Report of the
Lake Erie
Forage Task Group

March 2009

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Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

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1.0 Charges to the Forage Task Group in 2008-2009

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 eastern, central and western Lake Erie, incorporating new methods in survey design and analysis as necessary to refine these programs.

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.

5. Reassess the bioenergetics model's status and its data needs.

2.0 Status and Trends of Forage Fish Species

2.1 Synopsis of 2008 Forage Status and Trends

General Patterns

- Relative forage abundance is moderate to high (west to east)
- Increases in rainbow smelt abundance
- Round Goby remained high in 2008
- Emerald shiners generally decreased, but remained important
- Forage diversity is increasing
- Predator growth and condition remain good

Eastern Basin

- Moderate (Ontario) to high (New York) abundance of forage fish during 2008 was largely due to a rainbow smelt and round goby
- YOY yellow perch were abundant in record high numbers throughout basin as were YOY white perch in New York waters
- 2008 year class of rainbow smelt was moderately strong throughout basin; YAO smelt was near (New York) or below (Ontario) long-term average abundance
- Age 0 alewife were below average abundance, and age 0 gizzard shad were more abundant than usual, particularly in Ontario waters where record high numbers were observed
- Emerald shiners abundance decreased well below average
- Spottail shiner remain at low densities throughout basin
- Round goby densities decreased throughout basin but 2008 abundance was still second highest observed
- Average length of Age 0 smelt decreased slightly, while Age 1 smelt size increased, both age classes remain above long-term average
- Predator diets were diverse, dominated by fish species, primarily rainbow smelt and round goby
- Predator growth remains good; age-2 to -6 smallmouth bass were record long length-at-age in Long Pt. Bay, ON, and age 2 and 3 bass in NY were at or near record long length
- Age-1 walleye in 2008 were slightly below long-term average total length, while age-2 walleye remained very near long-term averages (NYS DEC).
- Lake trout size-at-age remain stable; among highest in the Great Lakes

Central Basin

- Overall increase in both age-0 and YAO forage abundance relative to 2007 due to exceptional age-0 rainbow smelt and YAO emerald shiner cohorts.
- Rainbow smelt were the only age-0 species that increased in all of Ohio's waters.
- Relative abundance of age-0 smelt has increased each year since 2005.
- Yearling-and-older emerald shiners and white perch were the only species that increased in both east and west areas of Ohio's waters.
- Yearling-and-older round goby abundance increased, but only in the west area of Ohio's waters.
- Mean size of age-0 yellow perch, rainbow smelt and gizzard shad increased from 2007. No long term trends in growth of forage species
- Predator diets were predominantly emerald shiner, rainbow smelt, round goby. Gizzard shad were consumed from August through October.

West Basin

- Age-0 gizzard shad catches down from 2007; both alewife and gizzard shad down well below long-term mean
- Age-0 smelt catches up from 2007; near long-term mean
- Age-0 emerald shiner down from 2007 and well below long-term mean; YAO down as well, but at long-term mean
- Age-0 white perch down from 2007, but still above long-term mean
- Round gobies third highest in time series; the four highest abundances in the time series have been in the last 5 years
- Yellow perch and walleye recruitment down from 2007; both below long-term mean; white bass recruitment up from 2007, still below long-term mean; smallmouth bass near long term mean
- Size of Age-0 walleye, yellow perch, white bass, white perch, and smallmouth bass comparable to long term means
- Fall walleye diets show reliance on gizzard shad and emerald shiners

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

Rainbow smelt have been the principal forage fish species of piscivores in the offshore waters of eastern Lake Erie. In 2008, smelt was the most abundant species captured in OMNR and NYSDEC fall index bottom trawl surveys (Table 2.2.1). Young-of-the-year (YOY) rainbow smelt were observed in average (New York) to above average numbers (Ontario), and catch rates of yearling-and-older (YAO) smelt were below average throughout all regions of the eastern basin including Pennsylvania waters. However, PFBC's entire fall trawl assessment in 2008 was limited to a single day effort at four sample locations and may therefore not accurately describe the abundance of forage fish species, which typically exhibit a high degree of spatial and temporal variation. Mean length of age-0 (63 mm FL) smelt decreased and age-1 (110 mm FL) smelt increased in 2008; both smelt age exceeded the long-term average for Ontario's trawl assessment time series (Figure 2.2.1).

The contribution of non-smelt fish species to the forage fish community of eastern Lake Erie was dominated in 2008 by round goby in Ontario, by trout perch, YOY white perch and round goby in New York, and by round goby in Pennsylvania waters (Table 2.2.1). Emerald shiners have remained below average abundance throughout eastern Lake Erie following record high catches in 2006. Spottail shiner abundance increased slightly in Ontario, but overall, their relative abundance remained low throughout all eastern basin regions in 2008. Age-0 clupeid species abundance was low in most areas of the eastern basin except for record high numbers of YOY gizzard shad in OMNR's offshore trawl survey (ON-DW).

Offshore-based eastern basin trawl surveys indicate the 2008 year class of yellow perch was exceptionally strong compared to historical levels. The 2008 perch year class was ranked highest ever in both the New York and Ontario's (ON-DW) trawl assessments.

Round gobies emerged as a new species among the eastern basin forage fish community during the late 1990s. 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 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. Goby densities decreased in all eastern basin areas during 2008 (Table 2.2.1).

During 2008, 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. These data have been or are in the process of being incorporated in the Forage Task Group's LTLA database.

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 in the eastern basin of Lake Erie, August 2008. 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. In 2006, a year of low YAO smelt abundance, round gobies were prominent in the diets of lean and Klondike strain lake trout, found in 53% and 68%, respectively of stomach samples containing food. In 2007 and 2008, smelt once again was the most frequently observed food item of both lean- and Klondike-strain lake trout. Round gobies occurred more frequently in the diets of Klondike- compared to lean-strain lake trout during all four years since 2005 that Klondike trout have been collected in coldwater assessment gear. Burbot diets remained diverse in 2008 with 7 different fish and invertebrate species found in stomach samples. Round gobies were the most frequently observed prey item in burbot diet, occurring in 71% of the stomachs sampled in 2008 compared to 23% for smelt. Gobies have been the preferred prey item of burbot in five of the last six years.

Age-2 and age-3 smallmouth bass cohorts sampled in 2008 autumn gill net collections (New York) were both more than 20 mm longer than the average for the entire time series. Additionally, age-2 smallmouth bass in 2008 were the longest ever observed in the 28-year time series of this survey. Beginning in the late 1990s and 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, which in 2008 reached record long mean length-at-age for each of ages 3 to 6 bass cohorts. 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 2008 were consistent with the recent 10-year average (1998 – 2007) and k condition coefficients remain high. Lake trout growth in Lake Erie continues to be among the highest in the Great Lakes.

2.3 Central Basin (by J. Deller and C. Murray)

In the central basin, overall forage abundance for age-0 and YAO increased each year since 2006 and for 2008 was above a ten year mean. The increase in forage abundance in 2008 was due to exceptional cohorts of age-0 rainbow smelt and YAO emerald shiners, both in the east areas of the basin (Tables 2.3.1 and 2.3.2). Since 2003 there has been a general trend in relative abundance of forage species being higher in the east relative to the west for both age-0 and YAO. White perch are the only exception to this trend. White perch relative abundance continues to be higher in the west relative to the east.

Rainbow smelt were the only age-0 species that increased basin wide (Ohio waters) compared to 2007. Relative abundance for age-0 rainbow smelt has increased basin wide each year since 2005 and reached record numbers in the east for 2008. Gizzard shad were the only other age-0 species that increased from 2007. Similar to rainbow smelt, relative abundance of YOY gizzard shad was highest in the eastern areas of the basin. Young-of-the-year round goby decreased from 2007 in both the east and west and were well below the long-term mean.

Yearling-and-older emerald shiners and white perch increased basin wide compared to 2007 and were above the long-term mean. Record numbers of YAO emerald shiners were caught in the east. Yearling-and-older round goby abundance increased in the west, but was above the long-term mean basin wide.

Walleye diets were primarily emerald shiners and rainbow smelt from May through October. Gizzard shad started to appear in diets in August and continued through October. Round gobies were consumed generally from June through September and were a higher proportion of the diets in the west compared to the east. Yellow perch were a small component of walleye diets and only occurred in August. White bass diets were also primarily emerald shiners and rainbow smelt throughout 2008. White bass also consumed zooplankton in June and gizzard shad in October. Smallmouth bass diets continue to be mostly round goby and gizzard shad in August through October.

During 2008, Lower Trophic Level Assessment samples were collected from May through September in the central basin. These data are being processed and completed files are incorporated in the Forage Task Group's LTLA database.

2.4 West Basin (by E. Weimer and M. Bur)

Western basin recruitment declined in 2008, with very few exceptions. Recruitment of age-0 yellow perch and walleye decreased from 2007 (Figure 2.4.1), falling to levels below long-term means. Age-0 gizzard shad (99.9/ha) decreased to the third lowest index since 1988, while alewife disappeared entirely (Figure 2.4.2). Abundance of age-0 emerald shiners (27.5/ha) and yearling-and-older (YAO) emerald shiners (51.5/ha) decreased in 2008 (Figure 2.4.3). Age-0 white bass (121.6/ha) increased in 2008, as did age-0 smallmouth bass (1.0/ha), just below the long-term mean. Numbers of all ages of round gobies (142.6/ha, third highest in time series) continue to remain at high levels; the four highest annual abundances in the time series have all been in the last five years. Age-0 rainbow smelt (59.0/ha) increased in 2008, the sixth highest abundance since 1988. Lengths of age-0 walleye, white bass, and smallmouth bass decreased in 2008 relative to 2007, while white perch and yellow perch lengths were up slightly.

Adult walleye diets taken from fall gillnet catches remained dominated by gizzard shad (68%) and emerald shiner (19%), despite the relative low abundance of these species in trawls. White perch were present in walleye diets (5%). Yearling walleye also relied on gizzard shad (45%), emerald shiners (41%), and white perch (11%) in their diets. Diets of yearling and older (YAO) yellow perch in 2008 were dominated by benthos (mostly Chironomidae) in both spring and autumn. As opposed to the trend exhibited during 2005-2007, autumn diets exhibited an increase in the proportion of zooplankton (*Bythotrephes longimanus*) and a decrease in the proportion of fish (round goby and gizzard shad) during 2008.

Water temperatures were similar in 2008 to the previous year, with peak surface temperature (26.1°C) recorded on July 28. Spring warming rate (May 1 to May 31) was 0.15°C per day, lower than in 2007. Seasonally averaged basin wide Secchi depth increased slightly from 2007, averaging 1.6 m [range 0.3m (April 18) to 4.9 m (July 28)]. Western basin bottom dissolved oxygen levels averaged 9.1 mg/l [range 0.5 (July 28) to 14.2 mg/l (April 18)], maintaining levels well above 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 in 2008 and 2007. Indicies are reported as arithmetic mean number caught per hectare (NPH) for the age groups young-of-the-year (YOY) and yearling-and-older (YAO). Long-term averages are reported as the mean of the annual trawl indices for survey years during the present (00's Avg.) and two previous decades (90's Avg. & 80's Avg.). Agency trawl surveys are described below. Pennsylvania FBC (PA-Fa) did not conduct a fall index trawl survey in 2006 and the 2008 survey was a reduced effort of four tows sampled in a single day.

	Trawl	YOY					YAO				
Species	**Survey**	**2008**	**2007**	**00's Avg.**	**90's Avg.**	**80's Avg.**	**2008**	**2007**	**00's Avg.**	**90's Avg.**	**80's Avg.**
Smelt	ON-DW	1293.0	991.3	1529.7	485.6	1382.9	77.3	232.8	223.1	404.7	969.0
	NY-Fa	2128.9	2889.6	1687.2	1450.9	NA	546.5	176.9	501.9	581.6	NA
	PA-Fa	15.1	260.2	149.5	550.8	7058.1	1.8	1006.3	134.2	378.0	2408.6
Emerald	ON-DW	16.0	29.3	508.6	54.8	20.5	95.2	149.8	905.6	46.4	38.1
Shiner	ON-OB	1.6	76.9	86.6	119.4	152.3	5.1	56.3	58.1	49.9	133.5
	NY-Fa	3.7	150.9	210.2	112.4	NA	18.2	84.8	305.7	105.4	NA
	PA-Fa	0.0	81.7	165.0	41.0	118.3	0.0	4713.1	629.2	14.5	45.6
Spottail	ON-OB	23.9	12.3	152.4	696.6	249.0	4.7	0.0	10.3	52.3	21.3
Shiner	ON-IB	0.0	0.3	1.9	111.6	291.3	0.0	0.0	0.4	2.0	9.4
	NY-Fa	0.3	0.1	6.3	19.9	NA	1.5	0.0	6.6	4.0	NA
	PA-Fa	0.0	0.0	0.0	4.0	2.0	0.0	0.0	0.1	7.9	12.4
Alewife	ON-DW	2.3	1.0	25.0	234.1	21.4	NA	NA	NA	NA	NA
	ON-OB	11.4	25.5	61.1	61.0	51.5	NA	NA	NA	NA	NA
	NY-Fa	5.6	22.2	104.8	52.0	NA	NA	NA	NA	NA	NA
	PA-Fa	0.0	8.0	1.4	7.7	16.6	NA	NA	NA	NA	NA
Gizzard	ON-DW	86.5	34.6	23.6	7.5	15.3	NA	NA	NA	NA	NA
Shad	ON-OB	2.6	12.3	6.2	9.6	24.1	NA	NA	NA	NA	NA
	NY-Fa	10.8	11.7	12.7	4.2	NA	NA	NA	NA	NA	NA
	PA-Fa	0.0	0.0	0.1	0.9	74.3	NA	NA	NA	NA	NA
White	ON-DW	5.4	0.1	3.2	2.2	5.6	NA	NA	NA	NA	NA
Perch	ON-OB	1.3	0.4	2.8	14.2	28.7	NA	NA	NA	NA	NA
	NY-Fa	431.5	34.6	90.3	29.4	NA	NA	NA	NA	NA	NA
	PA-Fa	0.7	444.6	213.2	101.1	NA	NA	NA	NA	NA	NA
Trout [a]	ON-DW	0.1	0.0	0.0	0.1	0.5	0.7	0.8	0.8	0.5	1.9
Perch	NY-Fa	996.4	561.2	859.0	410.0	NA	NA	NA	NA	NA	NA
	PA-Fa	0.0	46.2	47.0	23.2	NA	0.6	110.6	54.3	26.0	NA
Round [a]	ON-DW	452.6	973.2	257.3	0.0	0.0	NA	NA	NA	NA	NA
Goby	ON-OB	44.2	59.8	59.4	0.1	0.0	NA	NA	NA	NA	NA
	ON-IB	137.9	185.1	71.0	0.0	0.0	NA	NA	NA	NA	NA
	NY-Fa	290.7	1059.5	469.4	1.0	0.0	176.1	233.6	198.9	0.0	0.0
	PA-Fa	229.1	1092.3	778.9	30.3	0.0	212.6	951.5	408.8	5.6	0.0

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

[a] Ontario (ON-) trawl indices for round goby and New York State DEC (NY-) trawl indices for trout perch reported as "all ages" under the heading for YOY.

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 2007.

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 2007.

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 2007.

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 2007.

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 2007.

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 1998-2008. 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.

	year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	mean
Yellow	OH West	69.8	73.6	21.9	114.6	6	149	8.7	37.8	10	167	37.3	65.8
perch	OH East	38.1	21	1.3	13.6	2.5	47.5	1.9	156.2	18.9	177.8	52.8	47.9
	PA	13.7	7.2	15.7	388.4	11.9	788.0	2.4	6.7	-	10.0	-	138.2
White	OH West	91.9	334.1	581.3	779.7	293	310.1	759.7	1002.5	440.4	1381.2	544.9	597.4
perch	OH East	52.3	37.1	4.9	57.6	5.9	61.8	108	2034.5	46.1	1095.9	91.6	350.4
	PA	0.0	8.5	75.9	26.6	80.7	173.8	2.4	42.3	-	17.8	-	47.5
Rainbow	OH West	253.3	70.8	150.1	2.3	274.7	1753.9	352.1	10.7	94.3	98.1	635.2	306.0
smelt	OH East	953.8	282.4	1070.3	0	218.1	2914.1	388.9	44.4	570.7	702.4	3997.7	714.5
	PA	29.9	1.8	15.3	377.4	152.9	177.6	20.9	15.9	-	35.1	-	91.9
Round	OH West	130.1	95.1	21.7	43.9	37.8	22.6	13.9	37.2	19	26.9	17.4	44.8
goby	OH East	186.7	178.2	158.2	39.6	64.7	57.5	173.9	148.1	46.3	273.1	26.3	132.6
	PA	743.6	1114.4	781.1	1577.8	289.3	75.3	1011.3	204.0	-	227.8	-	669.4
Emerald	OH West	4928.5	408.4	127.2	50.5	39.4	477.6	7	567.1	587.2	52.6	36.3	724.6
shiner	OH East	150.5	599.4	500.6	2.2	0.5	903.1	0.8	279.8	1115.1	63.7	20.2	361.6
	PA	5.8	0.0	0.0	8.5	38.1	81.8	0.0	17.8	-	0.8	-	17.0
Spottail	OH West	1.4	5.6	0.4	5.9	1.6	0	0	0.2	0	3.1	3.7	1.8
shiner	OH East	2.7	3.9	0	0.7	0.2	0.5	0	1.1	0.2	0.5	0.2	1.0
	PA	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	-	0.1
Alewife	OH West	10	37.2	62.1	50.8	59.7	0.1	0	0	4.4	0	0	22.4
	OH East	0.1	9.2	12.4	0	1.1	0	0	0	3.6	0	0	2.6
	PA	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	-	0.0	-	0.0
Gizzard	OH West	33.8	104.3	117.1	60.3	24.6	402.6	0.6	12.3	32.7	195	35.7	98.3
shad	OH East	34.8	17	27.6	1.8	12.3	20.4	0.3	15.7	30.7	15.5	63.1	17.6
	PA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	-	0.0	-	0.1
Trout-	OH West	0.3	5.5	1	2	1.4	2	20.3	0.1	0.2	0.8	0.3	3.4
perch	OH East	1.3	4.8	0.4	0	0.3	1.4	1.4	1.6	0.1	5.4	0.1	1.7
	PA	23.1	10.0	23.0	7.8	45.6	78.0	6.7	0.3	-	10.9	-	22.8

(-) The Pennsylvania Fish and Boat Commission was unable to sample in 2006 and 2008.

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 1998-2008. 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.

	year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	mean
Yellow perch	OH West	6.3	40.7	61.6	5.7	51.7	3.2	216.5	18.3	4.2	19.8	56.6	42.8
	OH East	3.7	40	19.3	0.4	38.3	1.2	45.2	132.3	12.5	37	26.4	33.0
	PA MU3	2.5	7.9	3.9	41.3	37.5	75.6	18.3	1.9	-	27.4	-	24.0
White perch	OH West	5.6	35.2	91.1	21.7	91.5	28.2	83.9	34.1	32.4	27.1	76.5	45.1
	OH East	0.2	14.6	38.6	0.4	176.2	12	27	20.1	38.5	16.8	36.6	34.4
	PA MU3	0.0	1.9	0.6	2.4	38.5	28.6	6.2	0.0	-	0.8	-	8.8
Rainbow smelt	OH West	71	146.2	65.6	55.6	45.3	29.4	320.5	89.8	8.9	40.4	9.6	87.3
	OH East	58.2	2115.1	150.3	3.3	320.9	370.3	1360.2	30.8	17.3	532.4	64.9	495.9
	PA MU3	1.3	0.0	75.8	0.0	6.2	22.1	9.9	2.6	-	10.7	-	14.3
Round goby	OH West	164.9	82.5	27.5	54.8	39.2	25.4	27	33.6	20.4	26.3	57.9	50.2
	OH East	118.6	106.7	164.5	88.4	54.3	127.1	148.8	263	78.9	185.6	167.8	133.6
	PA MU3	113.1	55.3	126.5	55.2	238.3	59.1	767.0	206.7	-	361.1	-	220.3
Emerald shiner	OH West	1862.1	515.8	109.2	106.3	233.9	54.9	1.5	233.6	162.7	418.7	495	369.9
	OH East	22.8	502.6	830.5	0.7	133.2	432	0.4	479.6	451.1	27.8	1159.4	288.1
	PA MU3	0.0	0.0	0.0	0.0	107.4	217.5	0.0	123.0	-	769.5	-	135.3
Spottail shiner	OH West	28.3	5.8	8.7	3.5	6.6	1.6	5.3	0.3	1.2	2.3	2.3	6.4
	OH East	5	7.2	8.6	1.1	5.9	1	0.2	3.8	0.7	0.6	2.9	3.4
	PA MU3	0.4	0.0	0.0	0.0	2.2	0.0	0.0	0.0	-	0.0		0.3
Trout-perch	OH West	15.1	9.2	17.2	3.2	27.2	12.2	14	13.5	3.3	5.5	4.8	12.0
	OH East	14.8	9.3	15.3	2.2	8.5	2.9	7.7	76.2	4.8	6.7	8.4	14.8
	PA MU3	1.0	0.9	11.5	0.6	81.2	50.9	5.2	4.1	-	16.0	-	19.0

(-) The Pennsylvania Fish and Boat Commission was unable to sample in 2006 and 2008.

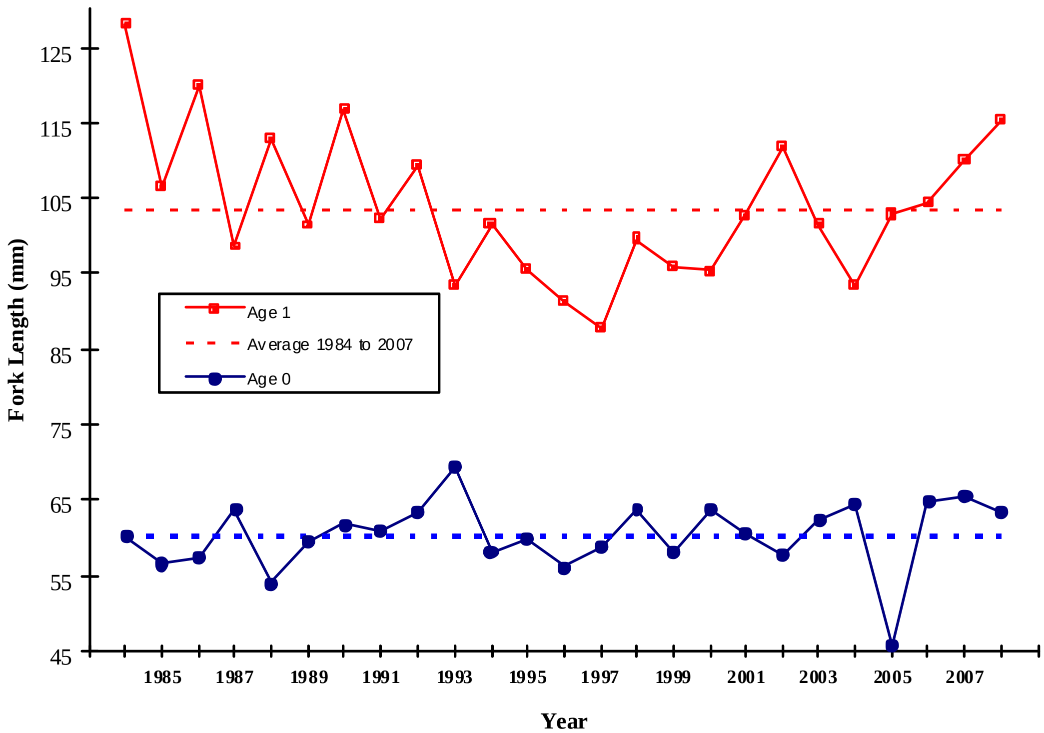

Figure 2.2.1 Mean fork length of age-0 and age-1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984-2008.

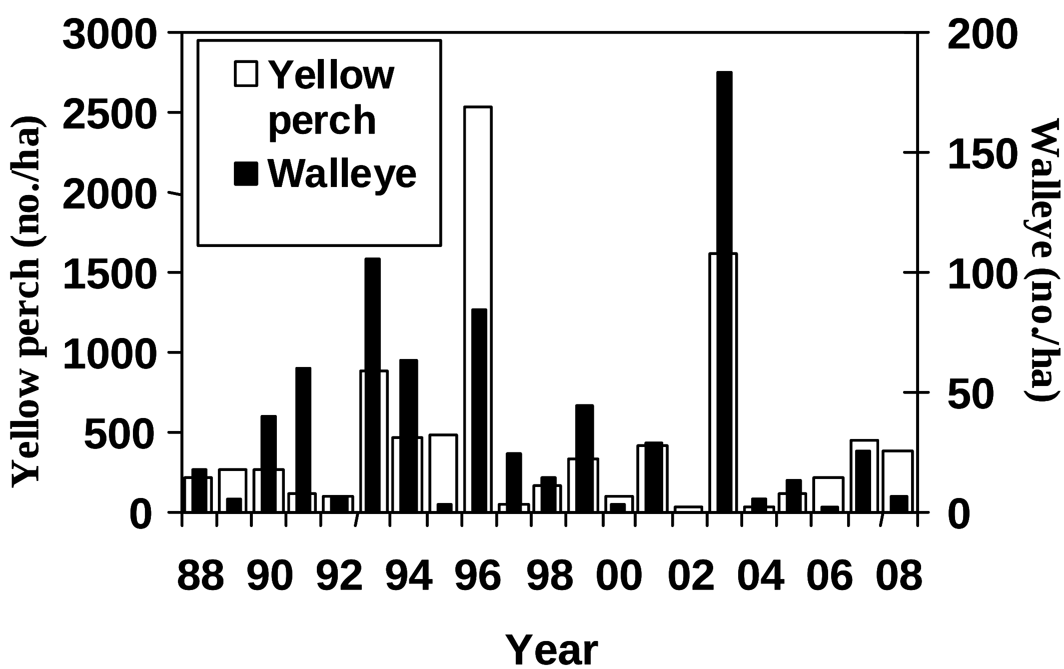

Figure 2.4.1 Density of age-0 yellow perch and walleye in the western basin of Lake Erie, August 1988-2008.

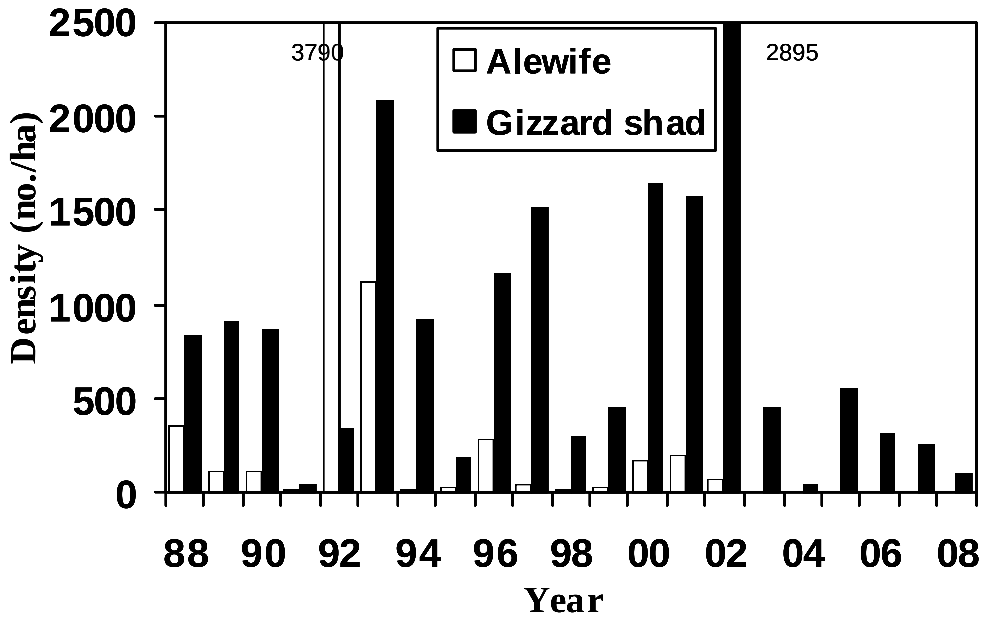

Figure 2.4.2 Density of age-0 alewife and gizzard shad in the western basin of Lake Erie, August 1988-2008.

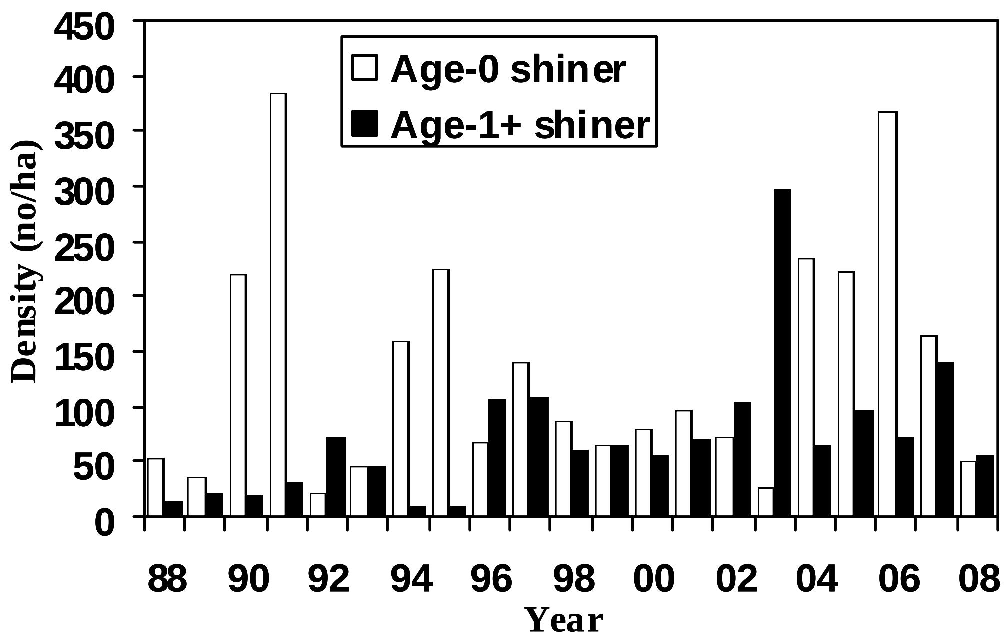

Figure 2.4.3 Density of age-0 and age-1+ shiners (*Notropis* spp.) in the western basin of Lake Erie, August 1988-2008.

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.

3.1 Trawl Calibration (by M. Bur, P. Kocovsky, and S. Mackey)

In September 2008, ODNR, Scudder Mackey (Habitat Solutions NA), and USGS conducted tests to estimate trawl dimensions (vertical height and wing spread) using two types of assessment gear (side-scan sonar and Notus, both are acoustic tools). The objectives were to determine: 1) the dimension of the trawls (both bottom and midwater) with each type of gear; and 2) if there was agreement between the two separate sonar equipment on trawl dimensions. These tests were similar to those run in 2006 by the MDNR (Forage Task Group 2007). The first four tests (each test consisted of a 10-17 minute tow) consisted of towing a bottom trawl with Notus acoustic mensuration sensors attached to each of the bottom trawl wings to determine trawl spread (width) and two sensors mounted on the headrope and one on the footrope to measure vertical height. Simultaneously a separate vessel towed a side-scan tow body with transducer to measure bottom trawl wing spread and height. The vessel with the side-scan made several measurements during each trawl test (usually 4-8). The next three test tests were run with side-scan only (the Notus sensors removed) to determine if wing spread and height were affected by the presence (size and weight) of the Notus sensors. A similar set of tests was conducted with the mid-water trawl (two tests with side-scan only and two tests with both side-scan and Notus).

One of the end outcomes was to ascertain if the independent measurements (Notus vs. side-scan) are similar. The Notus measurements were generally greater than for the side-scan. Bottom trawl wing spread was 12.9% greater for Notus (5.1 m, SD=0.8 m) than for side-scan (4.6 m, SD=0.4 m), and mid-water trawl wing spread was 6.8 % greater for Notus (7.6 m, SD=0.1 m) than for side-scan (7.3 m, SD=0.3 m).

The results differed with the experience of both MDNR and NYS DEC in comparing bottom trawl measurements using Netmind acoustic mensuration gear and side-scan. Both MDNR and NYS DEC observed greater wing spread measurements with Netmind gear attached. For tests with Notus and side-scan, the wing spread was greater when Notus was not attached than with the gear attached for both bottom trawl and mid-water trawl tows. Trawl wing spread measurements for the bottom trawl using side-scan with Notus attached were 4.5 m (SD=0.4 m) and 4.7 m (SD=0.4 m) without Notus, and for the mid-water trawl the wing spread was 7.2 m (SD=0.2 m) with Notus and 7.5 m (SD=0.3 m) without Notus. One of the differences between Notus and Netmind gear is that the wing sensors are 3.2 times heavier for Netmind, whereas the depth and gape/headline sensors for

Netmind were 1.6 times the weight of Notus (Table 3.1.1). It appears that size and weight of wing sensors may have a role with increasing the distance of wing spread. These results may show sufficient evidence that the presence of Netmind sensors on the wings has a more measurable effect on the small (7.9-11.6 m) trawls than the Notus sensors (7.9 m). Most confidence limits are overlapping for Notus measurements, which suggest that the observed differences might be due to error, not actual differences.

3.2 Summary of Species CPUE Statistics (by E. Weimer, J. Tyson and M. Bur)

Interagency trawling has been conducted in Ontario, Ohio and Michigan 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 of 65 trawls were used in the analyses in 2008 (Figure 3.2.1).

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 3.2.1). 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 in 2008, reaching a level similar to 2006 (Figure 3.2.2). Total forage biomass responded similarly (Figure 3.2.3). These decreases are similar between each functional group; abundance decreased by 28-61%, while biomass decreased by at least 42% relative to 2007. Relative biomass of clupeid, soft-rayed, and spiny-rayed species was 2%, 9%, and 89%, and, while similar to recent trends, was different than the respective historic averages of 26%, 12%, and 82% (Figure 3.2.3). Walleye show a clear preference for clupeids and soft-rayed fishes over spiny-rayed prey (Knight and Vondracek 1993), and the long-term decreases in biomass of clupeid and soft-rayed fish may struggle to satisfy predatory demand in Lake Erie.

Mean length of age-0 fishes in 2008 varied when compared to 2007 (Figure 3.2.4). Length of age-0 for select species include: walleye (137.6 mm), yellow perch (69.9 mm), white bass (69.9 mm), white perch (59.2mm), and smallmouth bass (70.2 mm). Long-term averages for the same species are: walleye (137.4 mm), yellow perch (66.7 mm), smallmouth bass (79.9 mm), white bass (67.6 mm), and white perch (57.5 mm).

Spatial maps of forage distribution were constructed using FPC-corrected site-specific catches (#/ha) of the functional forage groups (Figure 3.2.5). Abundance contours were generated using kriging contouring techniques to interpolate abundance among trawl locations. Clupeid catches were highest around Cedar Point, and the mouth of Sandusky Bay (southwest portion of the basin), with gizzard shad densities lowest along the north shore. Soft-rayed fish (predominantly round gobies and emerald shiners) were most abundant along the north shore and around the Bass Islands. Spiny-rayed abundance was highest in the center of the basin around the Bass Islands, with pockets of high abundance along both the north shore and in Sandusky Bay. Relative abundance of the dominant species includes: age-0 white perch (75%), yellow perch (9%), white bass (3%), and all-age round gobies (3%). Total forage abundance averaged 4,388 fish/ha across the western basin, falling 30% from 2007 to fall below the long-term average (5,260 fish/ha). Clupeid density was 100 fish/ha (average 1141 fish/ha), soft-rayed fish density was 391 fish/ha (average 519 fish/ha), and spiny-rayed fish density was 3,897 fish/ha (average 3,599 fish/ha).

3.3 Trawl Comparison Exercise (by 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.

Table 3.1.1. Size and weight of acoustic sensors for Notus and netmind net mensuration gear. Gape is equal to headrope height of the bottom.

	Notus	Netmind
Main wing		
Length (mm)	314	400
Diameter (mm)	76	115
Weight (Kg)	2.5	9.0
Secondary wing		
Length (mm)	314	330
Diameter (mm)	76	115
Weight (Kg)	2.5	7.0
Depth		
Length (mm)	314	330
Diameter (mm)	76	115
Weight (Kg)	2.5	7.0
Gape/Headline		
Length (mm)	610	400
Diameter (mm)		115
Width (mm)	280	-
Height (mm)	127	-
Weight (Kg)	7.2	9.0

Table 3.2.1. 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

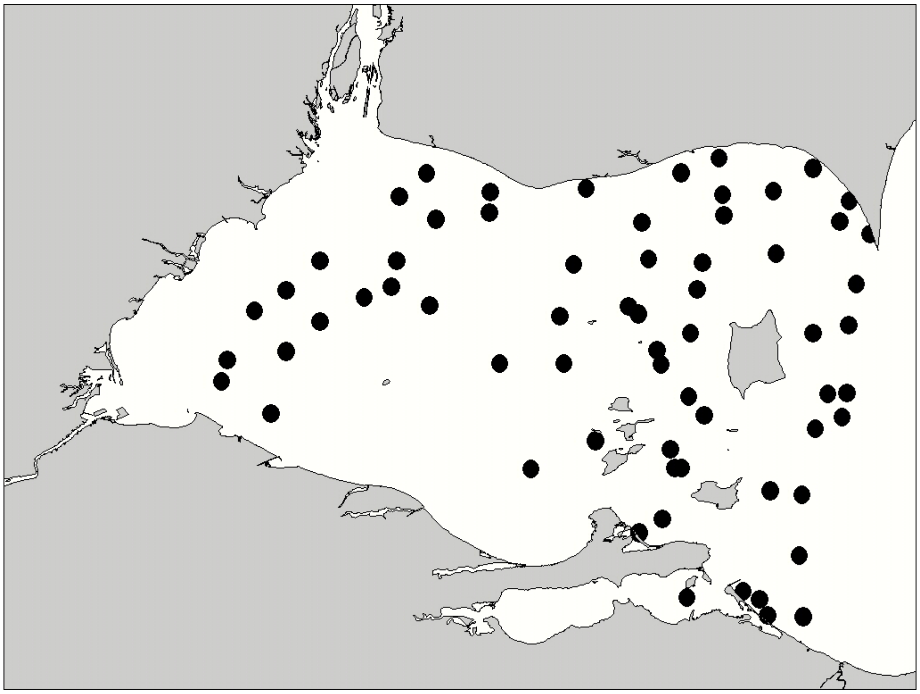

Figure 3.2.1 Trawl locations for the western basin interagency bottom trawl survey, August 2008.

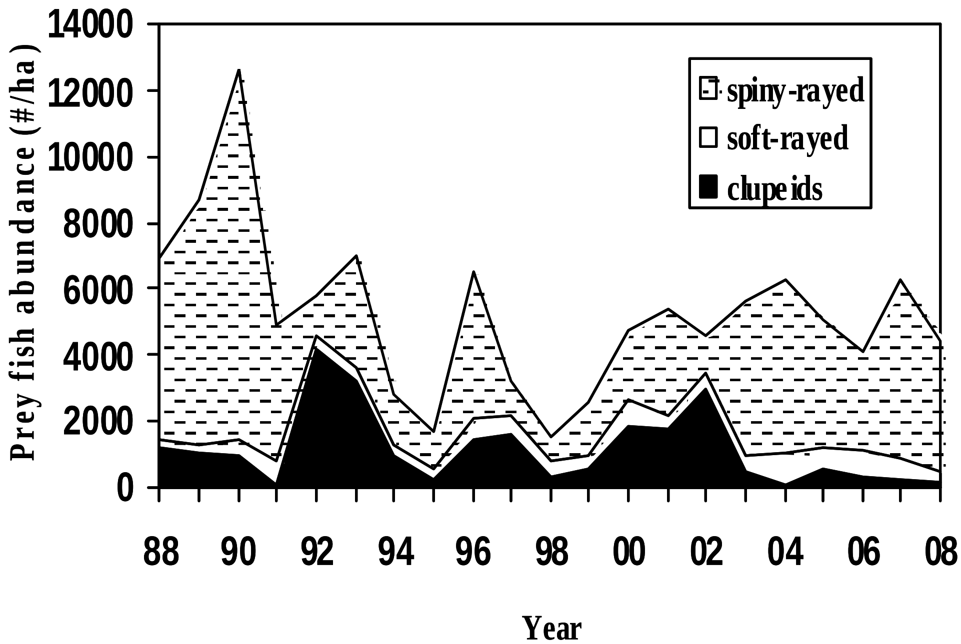

Figure 3.2.2 Mean density (no. / ha) of prey fish by functional group in western Lake Erie, August 1988-2008.

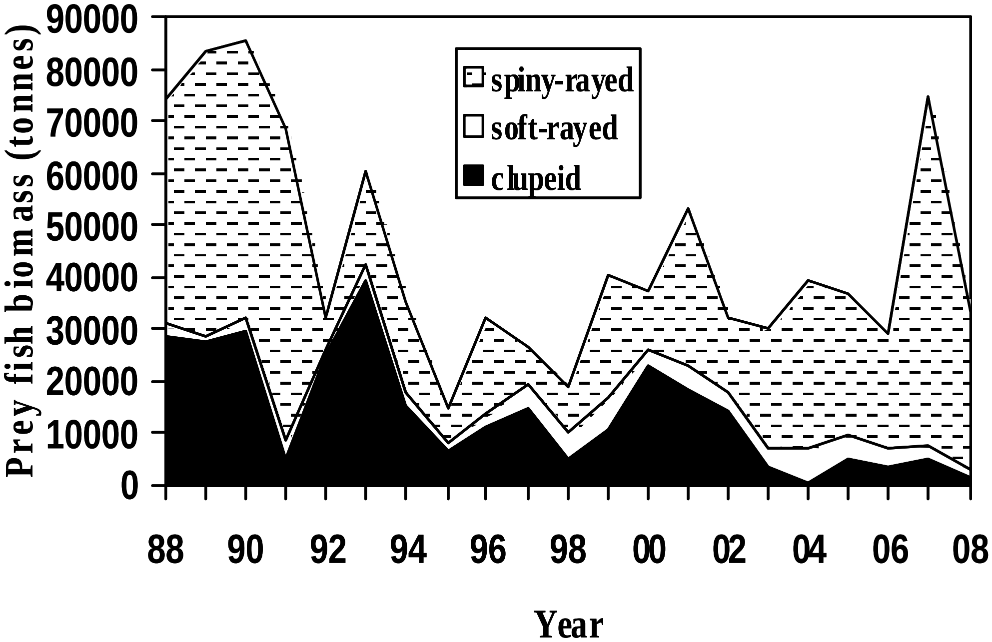

Figure 3.2.3 Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2008.

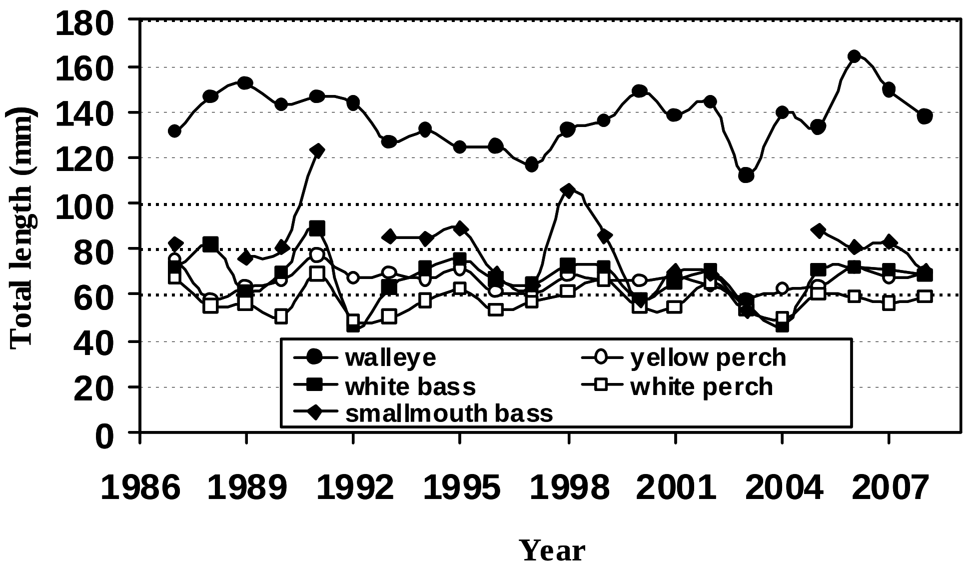

Figure 3.2.4 Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2008.

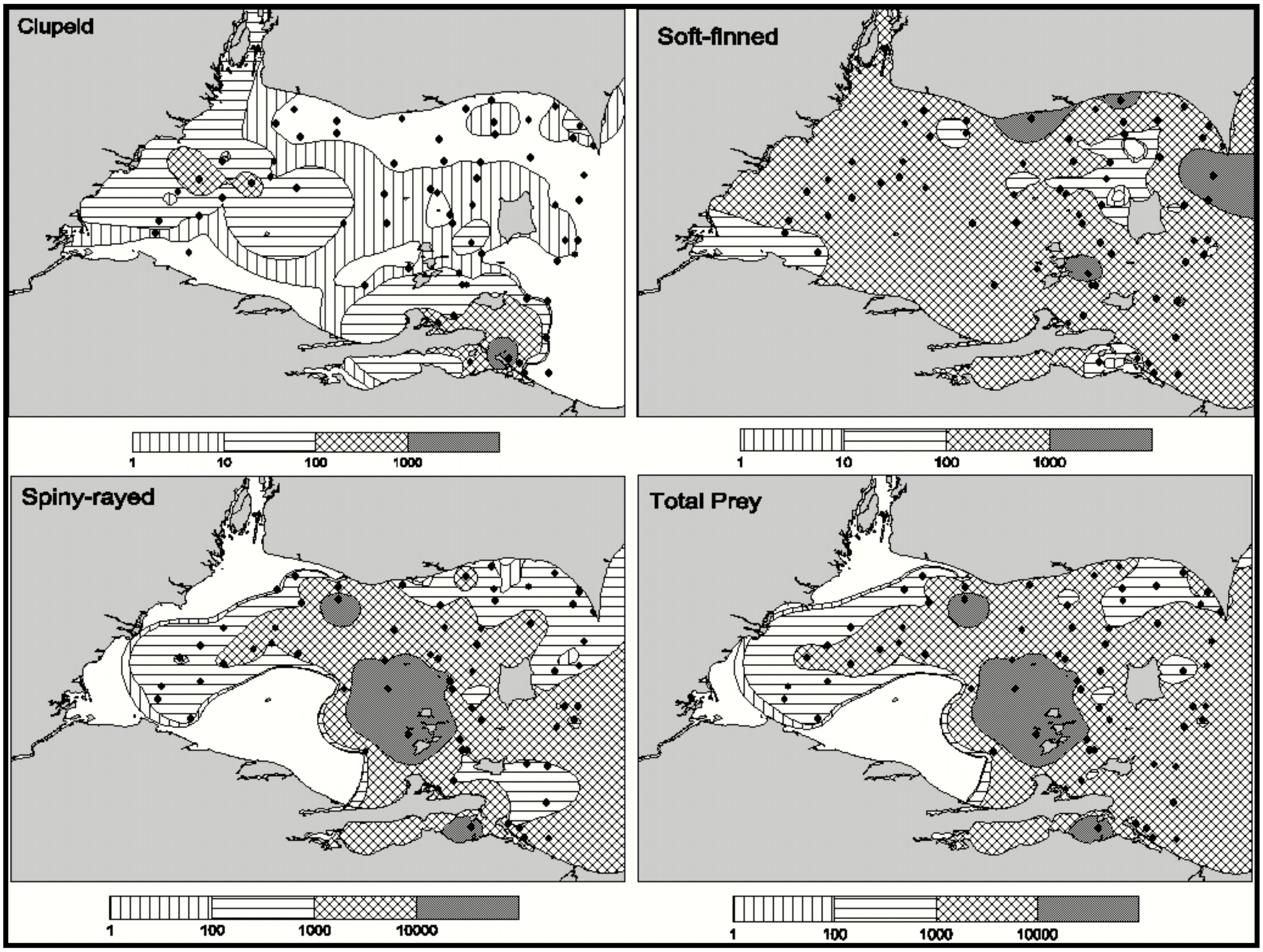

Figure 3.2.5 Spatial distribution of clupeids, soft-finned, spiny-rayed, and total forage abundance (individuals per hectare) in western Lake Erie, 2008. Black dots are locations for trawling and contour levels vary with the each functional fish group.

4.0 Hydroacoustic Survey Program

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

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. Finally, in 2008, several members of Lake Erie's FTG participated in a workshop, the most recent in a series of Great Lakes Acoustic 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 (in press)). 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.

Survey Methods

A thorough description of survey methodology as well as a thorough 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 during 2009. 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.

The 2008 Survey

In recent years, New York's annual contribution to the east basin survey is mid-water trawling by the *RV Argo* to describe fish species composition. Fish densities and distribution are measured by a scientific echosounder, a Simrad EY60 120 kHz split-beam GPT, aboard the Ontario Ministry of Natural Resources (OMNR) research vessel, *RV Erie Explorer*. Acoustic data acquisition for the 2008 survey was completed without incident and attained the full compliment of twelve acoustic transects totaling 186 nautical miles and 764,000 KB of raw acoustic data (Figure 4.1.1). However, mid-water trawl collections and water temperature-depth profile sampling in 2008 were abbreviated due to mechanical difficulties on the *RV Argo*. In all, both acoustic survey vessels combined for 37 temperature profiles, and the *RV Argo* made 9 mid-water trawl tows during a shortened 2008 mid-water trawling program.

Acoustic Series Results

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, 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 1999 to 2003 has been re-processed and analyzed using our new survey standards. This renewed data analysis effort is now briefly suspended to address other pressing report deadlines, but will resume during April, 2009. The five years of completed analysis of acoustic survey results using the new SOP describe trends in densities of pelagic forage fish and these new measures are shown in Table 4.1.1, along with a series of independent bottom trawl measures of yearling-and-older (YAO) rainbow smelt.

The 1999 to 2003 period represented a particularly useful interval to calibrate acoustic results with suspected YAO densities of rainbow smelt. This was a period when rainbow smelt were the dominant pelagic forage fish species in eastern Lake Erie, and also a time when smelt exhibited a characteristic pattern of alternate year dominance of YAO abundance. From 1999 to 2003 the independent bottom trawl surveys by eastern basin jurisdictions provided in a series of Lake Erie's FTG reports spanning this period (FTG 2000 to FTG 2004) show this alternate year abundance cycle for yearling-and-older (YAO) rainbow smelt (Table 4.1.1). This same alternate year abundance pattern was also apparent in the recently re-analyzed acoustic series for this period.

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 strong agreement of acoustic densities of YAO pelagic forage fish and our independent trawl measures of YAO rainbow smelt abundance. However, our 5-year period of initial analysis also highlighted some remaining uncertainty for characterizing rainbow smelt abundance. In the 2003 survey a few especially high density areas of fish in epilimnion strata seemed much too large, and an outlier from the remaining data, to be reasonably included with these initial results. Further work will be necessary to resolve these seemingly spurious observations. Mid-water trawling to support the acoustic survey was abbreviated in 2003, but other indicators suggest those high density cells may well describe densely concentrated young-of-the-year (YOY) rainbow smelt, or other YOY fishes.

The spatial distribution of pelagic fish densities for the YAO acoustic size range is shown in Figure 4.1.2. The distribution of acoustic transects and fish densities through this 1999 to 2003 period shows gradually improved spatial coverage of the east basin survey as this program progressed through more recent years. Also, this figure demonstrates the spatial distribution of pelagic forage fish densities can markedly differ across years. 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.

We expect to resume analysis of acoustic results for years 1997, 1998, and 2004 through 2008 during spring 2009. The entire 1997 to 2008 data series is expected to be thoroughly reported in a separate document with an accompanying description of survey methods and data processing procedures. Upon completion of this overview document, subsequent results will be updated annually in Lake Erie's FTG Report.

Discussion

The interagency fisheries acoustic survey of eastern Lake Erie has proven to be a highly successful, collaborative effort for rainbow smelt assessment between fisheries agencies in the Province of Ontario, New York and Pennsylvania. This ongoing program has also successfully partnered with academic researchers through the GLFC and addressed some previously unmet needs for the Lake Erie fisheries management community. This interagency acoustic partnership in forage fish assessment began in Lake Erie's east basin, and has now expanded into central and western basins using the eastern Lake Erie program as a model.

Some FTG representatives participated as core members of a Great Lakes acoustic study group charged with developing standards for fishery acoustic surveys in the Great Lakes. One of the principal accomplishments of the Acoustic Study Group was development of Great Lakes SOP document (Parker-Stetter et al. 2009, Rudstam et al. 2009 (in press)), with an accompanying SOP workshop, delivered in 2008. The ongoing, eastern basin Lake Erie acoustic survey represents an excellent example of a standard, inter-agency assessment of the pelagic forage fish community conducted in the Great Lakes. Lake Erie's acoustic survey has benefited from collaboration with experts from beyond our borders. Individuals leading Lake Erie's acoustic program are actively engaged in updating survey results for the entire data series and are targeting a comprehensive summary to be prepared as a separate report.

Finally, acoustic survey applications are expanding further as a fishery assessment tool in Lake Erie to include such endeavors as habitat mapping. As such, continued support will be required to efficiently administer acoustic surveys. Lake Erie's acoustic hardware and software are broadly shared among the five jurisdictions represented on the FTG. This inter-agency acoustic monitoring program will require a dedicated ongoing effort for maintenance, upgrades, expansion of site licenses, and periodic training of personnel to maintain it as a functional fish stock assessment tool. The GLFC and the Lake Erie Committee have demonstrated strong support for acoustic survey efforts on Lake Erie, and the biologists responsible for these surveys are very grateful for these efforts.

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

The 2008 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). This sample design, consisting of eight cross-basin transects, requires two acoustic survey vessels and two midwater trawling vessels. As in past surveys, midwater trawling from separate vessels was conducted to ground truth species composition and aid in single target detection analysis if needed.

Hydroacoustics

In 2008, the *R/V Musky II*, (United States Geological Survey; USGS) and *R/V Grandon* (ODNR-DOW) were the acoustic vessels. Due to weather constraints, four partial transects and two complete transects of acoustic data were collected from July 7 through July 11 (Figure 4.2.1). Acoustic transects corresponding to Loran-C TD lines were sampled from one half hour after sunset (around 2130) on either the north or south shore and continued to the opposite shore until the transect was completed or weather conditions forced cancellation of data collection. All sampling was conducted in waters 10 meters or deeper.

Hydroacoustics data were collected aboard the *R/V Musky II* and *R/V Grandon* using BioSonics DTX ® echosounders with 129-kHz transducers and BioSonics Visual Acquisition (release 5.1) software. Global Positioning Systems coordinates were collected using a Garmin ® GPSMAP 225 on the *R/V Musky II* and a Magellan 5000 on the *R/V Grandon*, both units were interfaced with the echosounder to obtain simultaneous latitude and longitude coordinates. The acoustic transducer on the *R/V Musky II* was mounted on a stainless steel bracket bolted to the starboard hull roughly equidistant between the bow and stern. The transducer on the *R/V Grandon* was towed from the starboard instrument davit attached to a Biofin® towing body. Both transducers were positioned approximately 1 m below the water surface.

Trawling

The *R/V Keenosay,* (Ontario Ministry of Natural Resources; OMNR) provided midwater trawling concurrent to the acoustic data collection in Ontario waters from July 7 through July 11. The *R/V Grandon* (ODNR-DOW) collected trawl data in Ohio waters during the two weeks following acoustic data collection from July 15 through July 29. Weather conditions forced the cancellation of two trawl tows. The remaining 49 trawl tows were completed according to the sample design. Whenever possible, trawl vessels attempted to distribute trawl effort above and below the thermocline to adequately assess species composition in each depth stratum. At the time of midwater trawling in Ohio, the thermocline was too close to the bottom to permit effective use of trawl equipment. Ohio trawl data are limited to the depth strata above the thermocline. Total length and total catch were recorded from each trawl by species and age group. 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. Trawl data were pooled and species composition was determined within each jurisdiction (Table 4.2.1).

Analysis

Acoustic transects and midwater trawl data were stratified along each transect into two depth layers for analysis: epilimnion (3 m to 18 m) and hypolimnion (> 18 m to 0.5 m above the bottom). These layers were chosen based on temperature and dissolved oxygen profiles and acoustic target size distributions.

Analysis of hydroacoustic data were conducted following the guidelines established in the *Standard Operating Procedures for Fisheries Acoustic Surveys in the Great Lakes* (Parker-Stetter et al. 2009). Hydroacoustics data were analyzed using EchoView ® version 4.5 software. Proportionate area backscattering coefficient and single targets identified using EchoView method 2 (recommended by Sonar Data, Inc., developer of EchoView software, for BioSonics data) were used to generate density estimates for 500-m intervals in each water stratum. *In situ* data were used to determine single target (TS) numbers and sizes for converting total area backscattering (Sv) into fish density estimates (fish per hectare) for each interval and depth stratum. The Nv statistic, a measure of the relationship between the number of single targets and Sv, was calculated for each interval-by-depth stratum cell to monitor the quality of using in situ data to calculate TS (Sawada et al. 1993). 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). Occasionally, using the mean TS value for the transect produced worse Nv values than either *in situ* TS or TS values derived from trawl data. In these cases, *in situ* TS was retained. Final density estimates for each interval and depth strata were calculated from data outputs from Echoview, using Excel spreadsheets.

Results

In 2008, average acoustic density within a transect was always highest in the epilimnion and lowest in the hypolimnion (Figure 4.2.2). Along each transect, acoustic densities were usually higher in the offshore areas of the basin relative to nearshore. Hypolimnion densities were usually below 5,000 fish per hectare. The only area where hypolimnion densities were above 5,000 fish per ha was in the furthest east transect, c58225. Densities in the epilimnion ranged from 2,500 to as high as 164,000 fish per hectare. The highest epilimnion densities also occurred in transect c58225.

Rainbow smelt and emerald shiners were the most abundant species in midwater trawl samples. In the epilimnion, both age groups of rainbow smelt combined to account for 84.9% of the species in Ontario waters (Table 4.2.1). The next largest component in Ontario was age-1+ emerald shiners (13.4%). In Ohio waters of the epilimnion, age-1+ emerald shiners accounted for 51.9%, while both age groups of rainbow smelt accounted for 41%. The hypolimnion in Ontario was almost exclusively age-1+ and age-0 rainbow smelt (74.6% and 23.6%, respectively). Age-1+ emerald shiners only accounted for 0.5% in the hypolimnion.

The thermocline in Ontario waters ranged from 15m to 17m based on temperature and dissolved oxygen profiles collected from the *R/V Keenosay*. In Ohio waters the thermocline ranged from 18m to 20m based on data collected on *the R/V Grandon* during trawling.

Discussion

Preliminary analysis of acoustic transects from 2008 showed average target density was always highest in the epilimnion and lowest in the hypolimnion. This trend is consistent with target densities of transects analyzed in 2007. There was a difference between the two years in the location along a transect where peak target densities occurred. In 2007, the highest densities occurred in the nearshore areas, whereas in 2008 the highest densities were in the offshore areas of the basin. There were also very large differences in total target density between the two years, with the highest density per 500-m interval in 2007 at 58,000 fish per hectare and in 2008 the highest density per 500-m interval was 140,000 fish per hectare. The difference in maximum densities is attributed to an exceptional cohort of age-0 rainbow smelt that was concentrated around the thermocline.

This is the second year we have presented analyses from hydroacoustics work in the central basin of Lake Erie since the program began in 2000. Procedures for acoustic analysis continue to evolve. We are actively participating in, and are applying current research and improvements to our acoustic analysis. The techniques and procedures outlined in the Great Lakes Acoustic Standard Operating Procedure (GL-SOP) have been applied to analysis of 2008 acoustic data. In 2008 we encountered extremely high Nv values due to age-0 rainbow smelt. Fish congregating around thermocline created long stretches of transects where Nv values were too high to allow for use of *in situ* TS. Following procedures established in the GL-SOP and Rudstam et al. (2009) we were able to improve the Nv values in most intervals, but in some instances the Nv values remained too high. Estimates of TS from equations based on trawl data can be used in place of *in situ* TS. In our analysis, using estimates of TS from trawl data did not improve Nv values relative to *in situ* TS. We feel the high Nv values are a result of extreme Sv, due to very high densities of age-0 rainbow smelt, rather than *in situ* TS. Even though density estimates in 2008 appear to be extreme compared to 2007, we feel 2008 estimates remain conservative, based on the methods used to solve for high Nv values. At this time we are not certain if the high Nv problem is unique to the central basin of Lake Erie, or if it has been encountered in other great lakes systems. We will be addressing this issue over the course of 2009.

4.3 West Basin Acoustic Survey (E. Weimer)

Introduction

A standardized inter-agency fishery acoustics program has been used to assess forage community abundance and distribution in the eastern basin of Lake Erie since 1993. The acoustic survey was expanded to the central basin in 2000 (Forage Task Group 2004). In 1997, a pilot program was conducted by Sandusky Fisheries Research Unit staff adjacent to Sheldon's Marsh in July to assess the feasibility of using acoustic technology in the shallow waters of the western basin. The pilot study showed much promise and results indicated an offshore to nearshore gradient in forage-sized fish abundance. As charged by the LEC, since 2004 a pilot western basin acoustic survey has been initiated to explore the utility of using down-looking and side-looking sonar for assessing pelagic forage fish abundance in the west basin. Multiplexing two different transducers, one looking down and one looking sideways has been used in other shallow-water systems to effectively sample more of the water column. While currently unprocessed, the 2004 data will be used in conjunction with current survey data to develop a standardized acoustic sampling program for the west basin of Lake Erie that will complement the ongoing acoustic surveys in the central and eastern basins and facilitate an annual lake snapshot of pelagic forage fish abundance and biomass.

Methods

Three standard transects, extending through both Canadian and Ohio waters, were surveyed July 14-18, 2008 (Figure 4.3.1). The distribution of transects was based upon previous work and was designed to capture the range and extent of variability seen in habitat types and likely forage fish densities. Mid-water trawling to determine community composition was not conducted in 2007.

Sampling on Transect 1 was performed with the Lake Erie BioSonics DT-X surface unit equipped with two 6.8-degree, 201-kHz, split-beam transducers, a Garmin global positioning system, and a Panasonic CF-30 laptop computer. Problems with the Lake Erie unit surfaced halfway through Transect 1, and the remaining transects were surveyed using the Ohio Inland

Fisheries Research (IFRE) BioSonics DT-X surface unit equipped with two 199.2-kHz split-beam transducers (7.0-degree down-facing, 6.4-degree side-facing). Each acoustic system was calibrated before the survey with a tungsten carbide reference sphere of known acoustic size.

The mobile survey, conducted aboard the ODNR's *RV Almar*, was initiated 0.5 h after sunset and completed by 0.5 h prior to sunrise. Transects were navigated with waypoints programmed in a Lowrance GPS, and speed was maintained at 8-9 kph using the GPS. The transducer was mounted on a fixed poles located on the port and starboard sides of the boat near mid-ship. The down-facing transducer was mounted 1 m below the surface, while the side-facing transducer was mounted 1.5 m below the surface. Data were collected using BioSonics Visual Acquisition 5.0.4 software. Collection settings during the survey were 10 pings/second, a pulse length of 0.2 msec, and a minimum threshold of -70 dB. The sampling environment (water temperature) was set at the temperature 2 m deep on the evening of sampling. Data were written to file and named by the date and time the file was collected. Files were automatically collected every 30 minutes. Latitude and longitude coordinates were written to the file as the data were collected to identify sample location.

Data were analyzed using SonarData's Echoview 4.5 software using a modified process developed by the Ohio Division of Wildlife Inland Fisheries Research Unit. This year, single target strengths between -41dB and -60dB were used for analysis to focus on forage-sized fish (15-165 mm). This target strength range was estimated using Love's dorsal aspect equation (Love 1971):

Total length = 10 ^ ((Target Strength + 26.1)/19.1) * 1000

This step was made necessary due to the amount of large targets sampled during this year's survey, especially in Transect 3. Data collected from side-facing transducers were not included in this analysis in an attempt to reconcile our survey methods with those recommended by the Great Lakes Acoustic Study Group. In addition, concerns over the quality of data collected with side-facing transducers have kept us from using this data in the western basin survey since 2005, and it is possible that we will no longer collect this data in following years.

Results

Mean western basin forage fish density and biomass estimates from down-viewing data were 5220 fish per hectare and 4.2 kg per hectare, respectively, significantly lower than in 2007 ($P<0.0001$). Density was also significantly lower in 2008 than in 2006 ($P<0.0001$), although biomass in 2008 was similar to 2006. Fish density (Figure 4.3.2) in 2008 was highest in Transect 2, similar to other years, while biomass (Figure 4.3.3) was highest in Transect 1, although not significantly different from Transect 2. Fish density appeared to be highest in Ohio waters of the western basin (Figure 4.3.4), although survey gaps make this statement difficult to quantify. The majority (75%) of forage fish in the survey were estimated to be 20-59 mm TL; 95% were between 20-109 mm.

Table 4.1.1. Indices of relative abundance of pelagic forage fish species in eastern Lake Erie from a basin-wide acoustic survey from 1999 to 2003, 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 (NPH) for the yearling-and-older (YAO) age group.

		Number per hectare				
Sampling Method	**East Basin Stratum**	**1999**	**2000**	**2001**	**2002**	**2003**
Btm. Trawl YAO Smelt	**ON-DW**	138	30	702	6	218
Btm. Trawl YAO Smelt	**NY-Fa**	805	74	138	117	282
Btm. Trawl YAO Smelt	**PA-Fa**	5	-	14	7	32
Btm. Trawl YAO Smelt	**juris. trwl ave. (area wgt.)**	109	13	152	13	72
Acoustic YAO Fish	**East Basin Acoustic (YAO)**	8,425	6,115	9,414	1,903	5,260

Ontario Ministry of Natural Resources Trawl Survey

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.

New York State Department of Environmental Conservation Trawl Survey

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

Pennsylvania Fish and Boat Commission Trawl Survey

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

Inter-agency East Basin Acoustic Survey

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. Species composition (expressed as % of catch within a water stratum) of midwater trawl samples by jurisdiction (Ontario, Ohio), species, life stage, and water stratum in the central basin of Lake Erie in July 2008. Epilimnion (surface to < 18 m depth) and Hypolimnion (> 14 m depth) refer to depth of water stratum. Life stages are: young of year (age-0) and yearling and older (age-1+).

		Percent composition	
Epilimnion	Life Stage	Ontario	Ohio
Rainbow smelt	age-0	40.3	39.1
Rainbow smelt	age-1+	44.6	1.9
Emerald shiner	age-1+	13.4	51.9
Hypolimnion			
Rainbow smelt	age-0	23.6	-
Rainbow smelt	age-1+	74.6	-
Emerald shiner	age-1+	0.5	-

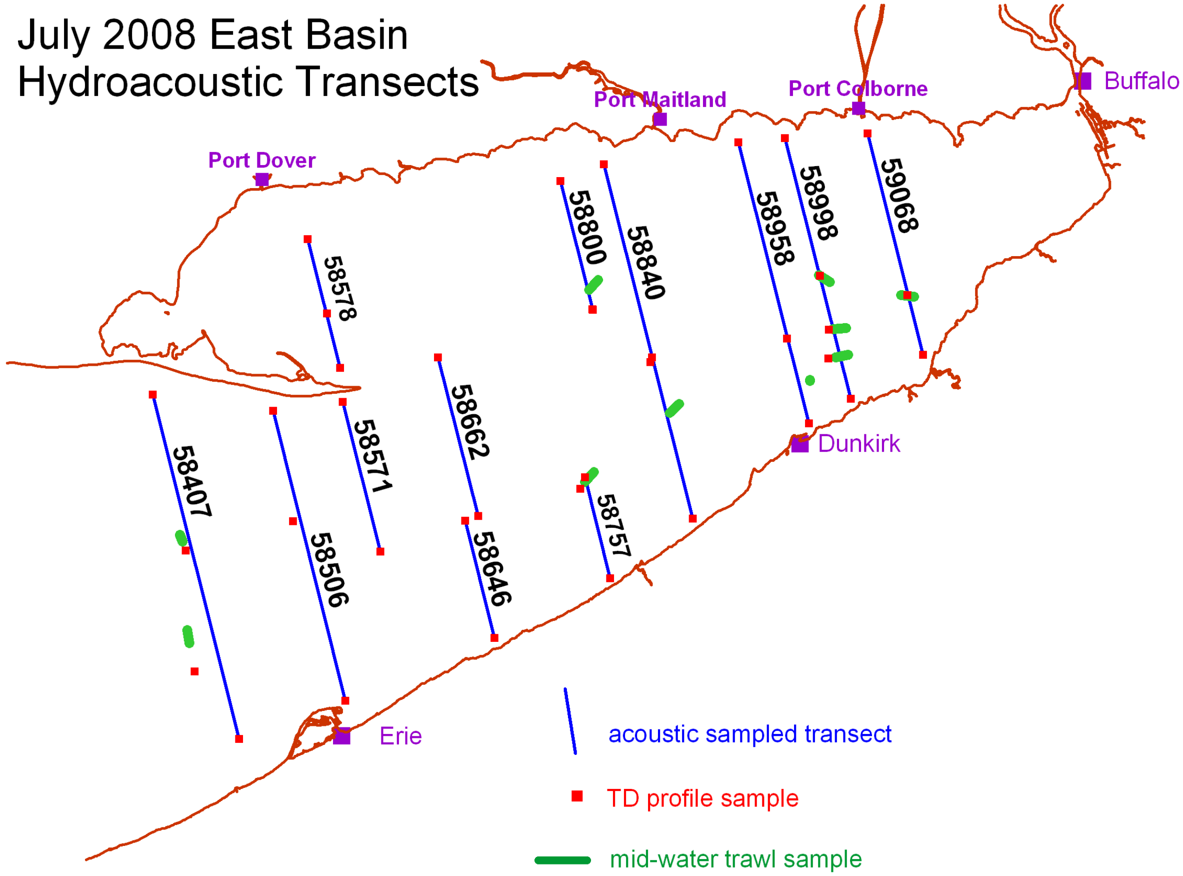

Figure 4.1.1. July 2008 eastern basin Lake Erie inter-agency acoustic survey transects, mid-water trawl and temperature profile sites visited by the Ontario Ministry of Natural Resources (OMNR) research vessel, *RV Erie Explorer* and the New York State Department of Environmental Conservation vessel, *RV Argo*.

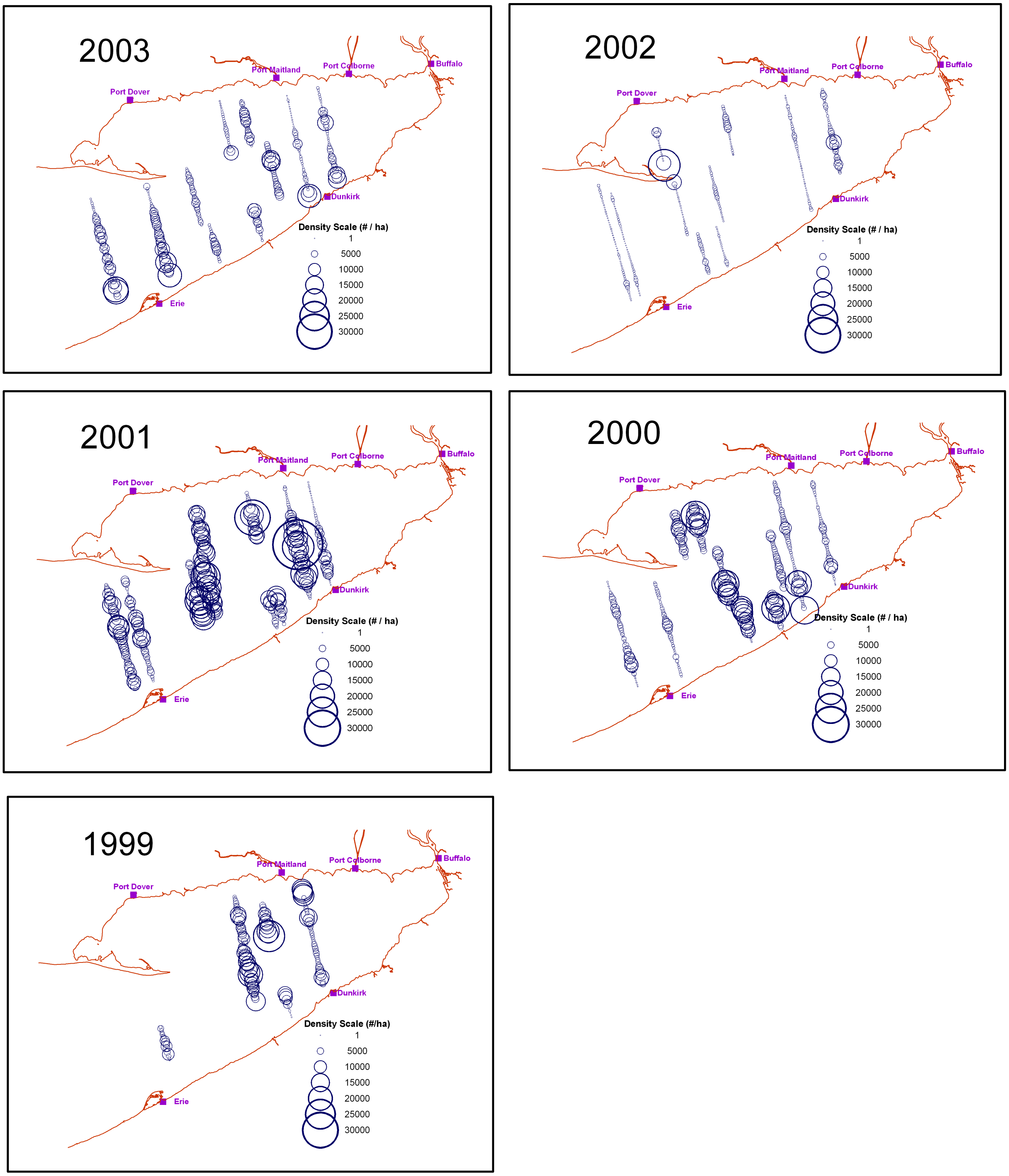

Figure 4.1.2. Relative density (No. fish / ha) of pelagic, adult forage-sized fish per 800-m segment along transects sampled with a 120-kHz split-beam echosounder during July fisheries acoustic surveys in eastern Lake Erie, 1999 to 2003.

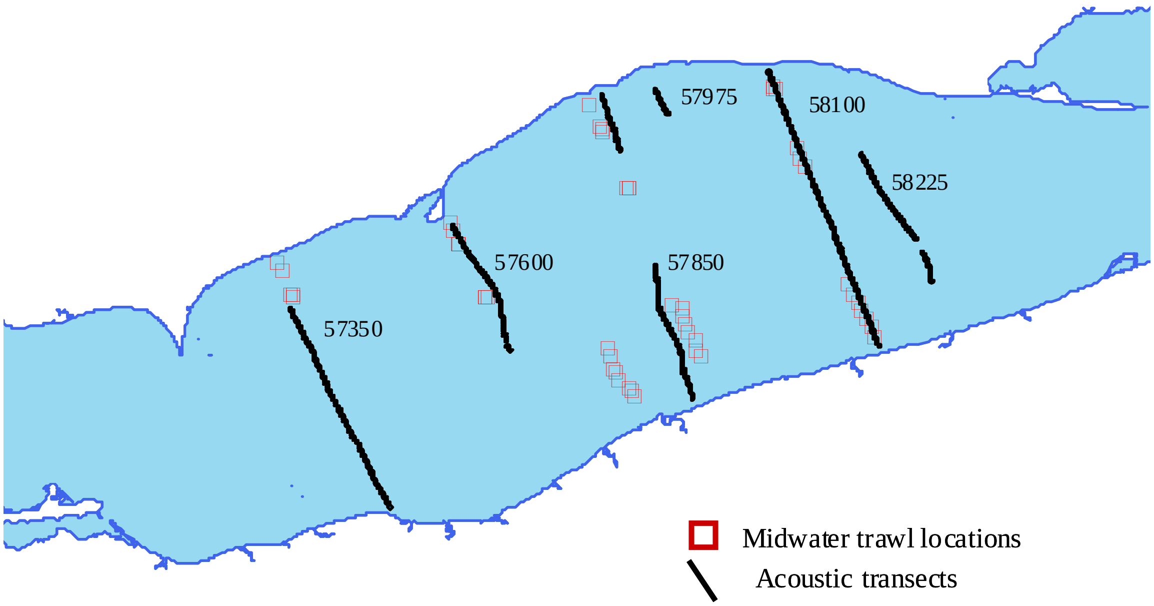

Figure 4.2.1 Acoustic transect lines and midwater trawl locations in the central basin, Lake Erie, 2008. Five digit numbers are transect lines from Loran-C TD lines

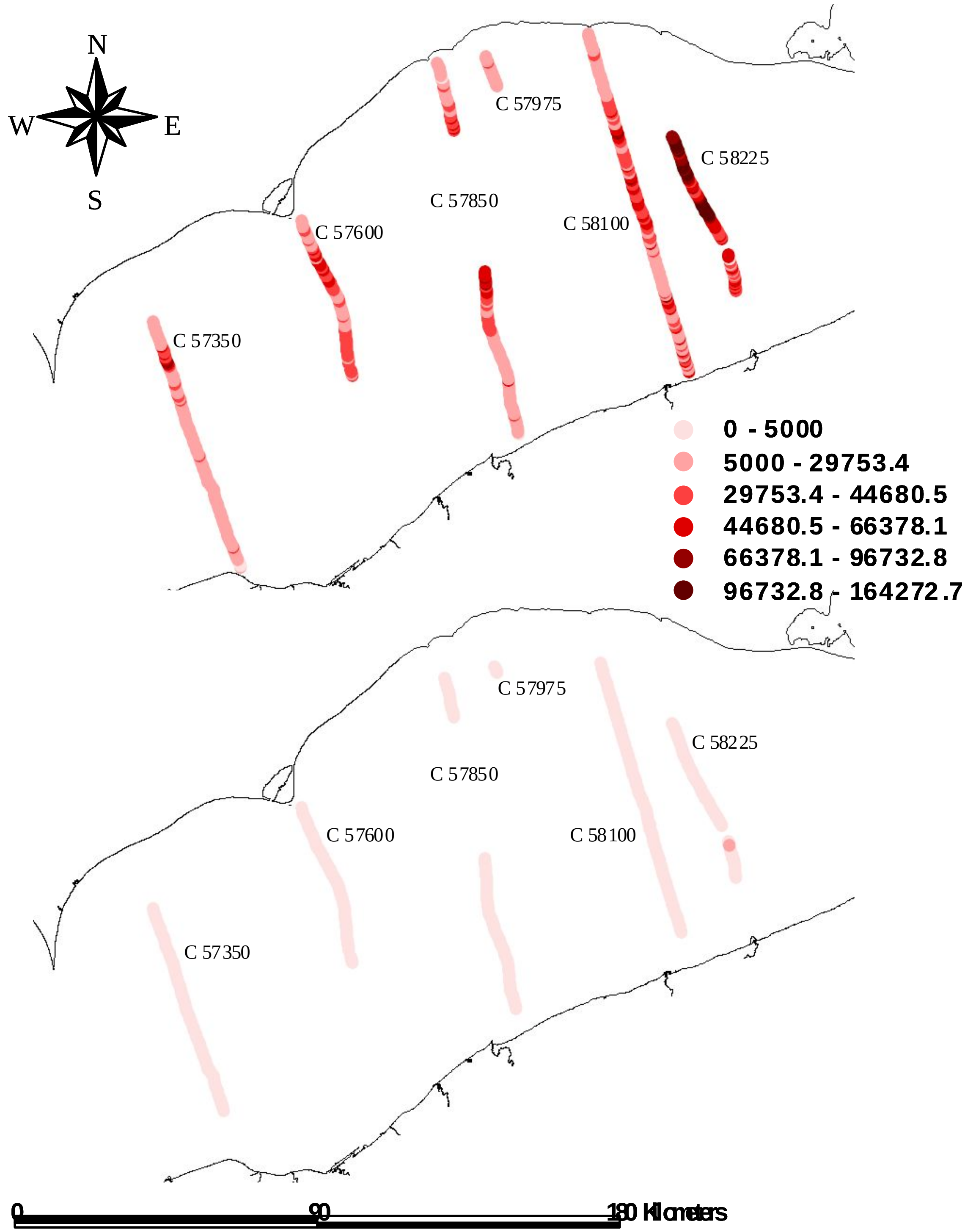

Figure 4.2.2. Graphical representation of fish density in the epilimnion and hypolimnion of the central basin of Lake Erie, 2008. Densities in the legend are fish per hectare. Five-digit C numbers to the right of a transect are the central basin transect number from Loran-C TD lines.

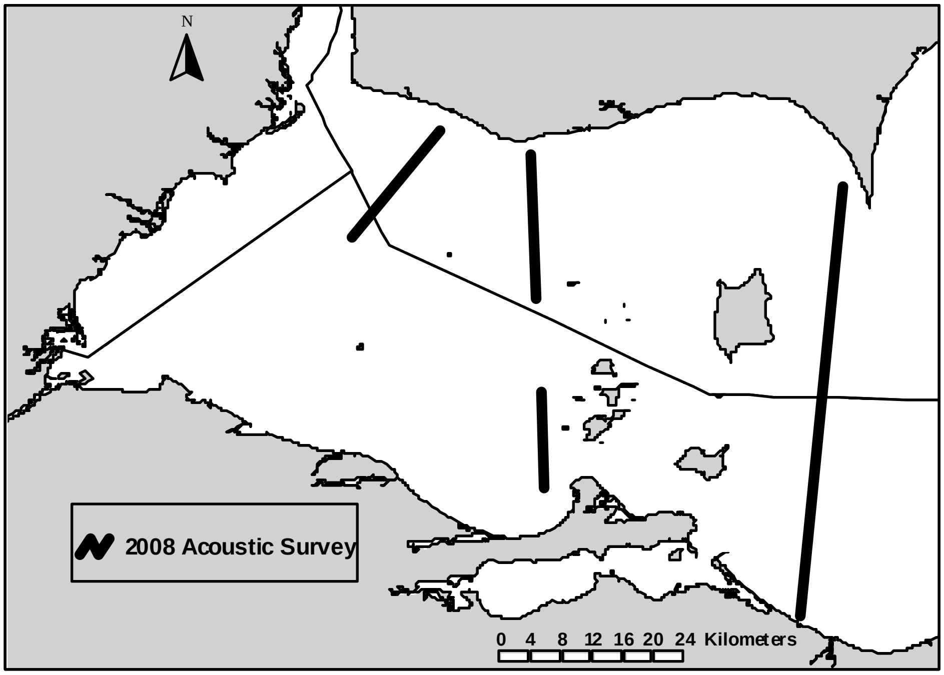

Figure 4.3.1. Three acoustic survey transects for the western basin July 14-18, 2008. Due to equipment malfunctions, only the northern half of Transect 1 (western transect) was completed. A thunderstorm caused the gap in Transect 2 (central transect).

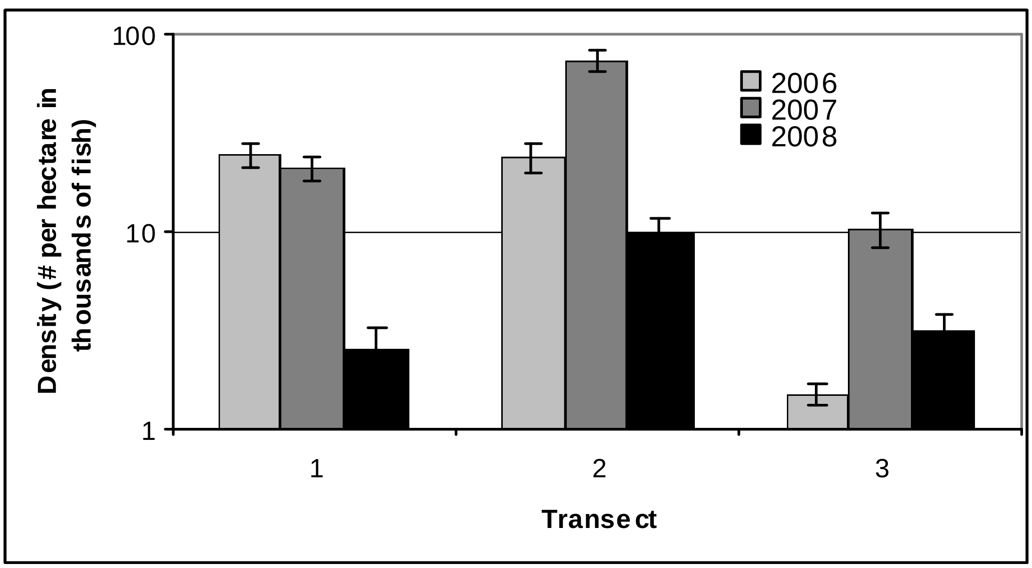

Figure 4.3.2. Estimated mean density (in thousands of fish/hectare) of western basin forage fish from down-viewing hydroacoustic survey data collected July, 2006-2008, along three transects.

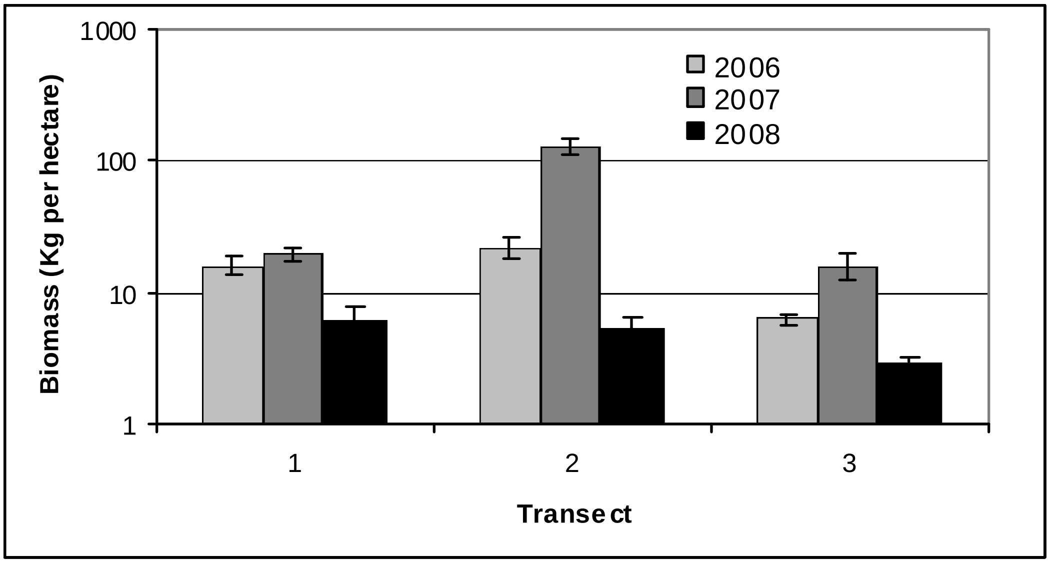

Figure 4.3.3. Estimated mean biomass (kg of fish/hectare) of western basin forage fish from down-viewing hydroacoustic survey data collected July, 2006-2008, along three transects.

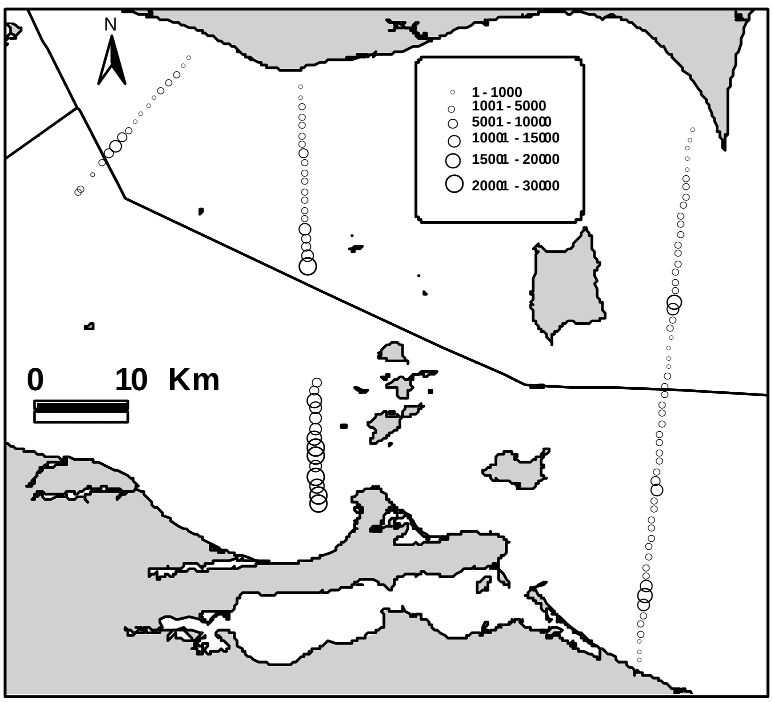

Figure 4.3.4. Spatial distribution of forage fish density from down-viewing hydroacoustic survey data collected July 14-18, 2008.

5.0 Interagency Lower Trophic Level Monitoring Program, 1999-2008

(by B. Trometer)

In 1999, the FTG initiated a Lower Trophic Level Assessment program (LTLA) within Lake Erie and Lake St. Clair (Figure 5.1.1). 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. The year 2008 marks the tenth year of this monitoring program. For this report, we will summarize the last ten years of data for three variables and the last nine years for zooplankton data. These variables are epilimnetic temperature, hypolimnetic or bottom dissolved oxygen, grazing pressure (chlorophyll *a* and total phosphorous) and zooplanktivory index. 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, 6, 7 and 8 from the western basin, stations 9, 10, 11, 12, 13 and 14 from the central basin, and stations 15, 16, 17, 18, 19 and 20 from the eastern basin (Figure 5.1.1).

Epilimnetic Temperature

Mean epilimnetic water temperature represents the average temperature of the water column when not stratified, or the upper warm layer when thermal stratification exists. This index, calculated for offshore stations only, should provide a good index of relative system production and growth rate potential for fishes, assuming prey resources are not limiting. As expected, temperatures were warmest in the western basin and coolest in the eastern basin (Figure 5.1.2). In 2008, the mean epilimnetic temperature was similar to the long term average for all three basins (west 20.0 C, central 18.3 C, and east 16.9 C).

Hypolimnetic Dissolved Oxygen

Figure 5.3 illustrates the mean hypolimnetic dissolved oxygen (DO) concentration (i.e. below the thermocline) for dates when the water column is stratified in each basin of Lake Erie by year. Stratification can begin in early June and continue through September in the central and eastern basins. DO 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. Low oxygen is an issue in the central basin. It happens almost annually at the offshore stations (10, 11 and 13) and inshore station 9. Typically, DO < 4 mg/L was first observed in mid July and persisted until late September when fall turnover remixes the water column. For 2008, data is from stations 11 and 12 only and hypolimnetic DO never went below 4 mg/L. Hypolimnetic DO is rarely limiting in the eastern basin due to greater water depths and cooler temperatures.

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 5.1.4), we see that grazing pressure is 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 2006, observed chlorophyll *a* was slightly higher than predicted in all basins indicating low grazing pressure. In 2007, observed chlorophyll *a* was much higher than predicted in the west basin indicating low grazing pressure and slightly lower than predicted in the central and eastern basins indicating high grazing pressure. In 2008, predicted was higher than observed in all three basins indicating high grazing pressure throughout the lake.

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. In general, zooplankton predation is deemed high in Lake Erie, as the average size of the community is more often less than this critical 0.57 mm size (Figure 5.1.5). In the western basin, mean zooplankton size was below 0.57 mm except in 2005 and 2006 indicating lower zooplanktivory in those two years. For 2005-2007, there is only data from 2 stations (3 and 4). In 2007, zooplanktivory at stations 3 and 4 was very high. In the central basin, mean zooplankton size has been 0.57mm or lower indicating high zooplanktivory from 1999-2004. We do not have the data from central basin stations for 2005 through 2007. In the eastern basin, zooplankton size was 0.57mm or lower for all but 2 years, indicating high zooplanktivory except in 2003 and 2006.

Distribution of New Zooplankters

For this review only data from stations 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18, 19, and 20 are 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 0.01 to 549/m^3 and were highest in 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, *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 and 9 in 2004. Data is not available for these stations from 2005 through 2007. In 2007 it was found at station 18.

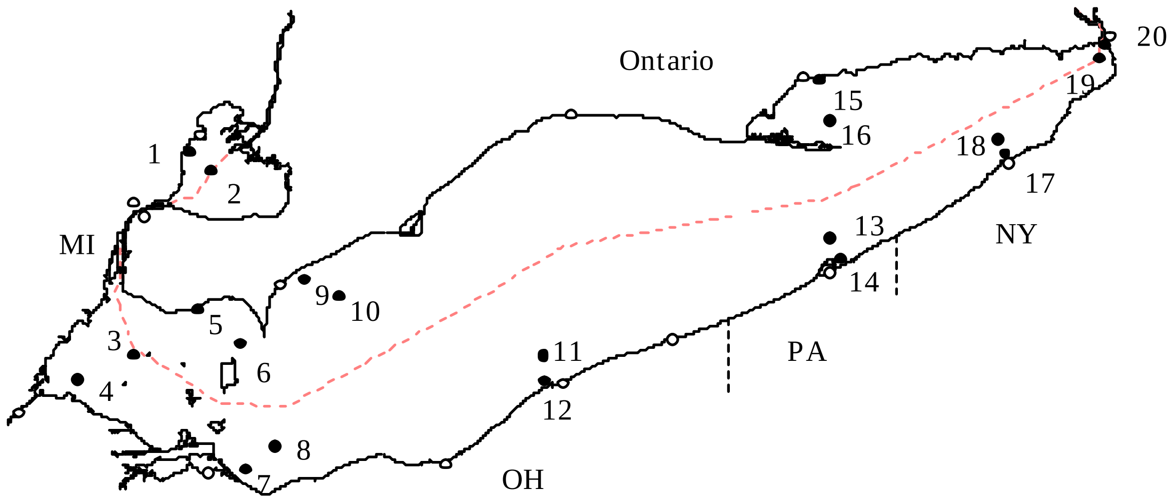

Figure 5.1.1. Lower trophic level sampling stations in Lakes Erie and St. Clair.

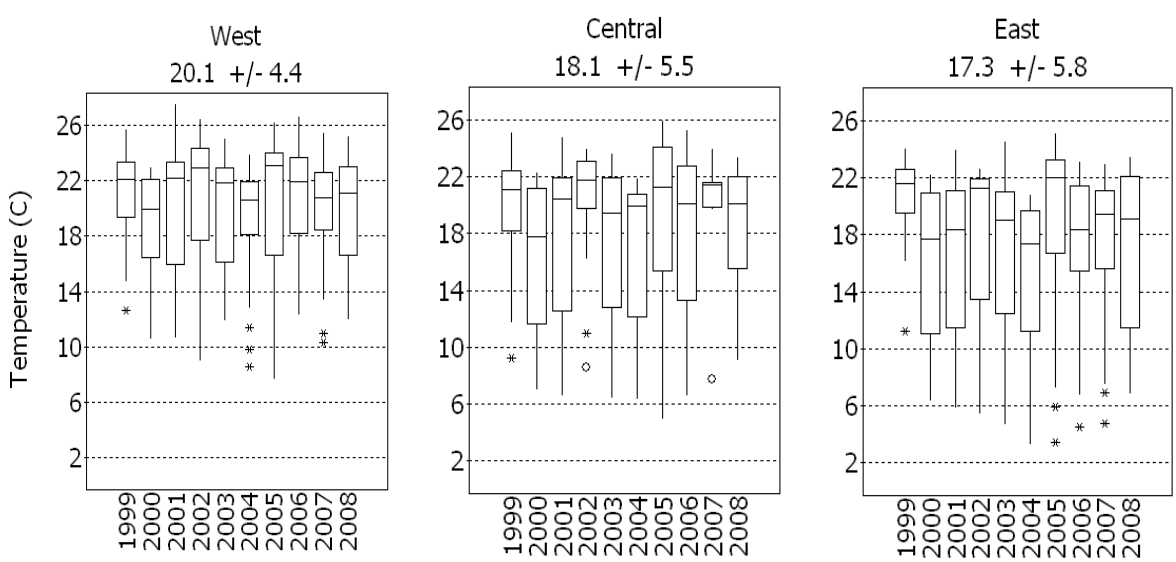

Figure 5.1.2. Epilimnetic water temperature (C) at offshore stations by basin in Lake Erie, May-Sept, 1999-2008. Box plots represent median, 25th, and 75th quartile. Long-term average water temperature is 20.1 C in the western basin, 18.1 C in the central basin and 17.3 C in the eastern basin. For this analysis only data from stations 3, 6, 8, 10, 11, 13, 16, and 18 were included.

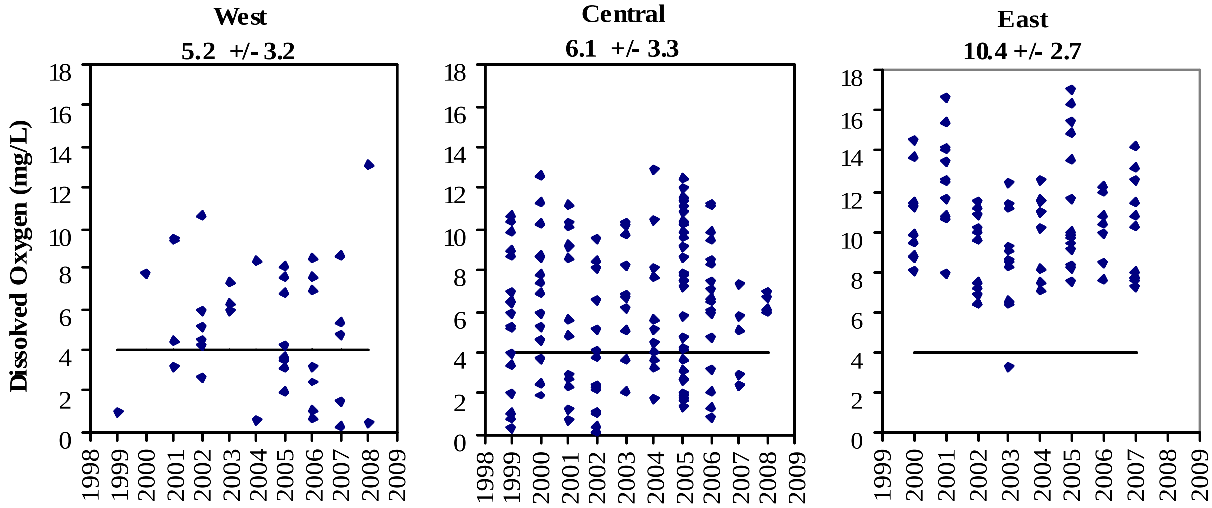

Figure 5.1.3. Mean hypolimnetic dissolved oxygen (mg/L) in each basin of Lake Erie, 1999-2007. Mean is calculated only on dates when the water column was stratified (typically from June to September). The horizontal line represents 4 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. Long-term average hypolimnetic dissolved oxygen is shown above each graph. For this analysis only data from stations 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17 and 18 were included. Stations 7, 14, 19 and 20 rarely stratified.

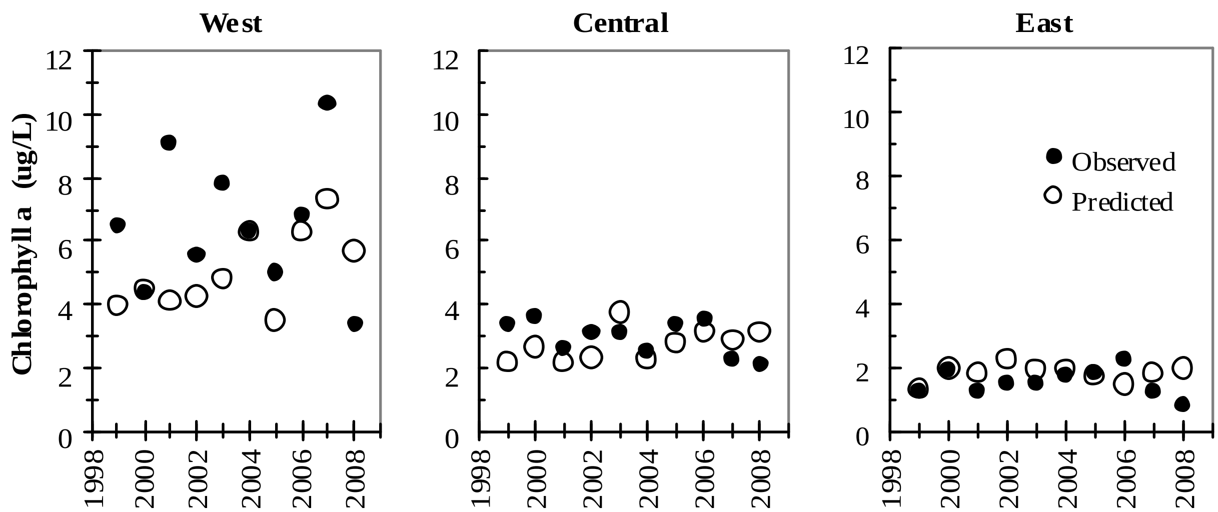

Figure 5.1.4. Observed and predicted chlorophyll *a* concentration (ug/L) in each basin of Lake Erie, 1999-2008. Chlorophyll *a* is predicted from equations presented in Mazumder 1994 for even-linked systems (those where grazing limits phytoplankton standing crop). For this analysis data from stations 3 through 20 were included.

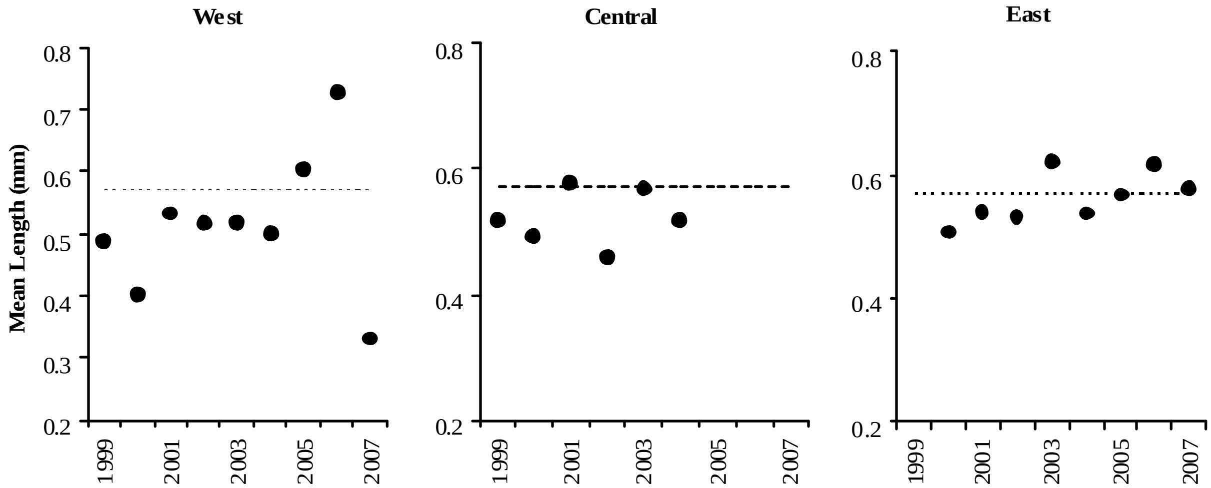

Figure 5.1.5. Mean length of the zooplankton community sampled with a 63µm plankton net hauled through the epilimnion of each basin of Lake Erie, 1999-2007. The horizontal dashed line depicts 0.57 mm; if the mean size of the zooplankton community is 0.57mm or less, predation by fish is considered to be intense (Mills et al. 1987, Johannsson et al. 1999). For this analysis only data from stations 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18, 19, and 20 were included.

6.0 Status of Bioenergetics Model of Predator Consumption

(J. Markham)

Since 2001, members of the Coldwater Task Group (CWTG) have been addressing some of the data limitations that were preventing annual consumption estimates of key coldwater predators. Recent gains in data were reported in the 2008 FTG report (Forage Task Group 2008). The progress included completion of the lake trout model and updated information on burbot and steelhead populations which will be incorporated into the model. We continue to collect information on steelhead diets and remain active in the Great Lakes Mass Marking Initiative (GLMMI). The data gathered through the GLMMI would allow us to develop a much more comprehensive model that would provide more meaningful results for a bioenergetics exercise. We will continue to work with the CWTG to fill gaps in the model.

7.0 Lakewide Round Goby Distribution (by B. Haas)

Round goby (*Apollonia 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). In 2008, round goby abundance indices have generally decreased from 2007. The only notable increase in goby abundance occurred in the west-central basin, near the Huron River in Ohio. 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.

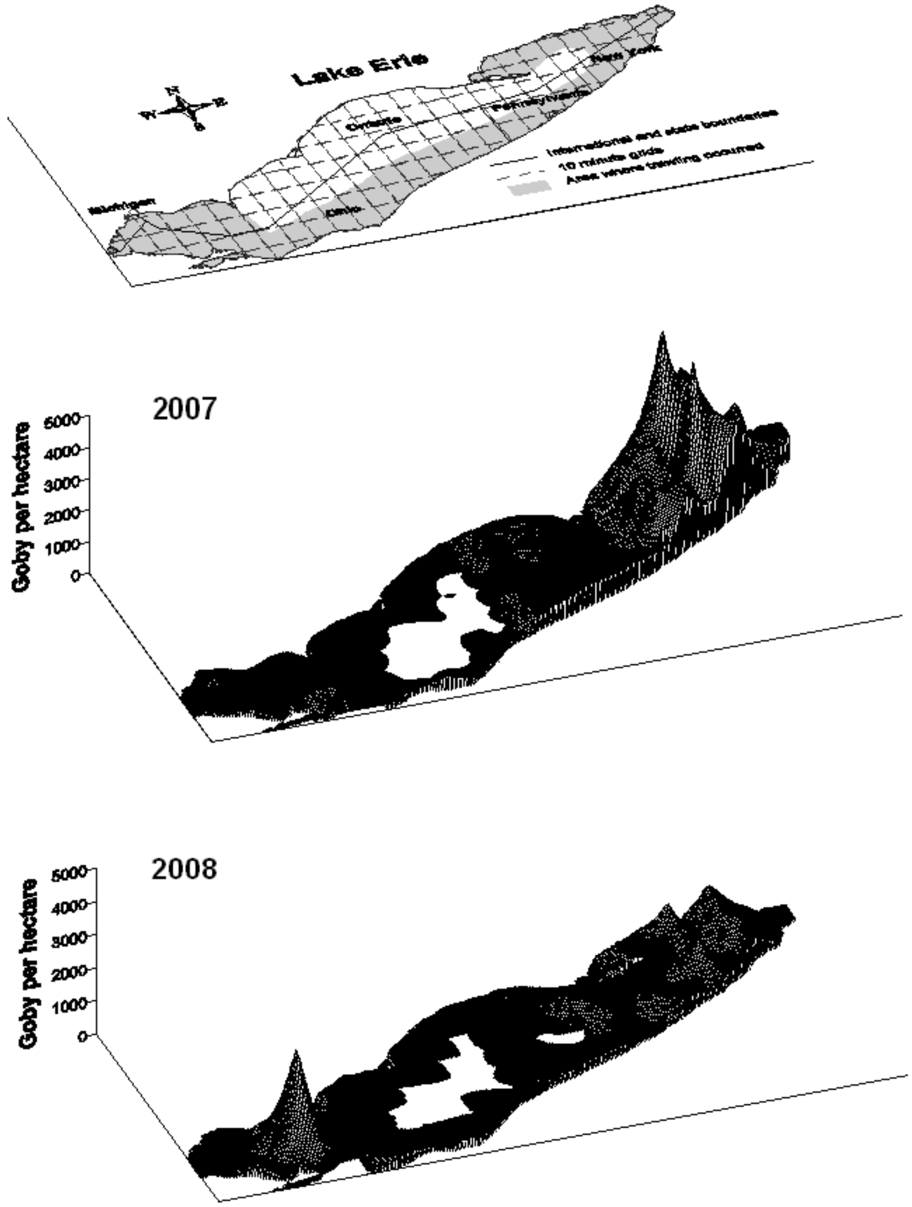

Figure 6.0.1 Two dimensional base map (upper) and three dimensional maps of round goby distribution in Lake Erie as density per hectare 2007 and 2008 estimated from bottom trawl catches. The base map shows state and provincial boundaries, the ten minute grid system used for trawl data summarization, and the area of the lake sampled with bottom trawls (shaded gray). The goby distribution maps were extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm.

8.0 *Hemimysis anomala* Distribution (by T. MacDougal, J. Markham, 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 ocean-going 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 this species is established and broadly distributed within the Great Lakes (NOAA- GLERL; Hemimysis fact sheet, February 2007).

In Lake Erie, *H. anomala* was first observed as a portion of the stomach contents of one white perch captured along the north shore of the eastern basin in August 2006 (Figure 8.0.1). In 2007, it was again present in both white perch (3 fish) and rock bass (1 fish) taken from the same area. Additionally, diet analysis of fish from the waters of Lake Erie's Ohio shoreline revealed the bloody red shrimp in the stomachs of five yellow perch in 2007. In 2008, diet analysis again revealed *Hemimysis* in white perch (2 fish) and rock bass (1 fish) from the eastern basin north shore, however none were found in fish from Ohio waters. The full range of use of this exotic by Lake Erie fish is not known as current collections for diet analysis have not been specifically designed to target all species and life stages that might utilize *Hemimysis*. Despite this, its absence in some diets may be notable. No mysids were found in stomachs from yellow perch taken from the eastern basin in 2006, 2007 or 2008 despite the fact that many more (order of magnitude) yellow perch were examined. *Hemimysis* were only found in yellow perch in Ohio waters in one year despite also examining the diets of white bass, smallmouth bass, whitefish.

Outside of fish diets, *H. anomala* can be difficult to locate because the species is nocturnal, preferring to hide in rocky cracks and crevices 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 individual was detected in waters associated with the NRG Steam Station in Dunkirk, NY and underwater video of the lakebed near Nantioke Shoal, Ontario revealed multiple swarms of what appear to be *H. anomala* in deepwater (~40m) 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 50-62 feet. Targeted sampling for *H. anomala*, conducted by the Canadian Department of Fisheries and Oceans (GLLFAS), along the north shore during 2007 and 2008, regularly found *Hemimysis* in large numbers in all three lake basins (K. Bowen, Dept. of Fisheries and Oceans, GLLFAS, pers comm.). There is no doubt that the species is now well established in Lake Erie.

The impact of this species on the Great Lakes is unknown, but based on its previous history, 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. It has the ability to reduce zooplankton biomass were 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. 2006). The Forage Task Group will continue to monitor and document the progression of this species and its impact on the Lake Erie ecosystem.

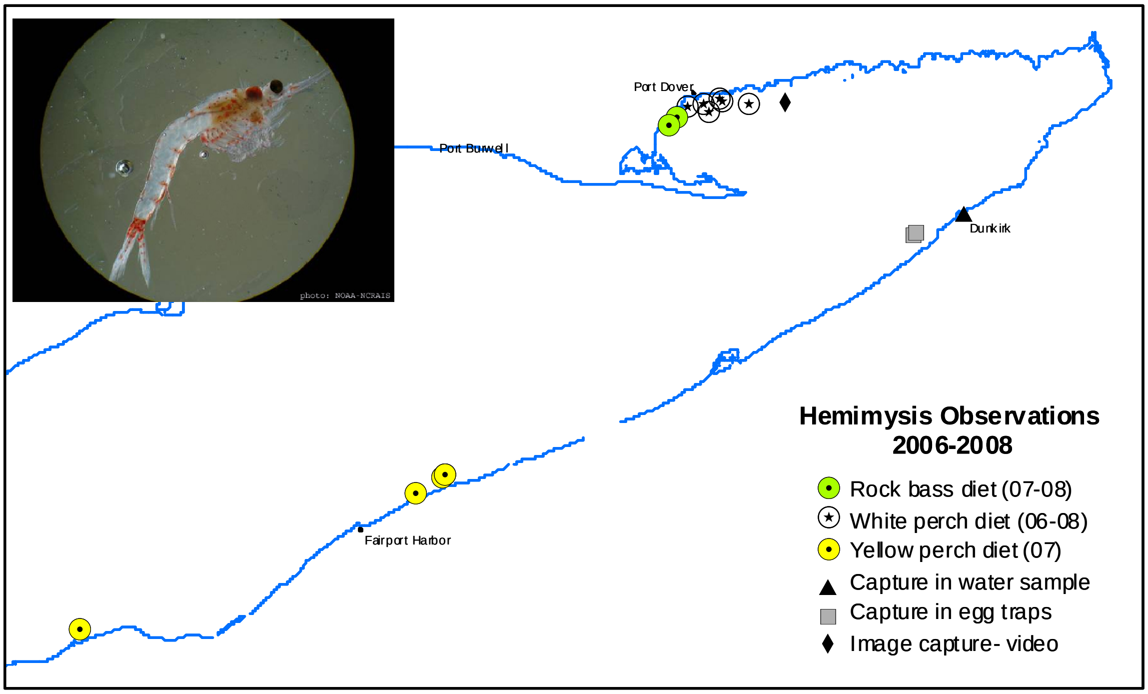

Figure 8.0.1 Locations of *Hemimysis anomala* in Lake Erie, by type of observation 2006-2008

9.0 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.

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