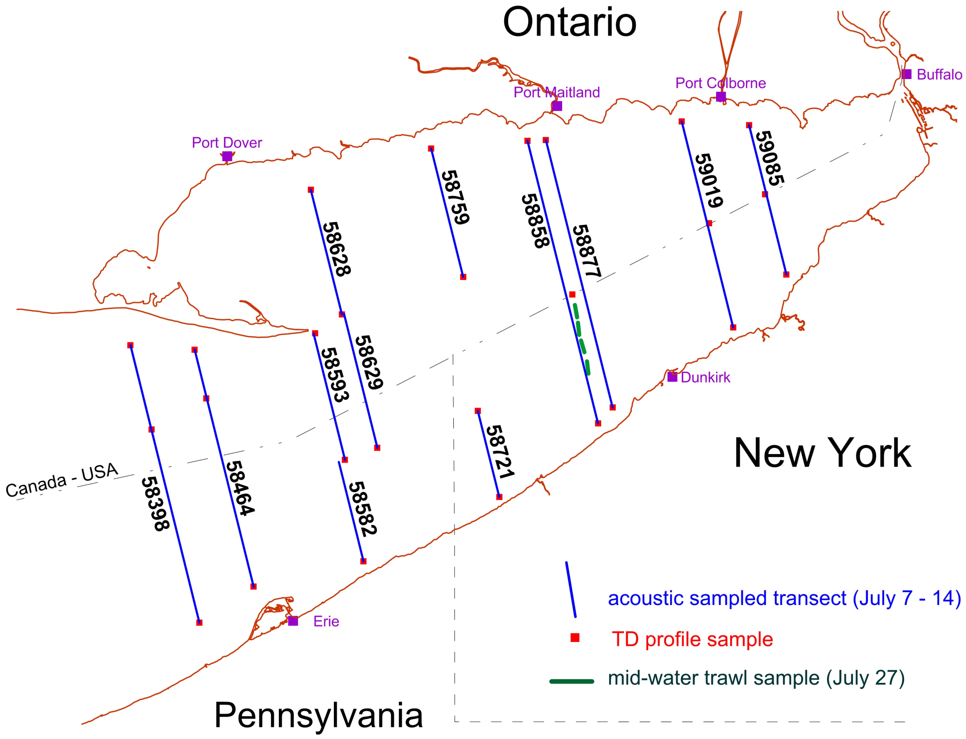


Figure 4.1.1. July 2010 eastern basin Lake Erie inter-agency acoustic survey transects, mid-water trawl and temperature profile sites sampled by the Ontario Ministry of Natural Resources (OMNR) research vessel, ***RV Erie Explorer*** and the New York State Department of Environmental Conservation vessel, ***RV Argo.***

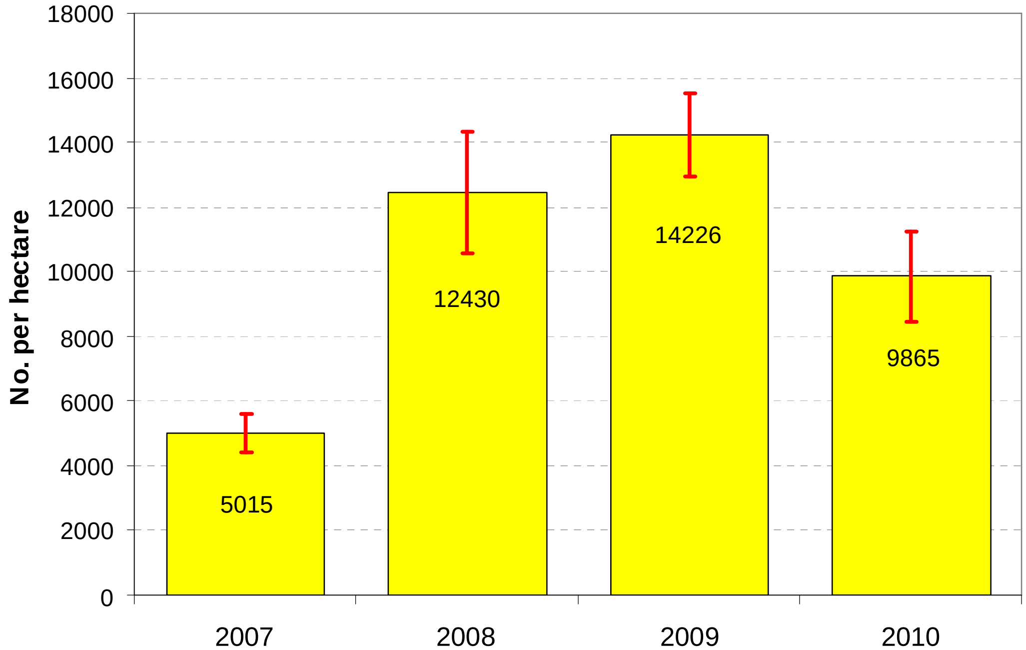


Figure 4.1.2. Mean density (Number per hectare) estimates of pelagic YAO rainbow smelt-sized forage fish sampled with a 120-kHz split-beam echosounder during July fisheries hydroacoustic assessments of eastern Lake Erie, 2007 - 2010. Density estimates were derived from a spatially stratified cluster analysis of acoustic transects comprised of 800-m length sample units. Standard error (of mean) bars shown.

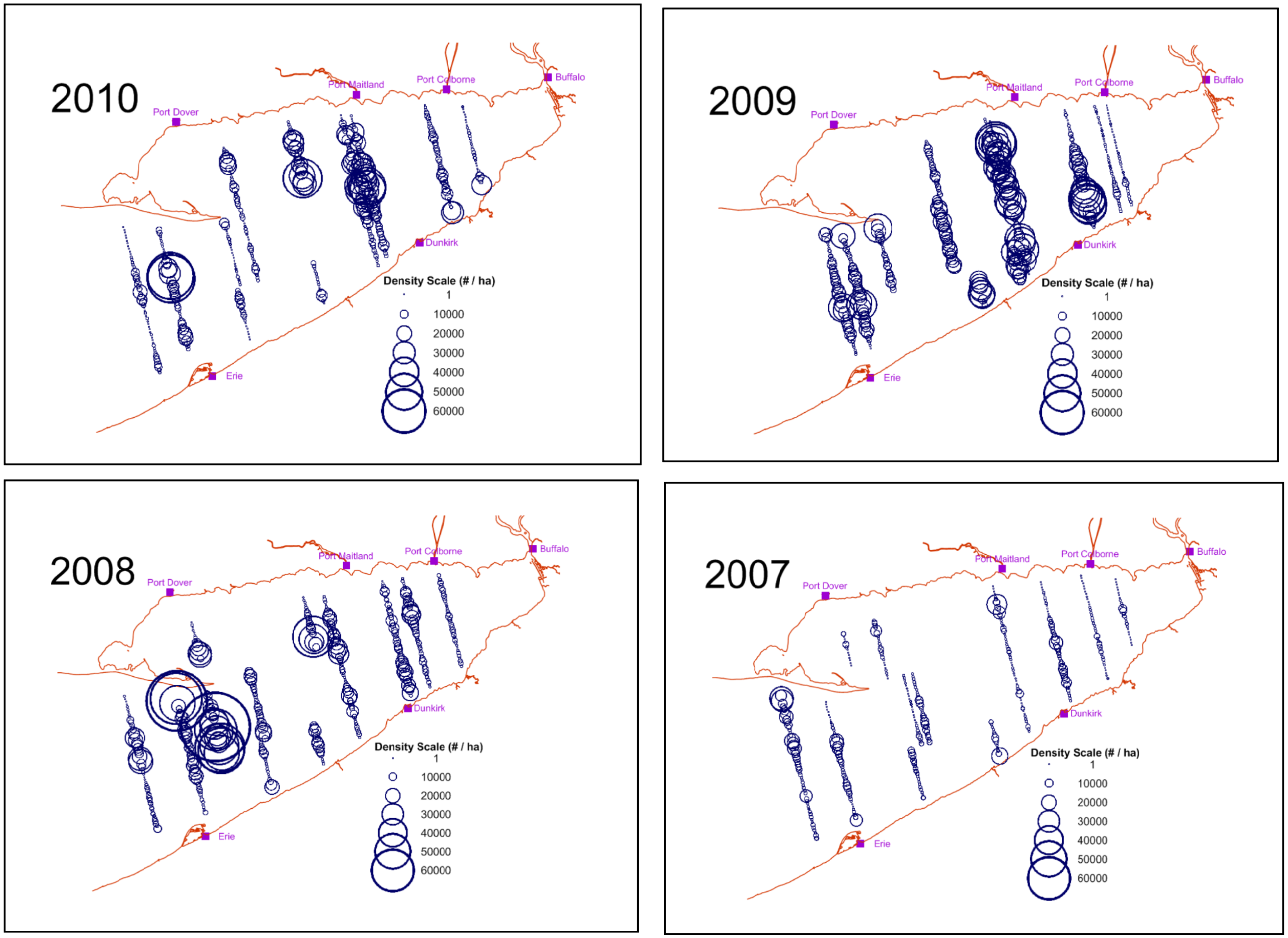


Figure 4.1.3. Relative density (No. fish / ha) of pelagic, YAO rainbow smelt-sized forage fish per 800-m interval along transects sampled with a 120-kHz split-beam echosounder during July fisheries acoustic surveys in eastern Lake Erie, 2007 to 2010.

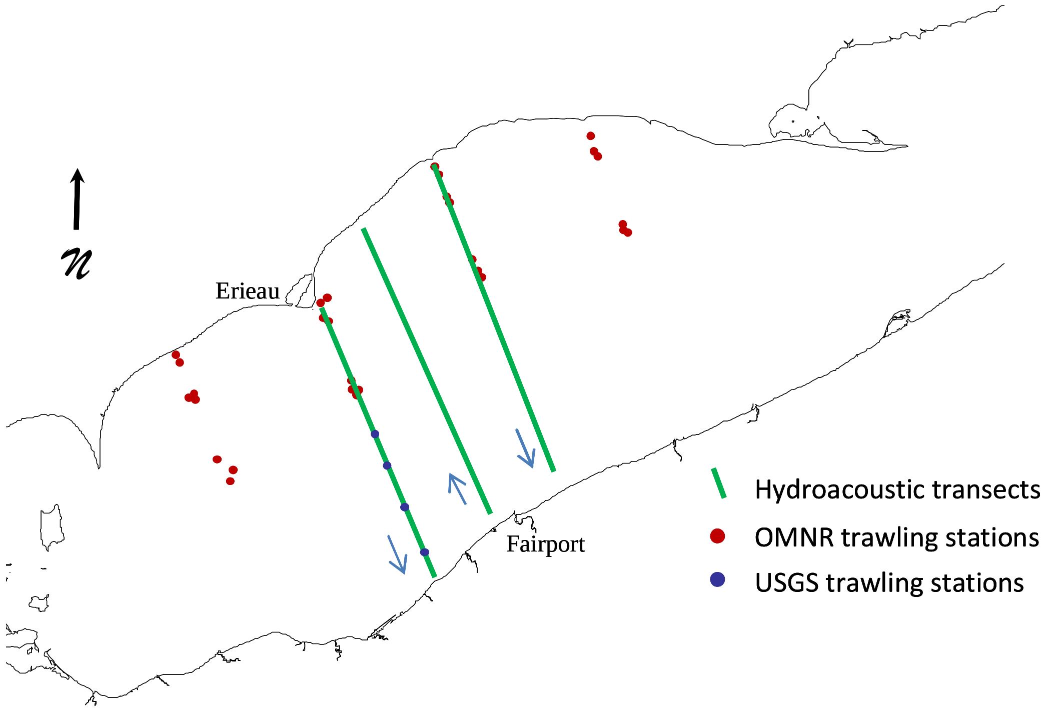
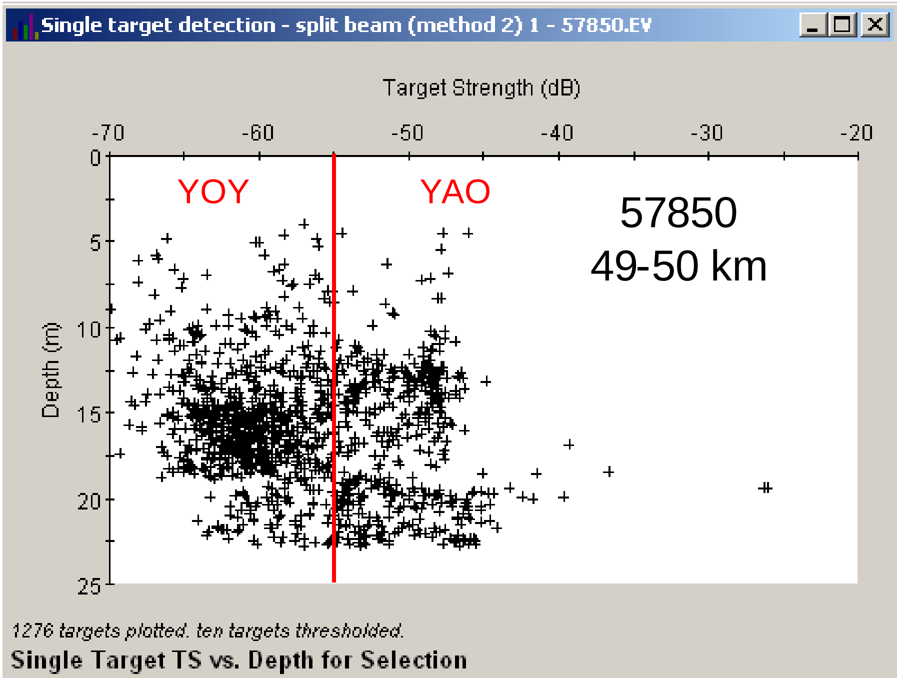


Figure 4.2.1 Hydroacoustic transects and midwater trawling stations in the central basin, Lake Erie. Arrows indicate direction of travel for hydroacoustic transects.



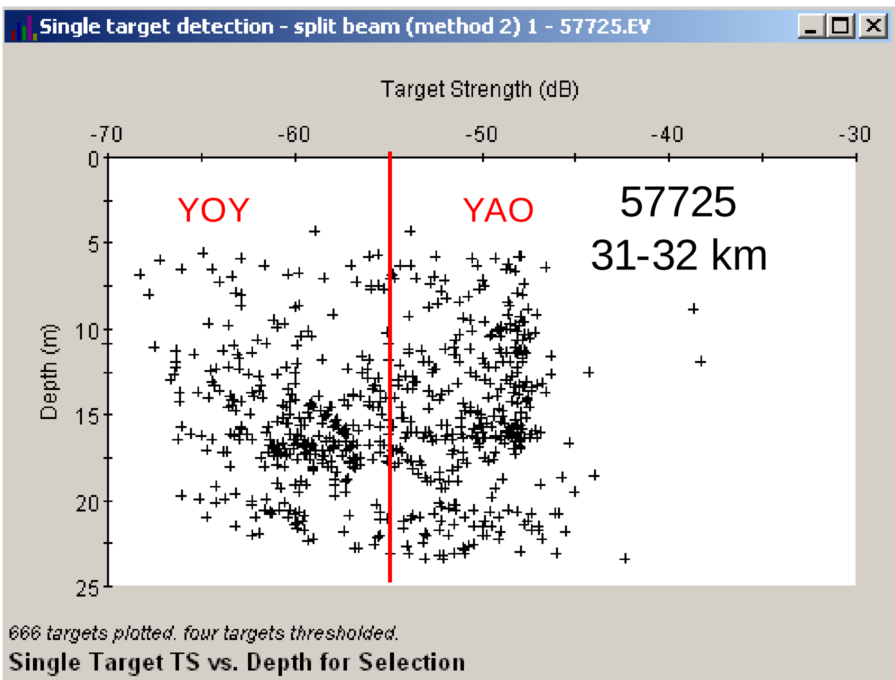


Figure 4.2.2. Target strength (TS) distribution by depth in two 1-km long segments of two transects sampled in central Lake Erie in 2010. Red vertical line is an approximate TS partition for YOY and YAO rainbow smelt, which was the most abundant species captured in trawls.

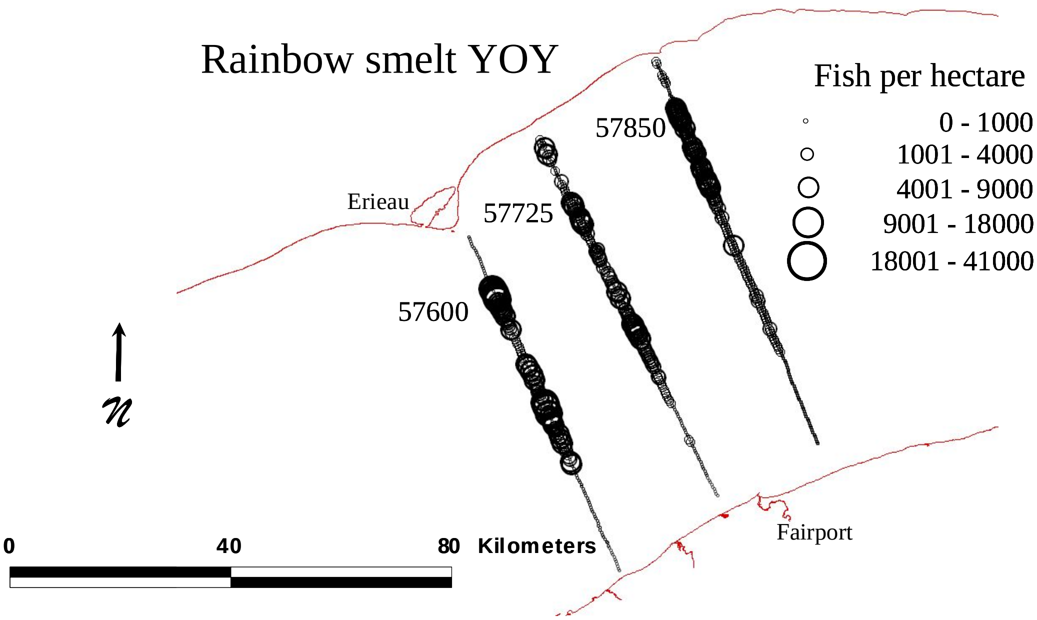


Figure 4.2.3 Density estimates of YOY rainbow smelt (No. fish /ha) per 500-m segment along hydroacoustic transects in the central basin, Lake Erie. Transects are Loran-TD lines sampled in July 2010.

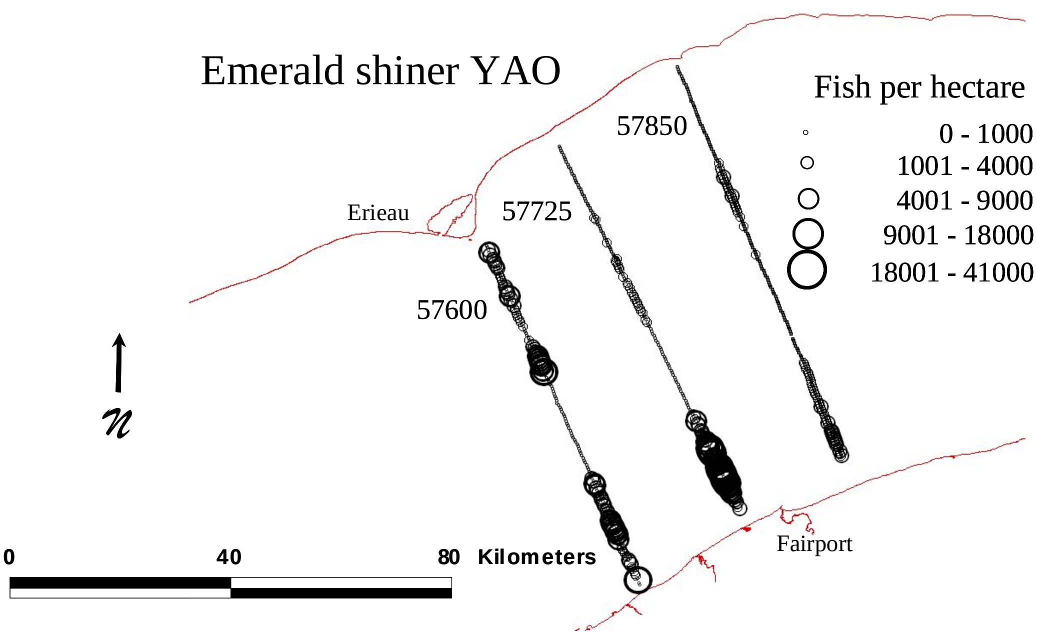


Figure 4.2.4 Density estimates of YAO emerald shiner (No. fish /ha) per 500-m segment along hydroacoustic transects in the central basin, Lake Erie. Transects are Loran-TD lines sampled in July 2010.

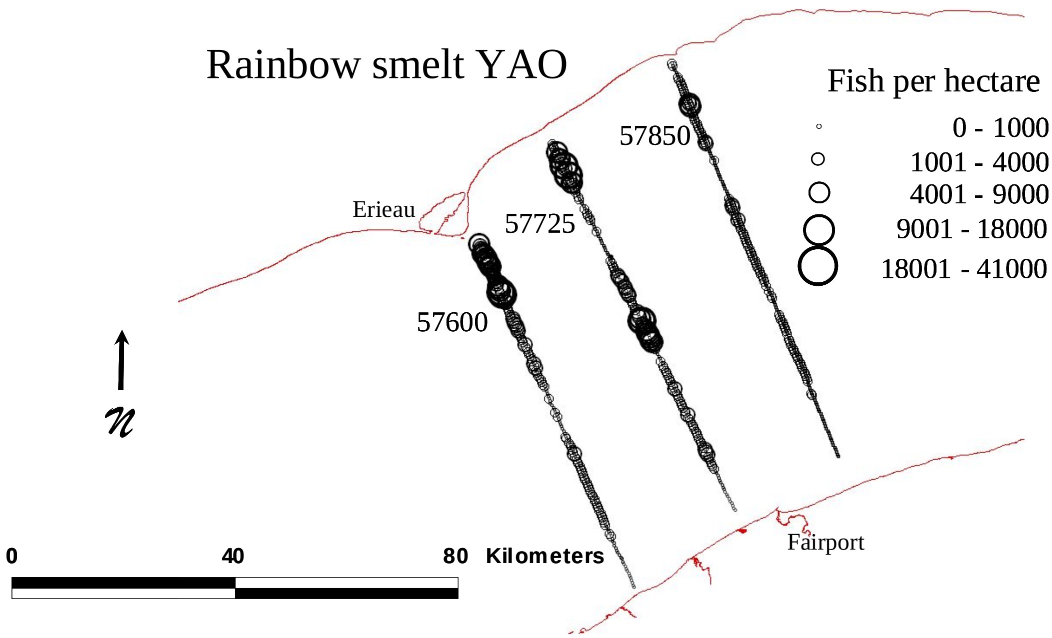


Figure 4.2.5 Density estimates of YAO rainbow smelt (No. fish /ha) per 500-m segment along hydroacoustic transects in the central basin, Lake Erie. Transects are Loran-TD lines sampled in July 2010.

5.0 Interagency Lower Trophic Level Monitoring Program, 1999-2009

(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 12 years of data for epilimnetic temperature, hypolimnetic or bottom dissolved oxygen, grazing pressure (chlorophyll *a* and total phosphorous), 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.

Surface Water Temperature

Surface water temperature represents the median temperature between 0 and 1 meter deep 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. Temperatures are slightly warmer in the western basin and cooler in the eastern basin (Figure 5.0.2). In 2010, the median surface temperature was lower than the long term median in the west basin (20.7 C) and slightly higher in the central (21.5 C) and east (20.3 C) basins.

Hypolimnetic Dissolved Oxygen

Figure 5.0.3 illustrates the mean hypolimnetic dissolved oxygen (DO) concentration (i.e. below the thermocline) for dates when the water column is stratified at each station in each basin of Lake Erie by year. Stratification can begin in early June and continue through September in the central and eastern basins. Dissolved oxygen less than 4 mg/L is deemed stressful to fish and other aquatic biota. In the western basin, shallow depths allow wind mixing to penetrate to the bottom, generally preventing thermal stratification. As a result, few observations exist to describe hypolimnetic DO, and when low oxygen occurs it is usually right at the water/sediment interface. In 2010, DO was below 4 mg/L at stations 5 and 6 on five occasions in June, July and August.

Low oxygen is an issue in the central basin. It happens almost annually at the offshore stations (8, 10, 11 and 13) and inshore station 9. Dissolved oxygen of less than 4 mg/L has been observed as early as mid June and can persist until late September when fall turnover remixes the water column. For 2010, mean hypolimnetic DO was below 4 mg/L at station 8 from end of June through end of August, at station 9 once in August and once in September, and at station 10 once in June and all dates in August and September.

Hypolimnetic DO is rarely limiting in the eastern basin due to greater water depths, a large hypolimnion and cooler water temperatures. In 2010, DO was below 4 mg/L at the new station 25 on July 14 and again on August 13. Similar to western basin sites, these low DO events at station 25 occurred at the water/sediment interface when a deep thermocline and subsequent narrow hypolimnion were present.

Grazing Pressure

Mazumder (1994) developed equations relating chlorophyll *a* with total phosphorus under varied trophic and grazing conditions. Central to his food-chain definitions was the degree to which phytoplankton was grazed by large herbivorous zooplankton. Dreissenid mussels may be the dominant source of grazing in infected waters (Nichols and Hopkins 1993). Heavily grazed systems were defined as “even-linked”, while those where grazers are controlled are functionally “odd-linked”. For a given total phosphorus concentration, chlorophyll *a* (a measure of phytoplankton standing crop) is predicted to be higher in “odd-linked” systems because less algae will be removed by the grazers. When this index was applied to our data collected from the three basins of Lake Erie (Figure 5.0.4), we see that grazing pressure is generally lowest in the western basin (more chlorophyll observed than predicted) and highest in the eastern basin. Note that the chlorophyll *a* levels in the west basin are highest and most variable.

In 2010, predicted Chlorophyll *a* was higher than observed in all three basins indicating high grazing pressure throughout the lake (Figure 5.0.4).

Lake Erie Fish Community Ecosystem Targets

The fish community objectives (FCO) for the lower trophic level ecosystem in Lake Erie are to maintain mesotrophic conditions that favor a dominance of cool-water organisms in the western, central and nearshore waters of the eastern basin (Ryan et al. 2003). For mesotrophic conditions, total phosphorus range is 10-20 μg/L and summer (June-August) water transparency measured using a Secchi disk range is 3-5 meters. Offshore waters of the eastern basin should be oligotrophic with phosphorus levels of 5-10 μg/L and summer Secchi depths ≥ 6 meters.

Phosphorus levels in the western basin have exceeded FCO targets since the beginning of this monitoring program (Figure 5.0.5). In three of the last four years total phosphorus levels have even been in the hyper-eutrophy range (>48 μg/L). In the central basin total phosphorus levels have been on the increase and have also exceeded FCO targets in 2004, 2006, 2008 and 2010. The phosphorus levels in the eastern basin inshore areas fell just below FCO targets from 1999 through 2007, but have been within the FCO target for the last 3 years. Offshore waters have been within FCO targets for most years except 2008 and 2010.

Water transparency has been below the FCO target in the western basin and within the targets for the central basin (Figure 5.0.6). Transparency was above FCO targets in the east inshore stations from 1999 through 2007, but has been within the FCO for the last 3 years. Transparency was within targets for the east offshore stations from 1999 through 2007, but has fallen below target in 2008 and 2010.

Zooplanktivory Index

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, zooplankton predation was high in all basins of Lake Erie, as the average size of the community was generally less than this critical 0.57 mm size (Figure 5.0.7). Since 2005, zooplanktivory has been low in the western basin for all years except in 2007, and in the central basin for all years except 2005 and 2007. The zooplanktivory index has been most stable in the eastern basin, but is showing a decreasing trend with the most recent years at or above the critical size level (2009 and 2010 samples are still being analyzed).

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 510/m^3 and were generally higher from July through September.

Cercopagis pengoi was first collected in Lake Ontario in 1998, and by 2001 was collected in 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/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 this sampling effort in August 2001 at stations 5 and 6, and at station 9 by September 2001. It 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 2008. In 2007 it was found at station 18, the first record for the eastern basin. Densities were relatively low ranging from 0.002 to 61/m^3.

Microcystis blooms in western Lake Erie (E. Weimer and J. Chaffin)

Following decades of eutrophication and annual blooms of cyanobacteria, the passage of the Great Lakes Water Quality Agreement in 1972, and the pollution control measures that followed substantially reduced phosphorus and phytoplankton levels in Lake Erie and limited cyanobacteria biomass. However, the past decade has witnessed increases in total phytoplankton and the return of cyanobacteria blooms in the western basin. Unlike previous blooms, which were dominated by nitrogen-fixing species like *Anabaena* spp. and *Aphanizomenon* spp., current blooms consist of *Microcystis* spp., a non-nitrogen fixer. While bloom intensity since the mid 1990s has varied, the annual occurrence of *Microcystis* blooms has created concern among managers that Lake Erie is once again becoming eutrophic.

Causes of *Microcystis* blooms and eutrophication in western Lake Erie have been linked to several potential sources. Watershed practices have increased the amount of biologically available phosphorus flowing into the western basin, and small tributaries are providing a potential source of *Microcystis* to the lake. Turbidity, particularly suspended sediments in and around Maumee Bay, provides ideal growth conditions for *Microcystis*, because it can float near the surface while other phytoplankton sink out of the sunlight. Invasive *Dreissenid* mussels selectively avoid cyanobacteria during feeding, and excreted nutrients, particularly forms of nitrogen and phosphorus, are readily available for uptake by *Microcystis*. Internal lake processes also increase the availability of nutrients.

Researchers are examining factors that influence the presence and intensity of *Microcystis* blooms in Lake Erie, and are searching for management levers that can be used to halt or reverse this trend. The University of Toledo has been monitoring *Microcystis* in Maumee Bay and western Lake Erie since 2002, looking at conditions that promote blooms and the cellular 'health' of the cyanobacteria in an attempt to identify deficiencies that limit growth. Researchers from Ohio State University and collaborators at Ohio State University's, F. Stone Laboratory are looking at the timing and intensity of blooms in the Maumee and Sandusky systems. Researchers from Heidelberg University are examining nutrient loading in tributaries and in Lake Erie, and investigating the effects of toxic microcystins on larval mayflies in the Lake Erie benthos. USGS researchers are developing genetic approaches to rapidly assay *Microcystis* biomass and potential toxicity. NOAA has developed an experimental forecast bulletin for harmful algal blooms in western Lake Erie. These represent just a few of the efforts being made to address this issue.

The Lake Erie lower trophic program has been collecting bi-weekly total phosphorus and phytoplankton samples from May through September in Lake Erie since 1998. These samples coincide with the *Microcystis* increase, and may be valuable in identifying lakewide trends and conditions that favor these increases. As reported in the Lower Trophic section of this report, total phosphorus has shown an increasing trend in all basins (Figure 5.0.5). Most of the phytoplankton data are not available as many samples remain archived due to the financial constraints of processing. Currently, the FTG has a total of 881 phytoplankton samples archived at The Ohio State University's Museum of Biological Diversity. Some phytoplankton samples from Ohio waters of the western and central basins have been processed, but are not currently organized in a useable format. The FTG will organize these data in the upcoming year for use in the 2012 report, and will pursue opportunities to process the archived samples as funding allows.

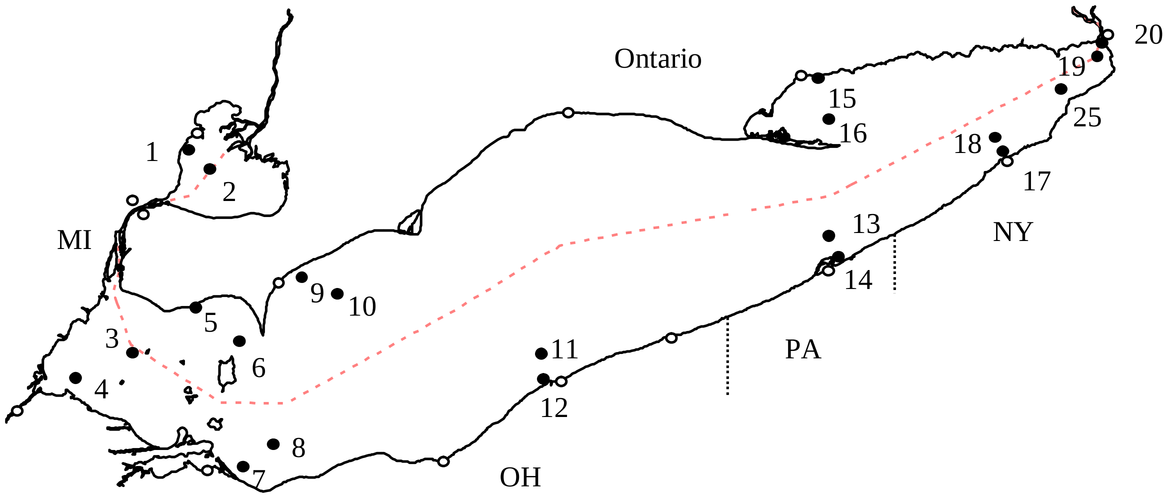


Figure 5.0.1. Lower trophic level sampling stations in Lakes Erie and St. Clair. Station 25 was added in 2009.

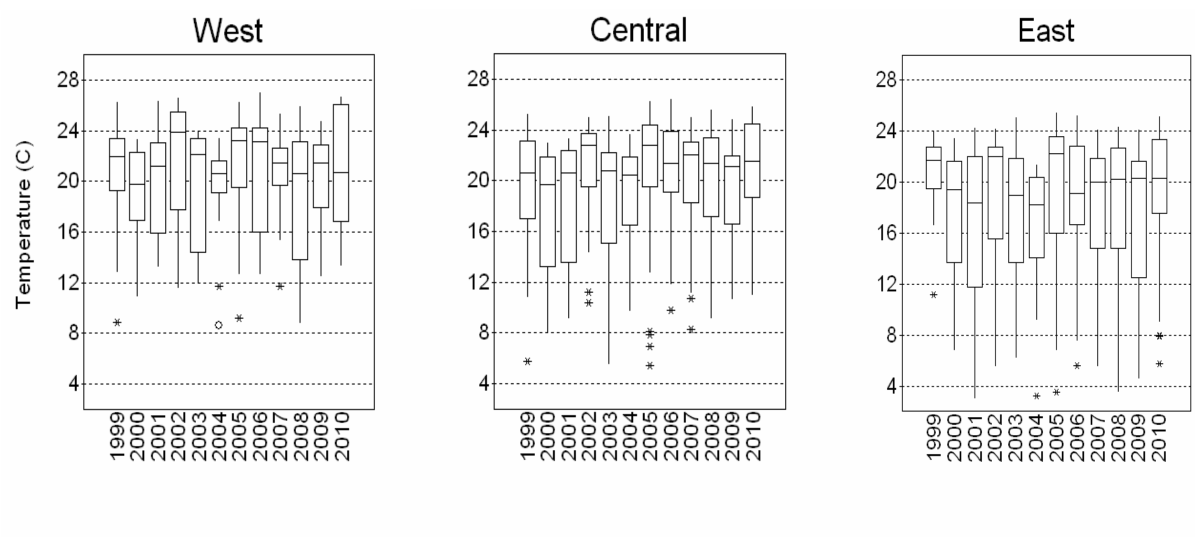


Figure 5.0.2. Median surface water temperature (C) at offshore stations by basin in Lake Erie, May-Sept, 1999-2010. The boxes represent median, 25th, and 75th quartile. The whiskers indicate the range of typical data values. The "*" represent possible outliers and the "o" represent probable outliers. Long-term median water temperature is 21.2 C in the western basin, 21.3 C in the central basin and 20.0 C in the eastern basin. For this analysis data from stations 3, 6, 8, 10, 11, 13, 16, 18, 19 and 25 were included.

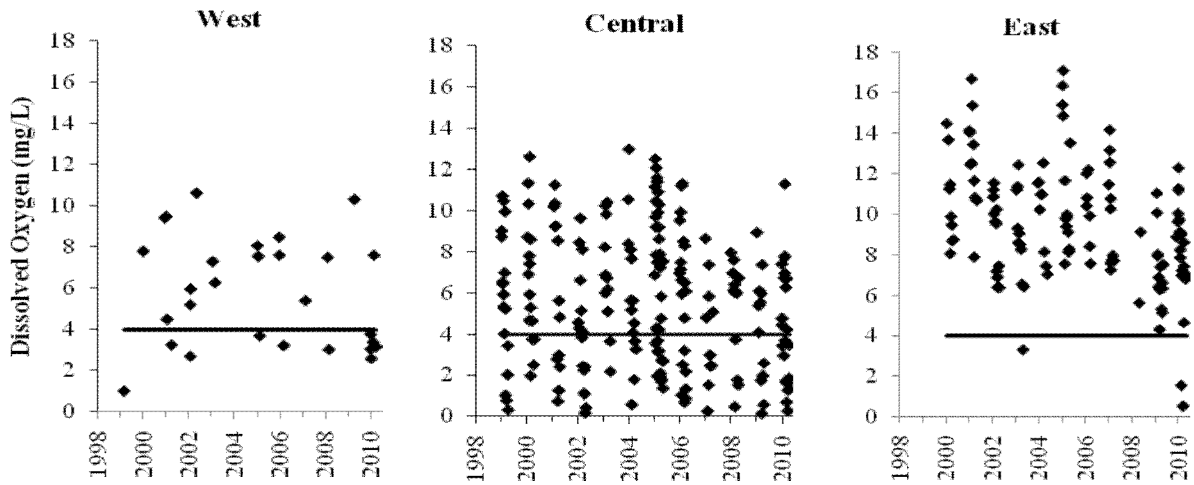


Figure 5.0.3. Mean hypolimnetic dissolved oxygen (mg/L) in each basin of Lake Erie, 1999-2010. The mean is an average of all hypolimnion DO measurements by date and is calculated only for dates when the water column was stratified (typically from June to September). The horizontal line represents 4 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. For this analysis only data from stations 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18 and 25 were included. Stations 7, 14, 19 and 20 rarely stratified.

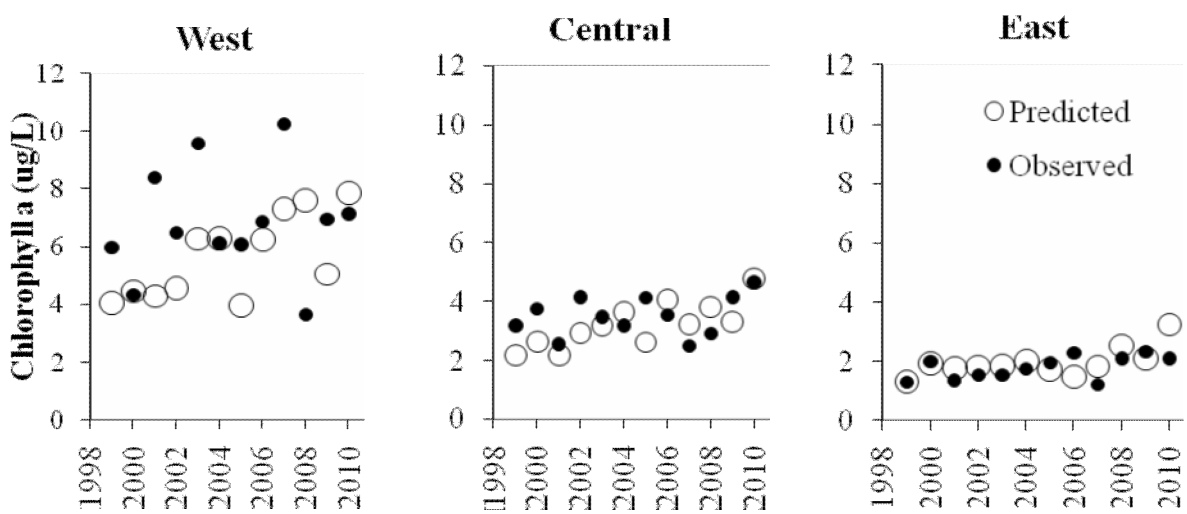


Figure 5.0.4. Observed and predicted chlorophyll *a* concentration (ug/L) in each basin of Lake Erie, 1999-2010. Chlorophyll *a* is predicted from equations presented in Mazumder 1994 for even-linked systems (those where grazing limits phytoplankton standing crop). For this analysis data from stations 3 through 20 and 25 were included.

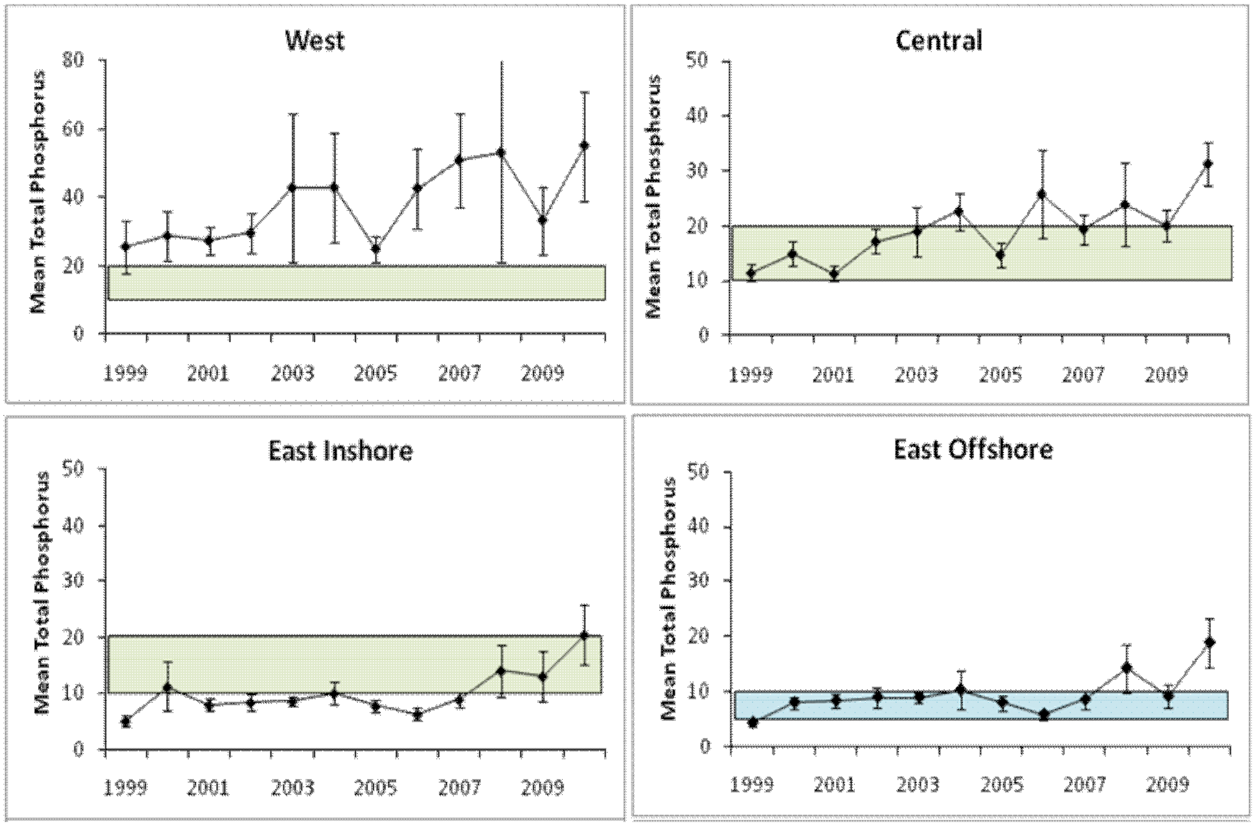


Figure 5.0.5 Mean total phosphorus (µg/L) and 95% confidence limits (approximated as 2 SE's) by basin (1999-2010). The east basin is separated into inshore and offshore. West includes stations 3, 4, 5 and 6; central inshore includes stations 7, 8, 9, 10, 11, 12, 13 and 14; east inshore includes 15, 17 and 20; and east offshore includes 16, 18, 19 and 25. Shaded areas represent the targets of 10-20 µg/L for west, central and east inshore areas and 5-10 µg/L for the east offshore areas.

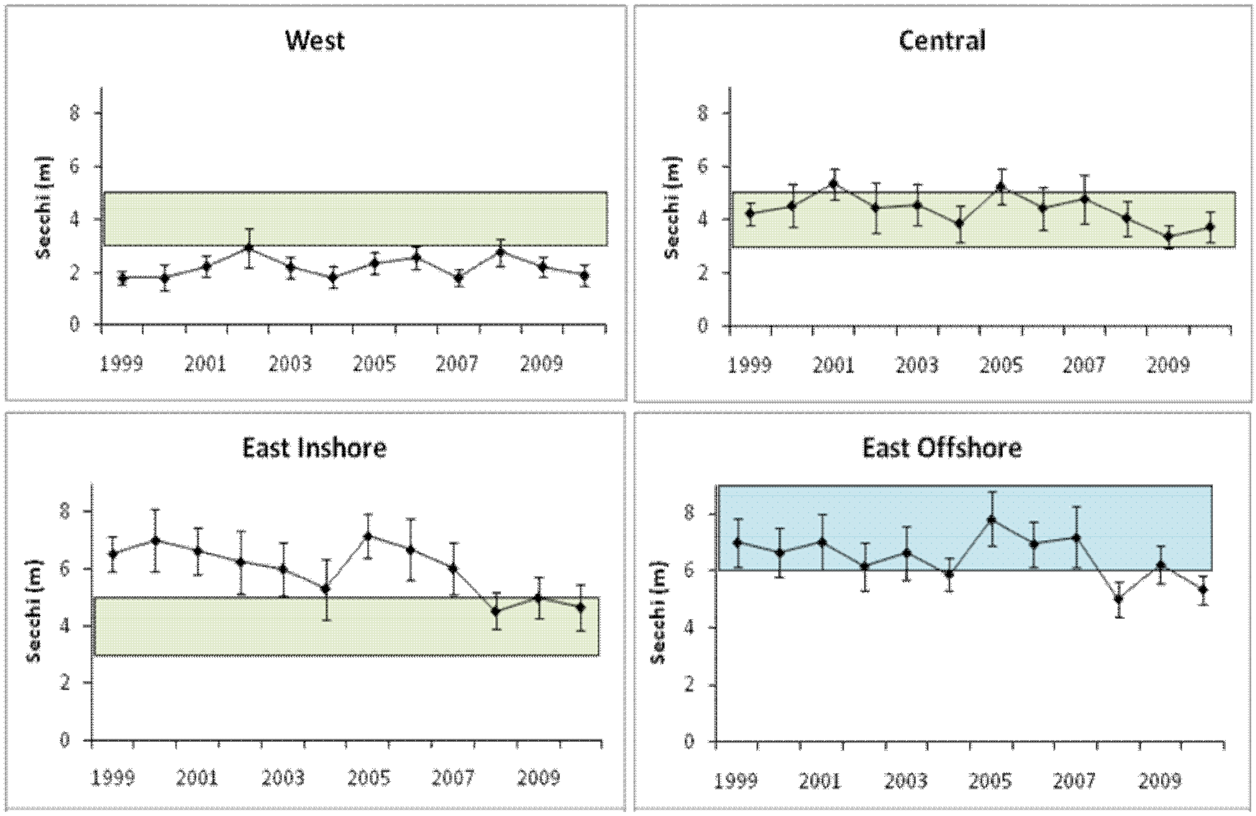


Figure 5.0.6 Mean Secchi depth (m) and 95% confidence limits (approximated as 2 SE's) by basin (1999-2010). The east basin is separated into inshore and offshore. West includes stations 3, 4, 5 and 6; central inshore includes stations 7, 8, 9, 10, 11, 12, 13 and 14; east inshore includes 15, 17 and 20; and east offshore includes 16, 18, 19 and 25. Shaded areas represent the targets of 3-5 m for west, central and east inshore areas and ≥ 6 m for the east offshore areas.

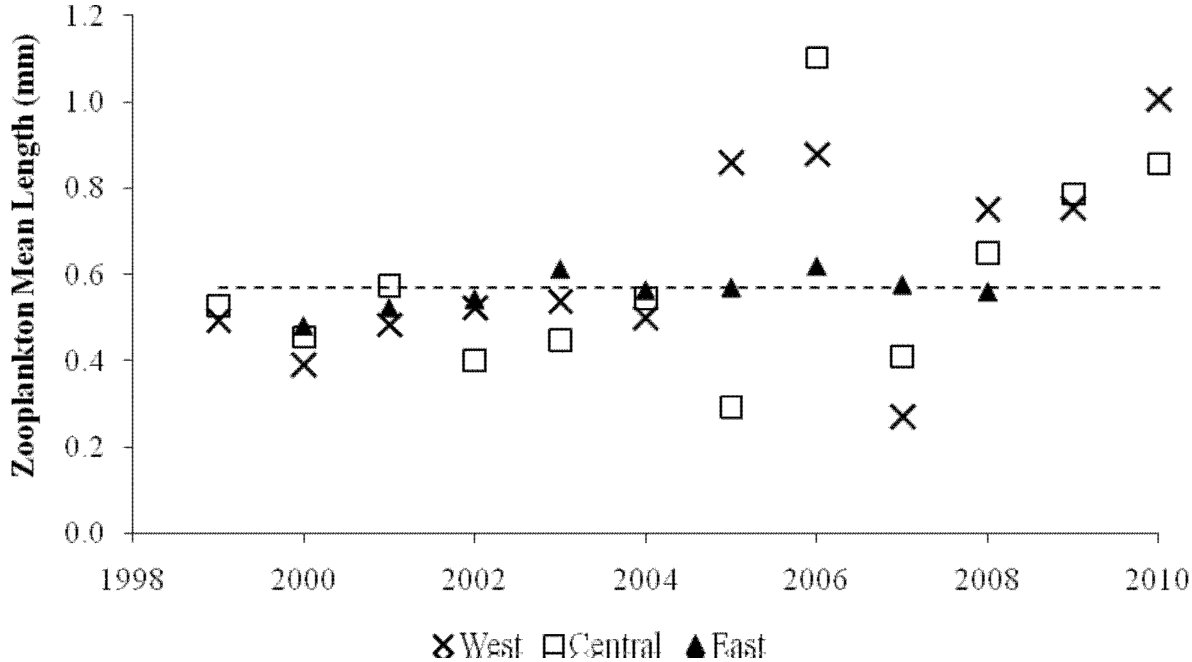


Figure 5.0.7. Mean length of the zooplankton community sampled with a 63 µm plankton net hauled through the epilimnion of each basin of Lake Erie, 1999-2010. The horizontal dashed line depicts 0.57 mm; if the mean size of the zooplankton community is 0.57 mm or less, predation by fish is considered to be intense (Mills et al. 1987, Johannsson et al. 1999). For this analysis data from stations 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18, 19 and 20 were included.

6.0 Lakewide Round Goby Distribution (E. Weimer and B. Haas)

Round goby (*Neogobius melanostomus*), were first discovered in the St. Clair River in 1990, and became established in the central basin of Lake Erie in 1994. In the past, the Forage Task Group has provided annual maps chronicling the spread of round goby throughout Lake Erie. Round goby are present in all bottom trawling surveys and have become established in all areas of Lake Erie (Figure 6.0.1). Round goby abundance indices have generally decreased lakewide since 2007, and are at or below average (Figure 6.0.2). In 2010, the only notable increase in goby abundance occurred in Ohio waters of the central basin. Please refer to previous Forage Task Group reports for information on the yearly spread and distribution of round goby in Lake Erie prior to 2006.

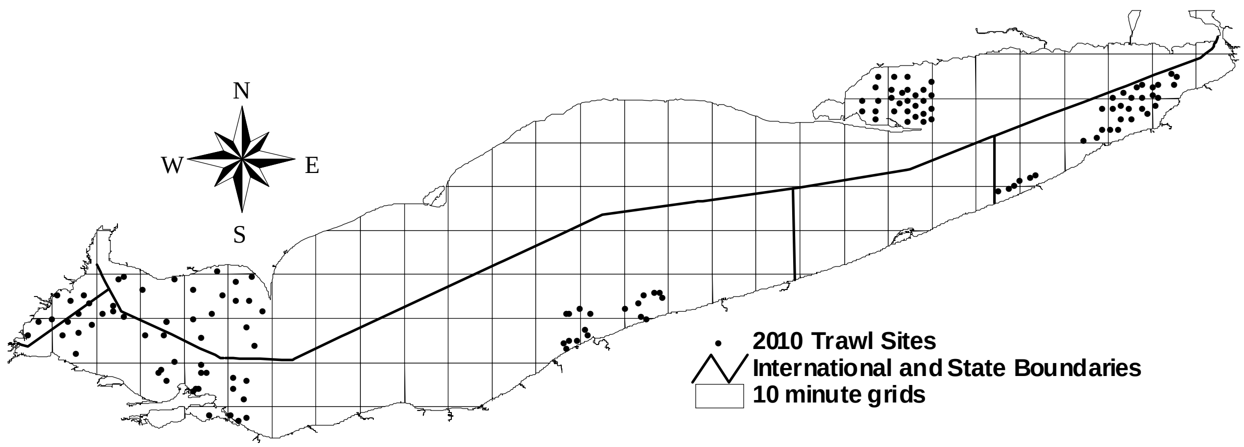


Figure 6.0.1 Map of Lake Erie interagency fall bottom trawling sites (●) used to assess round goby abundance and distribution in 2010. Map includes international and state boundaries, and 10 minute grid system used

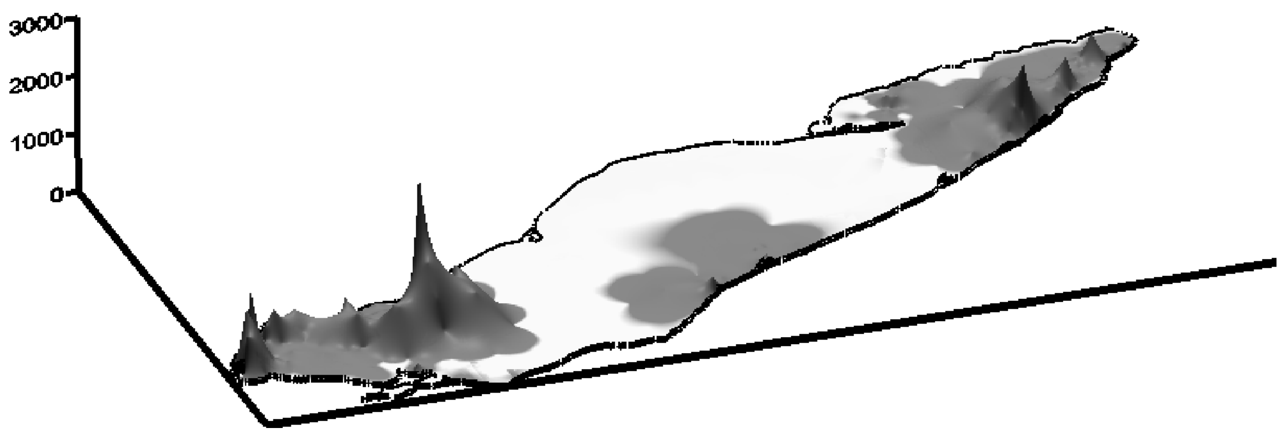


Figure 6.0.2 Three dimensional map of 2010 round goby distribution. Goby distributions were extrapolated from individual fall bottom trawl catches and averaged within 10 minute grids using Surfer© software with a kriging algorithm.

7.0 *Hemimysis anomala* (T. MacDougal, J. Markham, A. Pérez-Fuentetaja and J. Deller)

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 *H. 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 H. anomala was established and broadly distributed within the Great Lakes at this point. (NOAA- GLERL; *Hemimysis* fact sheet, February 2007).

Hemimysis anomala have been observed in the diets of a number of Lake Erie fish species, the list of which continues to expand. First observed in white perch in 2006, they had also been observed in the stomachs of rock bass and, less frequently yellow perch in 2009. 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).

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 species use since 2006. To date the primary and most consistent consumer of *H. anomala* is white perch, which has proportionally increased from 3% in 2006 to 14% in 2009. In 2010, while still the primary consumer, only 3% of white perch examined were observed to have consumed HA (Figure 7.0.1). Rock bass are the second most consistent consumer, being found in 1-3% of examined individuals in 2007-2009 (but not in 2006 or 2010). *Hemimysis anomala* have not been observed in any yellow perch from Long Point Bay over the same time period.

Conversely, yellow perch were the first known consumers of *H. anomala* reported in the central basin. Approximately 250 yellow perch diets are examined each year in the central basin by ODNR. There have been 5 occurrences of yellow perch consuming *H. anomala* since they were first detected in Lake Erie (Figure 7.0.1). The ODNR also samples diets of white bass, walleye and smallmouth bass from fall gillnet surveys and have not found H. anomala in any of their diets. The ODNR does not sample white perch or rock bass diets in the central basin. 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 waters. This suggests that the islands of the western basin likely also harbor this mysid. Occurrences of *H. anomala* in white perch enjoy the widest spatial distribution of observations (Figure 7.0.2). Consideration of the distribution of use-by-species is limited by the fact that all species known to use *H. anomala* are not sampled evenly or consistently across the whole lake. *H. anomala* are probably more widely distributed than what can be shown through consumption by predators.

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).

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 waters surface in a shallow zone (NOAA- GLERL; Hemimysis fact sheet, February 2007).

In 2007, one free-swimming individual was detected in waters associated with the NRG 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 13.7-18.9m. *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.). In 2010 these same traps were deployed in association with a subset of the Long Point Bay index gillnets in an attempt to better understand relationships between *H. anomala* abundance, substrate type, presence of fish and consumption by fish. Unfortunately, although *H. anomala* consuming fish were caught, few (n=2) free-swimming *H. anomala* were trapped.

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 (A. Pérez-Fuentetaja, SUNY, Buffalo State College pers. comm.). 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.

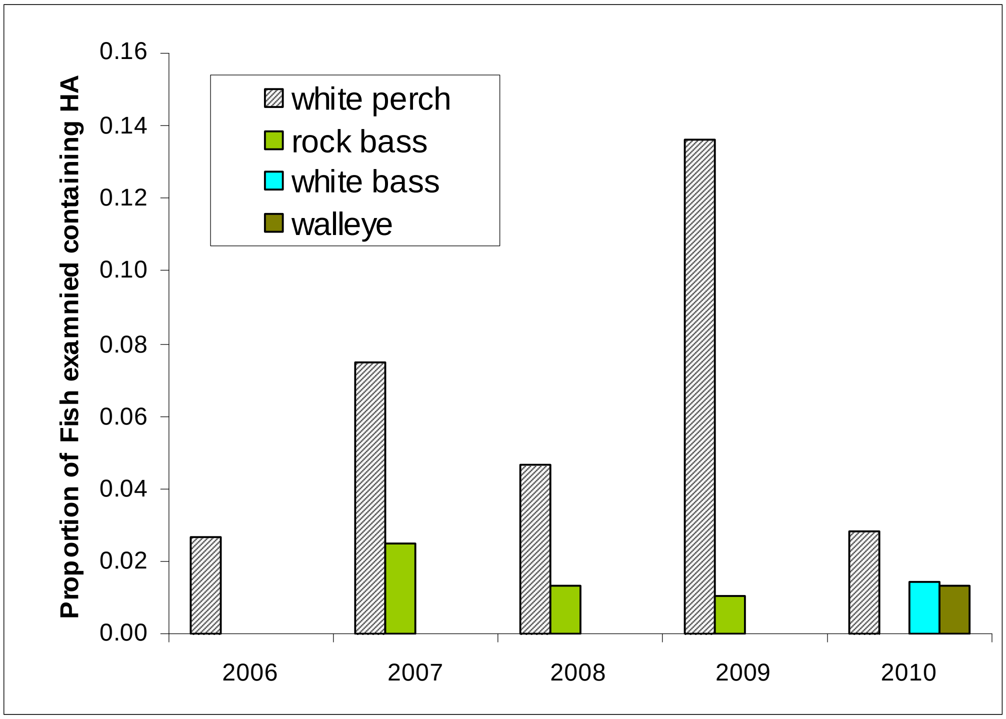


Figure 7.0.1 Occurrence of *Hemimysis anomala* in the diets of four fish species (proportion of fish stomach examined) captured in by gillnet in Long Point Bay, Ontario, 2006 – 2010

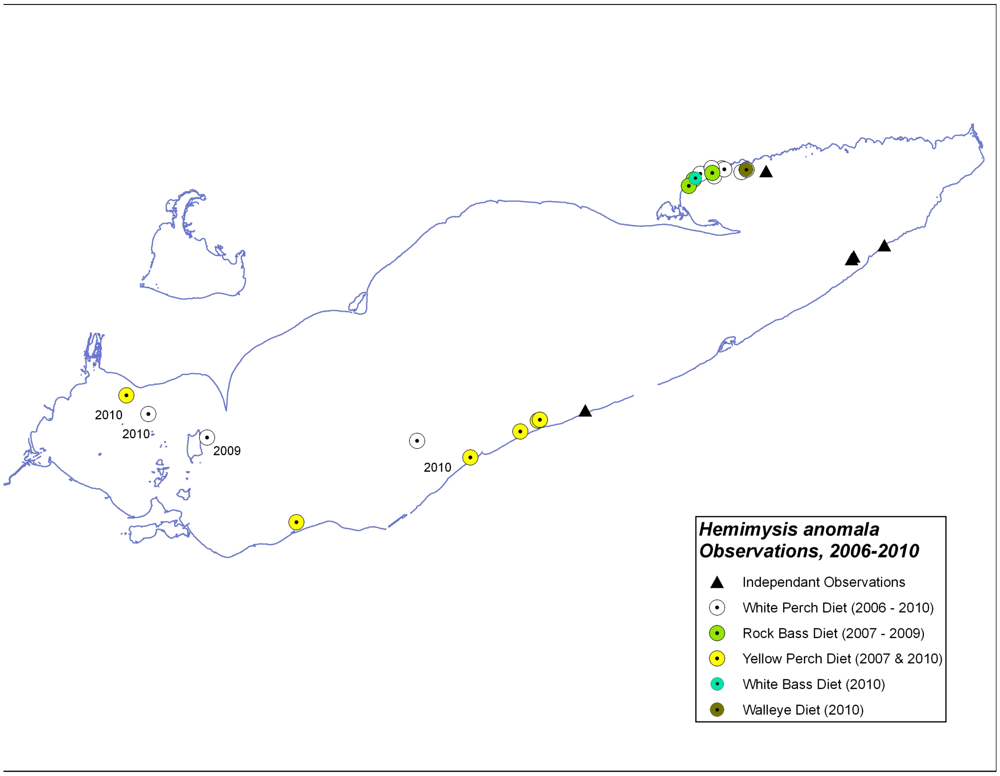


Figure 7.0.2 Distribution of *Hemimysis anomala* observations in Lake Erie, 2006 – 2010

8.0 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.

Acknowledgments

The FTG is grateful to Andrea Stoneman (USGS) for contributing to the west basin forage abundance, section 2.4; Jeff Tyson (ODOW) for input on trawl CPUE statistical summaries, section 3.1; Dr. Lars Rudstam (Cornell University), Dr. Dave Warner (USGS) and Don Einhouse for their continued support of hydroacoustic surveys, section 4.0; Justin Chaffin (University of Toledo) for contributions to *Microcystis* blooms in Lake Erie, section 5.0; Bob Haas (Retired, MDNR) for input on the round goby distribution, section 6.0; and Sherr Vue (Ohio State University) and Andy Cook (OMNR) for contributions to multiple sections of this report.

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