Report of the Lake Erie Forage Task Group

March 2007

Members:

Chuck Murray	- Pennsylvania Fish and Boat Commission, (PFBC) {Co-chair}
Jim Francis	- Michigan Department Natural Resources, (MDNR) {Co-chair}
Mike Bur	- United States Geological Service - Biological Resources Division (USGS)
John Deller	- Ohio Department of Natural Resources, (ODNR)
Don Einhouse	- New York Department of Environmental Conservation, (NYS DEC)
Tim Johnson	- Ontario Ministry of Natural Resources, (OMNR)
Jim Markham	- New York Department of Environmental Conservation, (NYS DEC)
Tom MacDougall	- Ontario Ministry of Natural Resources, (OMNR)
Elizabeth Trometer	- United States Fish and Wildlife Service, (USFWS)
Eric Weimer	- Ohio Department of Natural Resources, (ODNR)
Larry Witzel	- Ontario Ministry of Natural Resources, (OMNR)

Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

Table of Contents

1.0 Charges to the Forage Task Group in 2006-2007

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 and central Lake Erie, incorporating new methods in survey design and analysis as necessary to refine these programs. Promote the development of an acoustic survey for western Lake Erie.

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 2007 Forage Status and Trends

General Patterns

- Age-0 smelt abundance increased in central and west basins
- Emerald shiner age-0 abundance increased to near record levels lake wide
- Increasing occurrence of emerald shiners in walleye diets in east basin, clupeids and shiners were primary diet items in central and west basins; round goby are major component in burbot, smallmouth bass and Klondike strain lake trout diets
- Predator growth tended to be at long term average

Eastern Basin

- Record high density of emerald shiner was a major contributor to above average forage fish abundance in 2006
- 2006 year class of rainbow smelt was moderately strong in Ontario and moderately weak in New York; yearling-and-older (YAO) smelt was below long-term average abundance, but was comprised of more and older age classes than in past years
- Age-0 alewife, gizzard shad and white perch increased
- Spottail shiner decreased in most areas as did trout perch in the southern half of the basin where they are most common
- Round goby increased in offshore areas and decreased in some nearshore areas
- Age-0 and age-1 smelt increased to above average length
- Predator diets were diverse, dominated by fish species, primarily round gobies, rainbow smelt, and emerald shiner
- Predator growth remains good; age-2 to age-6 smallmouth bass were above average size in Long Pt. Bay; as were age-2 and age-3 bass in New York waters
- Lengths for Juvenile (age-1 and age-2) walleye were near the long-term average (NYS DEC)
- Lake trout size-at-age remain stable; among the highest in the Great Lakes

Central Basin

- Overall decrease in age-0 forage abundance from 2005 due to an extreme fluctuation in white perch age-0 index
- Basin wide increases in age-0 rainbow smelt, emerald shiner and gizzard shad indices from 2005
- Overall decrease in YAO forage abundance for the second year in a row; YAO forage indices below a ten-year mean
- Round goby age-0 and YAO declined from 2005
- No long term trends in growth of forage species, only YAO smelt have increased in size since 2004
- Predator diets dominated by gizzard shad, emerald shiners and round goby

West Basin

- Age-0 clupeid catches down from 2005; both alewife and gizzard shad down well below long-term mean
- Age-0 smelt catches up from 2005; fifth highest in time series
- Age-0 emerald shiner similar to 2005 and third highest in time series; YAO up from 2005 but remains below long-term mean
- Age-0 white perch, age-0 trout-perch, and adult trout-perch down from 2005, but still near long-term mean; round gobies up to second highest in time series
- Yellow perch recruitment up and walleye recruitment down from 2005, both still well below long-term mean; age-0 smallmouth bass above long-term mean
- Predator size-at-age comparable to long term mean
- Fall walleye diets show reliance on gizzard shad and emerald shiners

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

Rainbow smelt have been the principal forage fish species of piscivores in the offshore waters of eastern Lake Erie. In 2006 however, emerald shiner was the most abundant species captured in agency fall index bottom trawl surveys (Table 2.2.1). Agency assessments of rainbow smelt during 2006 were mixed. Young-of-the-year (YOY) rainbow smelt were observed in above average numbers in Ontario and below average numbers in New York. Agency trawl catches indicate YAO smelt abundance significantly increased in Ontario (from 2005), but decreased in New York. Compared to historical patterns, YAO smelt were well below average abundance throughout eastern Lake Erie, but more and older age classes were represented in the 2006 smelt catch than in previous years. Mean length of age-0 (64.9 mm FL) and age-1 (104 mm FL) smelt increased in 2006 with both age classes exceeding their long-term average for Ontario's trawl survey (Figure 2.2.1).

The contribution of non-smelt fish species to the forage fish community of eastern Lake Erie was dominated in 2006 by emerald shiner (Table 2.2.1). Catches of YAO emerald shiner in 2006 were the highest observed during the respective time periods of Ontario's (23 survey years since 1984) and New York's (15 survey years since 1992) trawl surveys. Age-0 emerald shiners also were very abundant, with record high numbers observed in New York waters, and third highest year of abundance in Ontario. Spottail shiner abundance decreased in some regions and was unchanged in other areas, but overall their relative abundance basin wide remained below the long-term average for all of the agency surveys. Age-0 clupeid species appeared to increase (from 2005) in most areas of the East Basin, with catches of YOY alewife reaching record high numbers in one of OMNR's nearshore trawl surveys. Trout-perch were less abundant in southern areas of the east basin where they are most often found and slightly more abundant in the Long Pt. Bay area where density of this species remains comparatively sparse.

Offshore-based east basin trawl surveys indicate the 2006 year class of yellow perch was relatively strong compared to historical levels. The 2006 perch year class was ranked second highest since 1992 by New York's trawl assessment and third highest since 1986 by Ontario's offshore trawl survey. In contrast, Ontario's two nearshore based trawl surveys in Long Point Bay have characterized the 2006 perch year class as very weak.

Round gobies emerged as a new species among the eastern basin forage fish community during the late 90's. 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. By 2004, abundance of round goby peaked in Ontario and New York waters of eastern Lake Erie. Goby densities increased in 2006 from the previous year in offshore areas of the basin, while remaining the same or declining slightly in nearshore areas of Long Pt. Bay (Table 2.2.1).

During 2006, 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. Examination of angler-caught adult walleye found rainbow smelt as the dominant prey of walleye each summer starting in 1993. Beginning in 2001 prey fish other than rainbow smelt made a small, but measurable, contribution to the walleye diet. However, 2006 walleye stomach collections were noteworthy because several other prey fish species contributed measurably to walleye diets. Increased species diversity observed in walleye stomachs, lower smelt abundance, and an especially high abundance of emerald shiners are consistent observations among New York's walleye diet and forage fish trawling program. Round goby remain the largest component of the diet of adult smallmouth bass caught in gill net surveys since 2000. 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 2006. However, the composition of the diet items continues to evolve. Smelt have been the dominant food item in lean-strain lake trout since coldwater surveys began in the early 1980's in Lake Erie, occurring in 85 – 95% of the stomachs. However, round gobies occurred in equal amounts to smelt (53%) in 2006. In Klondike strain lake trout, round gobies were the dominant food item, occurring in 68% of the stomachs compared to 32% for smelt. Burbot diets remained diverse with 9 different fish and invertebrate species found in stomach samples. Round gobies were once again the dominant prey item in burbot, occurring in 63% of the stomachs compared to 19% for smelt. Gobies have been the preferred diet item for burbot for three of the past four years.

Age-2 and age-3 smallmouth bass cohorts sampled in 2006 autumn gill net collections were both more than 20 mm longer than the average for the entire time series and both remained near the longest ever observed in the 26-year time series. Length-at-age trends from New York's juvenile walleye (age-1 and age-2) assessment were very near long term average sizes. Mean lengths-at-age and mean weights-at-age of lake trout remain consistent with the 10-year average (1996 – 2005) 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 decreased from 2005. Forage indices were generally higher in the eastern areas of the basin relative to the west. Only age-0 indices in the eastern portion of the basin were above the ten year mean (Tables 2.3.1 and 2.3.2).

The overall decline in forage abundance was due to age-0 white perch indices that went from record high levels in 2005 to average in the west and well below average in the eastern portions of the basin in 2006. If an average white perch cohort is substituted for the exceptional

2005 cohort, forage abundance is about the same for 2006 as in 2005 in the west and about twice the abundance of 2005 in the east. With this substitution, forage abundance in the west has been stable, but remains below a ten year mean, and the east has increased since 2004 and is above the ten year mean.

Emerald shiner and gizzard shad age-0 indices have increased since 2004, with emerald shiners reaching some of the highest levels in the time series. Rainbow smelt age-0 indices also increased basin wide but were below the ten year mean. Round goby indices continue to oscillate. Age-0 goby indices declined from 2005 to one of the lowest levels in the time series.

Yearling-and-older forage abundance has decreased in each of the last two years. The decrease in 2005 is generally attributed to the poor 2004 cohort. The decrease in 2006 could be attributed to the 2005 age-0 white perch cohort not recruiting to the YAO index as would be expected from a cohort of that size. All other YAO indices declined from 2005. Emerald shiners in the east were the only species that was above the ten year mean. YAO round goby abundance has declined to one of the lowest levels in the time series. In Ohio waters of the central basin, mean size of forage species generally increased from 2005. There were no differences in growth (mean length) from west to east and there are no long term trends. Mean size of YAO smelt has increased for the last two years and is probably due to poor recruitment from the 2005 cohort, shifting the population toward older cohorts.

There were some differences in predator diets in 2006 compared to past surveys. In previous years, smallmouth bass diets have been primarily rainbow smelt in May, and round goby from June through October. In 2006, smallmouth bass diets in May and June were primarily white perch (May 69%; June 58%), further reflecting the high 2005 white perch indices. Round goby were the primary diet item from July through October (July 100%; August 95%; September 78%; October 92%). Walleye diets in previous fall gillnet surveys tended to switch from primarily gizzard shad in the west to emerald shiners in the east. In 2006, walleye diets were consistently dominated by gizzard shad (West 67%; East 71%) in all areas of the central basin, reflecting the increased age-0 gizzard shad indices in both the west and east portions of the basin. White bass diets in the fall gillnet survey continue to be primarily emerald shiners (West 73%; East 57%) in all areas of the basin. In 2005 and again in 2006, rainbow smelt, usually a large component of predator diets, were almost absent from predator diets in the fall, further reflecting the below average rainbow smelt abundance. Round goby continue to be important diet items in yellow perch in May (26%) and October (19%).

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

Western basin recruitment varied in 2006 compared to 2005. Increases were notable for age-0 rainbow smelt (99.5/ ha, fifth highest index since 1987) and round goby (86.8/ha, second highest in time series). Recruitment of age-0 yellow perch improved in 2006, while walleye decreased from 2005 (Figure 2.4.1), although both were still well below long-term means. Both gizzard shad (311.1/ha) and alewife (0.11/ha) indices decreased from 2005 (Figure 2.4.2). Recruitment of emerald shiners remained relatively consistent in 2006. Recruitment of YOY shiners increased in 2006, while yearling-and-older (YAO) shiner production was down relative to 2005 (Figure 2.4.3). Age-0 white bass and white perch CPUE was down in 2006 (137.8/ha and 2567.2/ha, respectively), while age-0 smallmouth bass increased to 4.6/ha, the second highest index in the series. Lengths of age-0 walleye, yellow perch, and white bass showed increases in 2006 relative to 2005, while white perch and smallmouth bass lengths were down slightly.

Walleye diets remained dominated by clupeids (46%) and emerald shiner (34%), despite the relative low abundance of these species in trawls. White perch were present in walleye diets (2%). Yellow perch diets were dominated seasonally by zooplankton (*Daphnia* and *Bythotrephes*) and other invertebrates (*Hexagenia* and *Chironomidae*). Round gobies, emerald shiners, and trout-perch were notable fish components of yellow perch diets.

Water temperatures were cooler in 2006 than in the previous year, with peak surface temperature (27.3°C) recorded on August 21. Spring warming rate (May 1 to May 31) was 0.33°C per day. Seasonally averaged basin wide Secchi depth decreased slightly from 2005, averaging 1.8 m [range 0.3m (early May and early September) to 5.8 m (mid July)]. Western basin bottom dissolved oxygen levels averaged 7.7 mg/l [range 0.1 (August 10) to 10.7 mg/l (May 15)]. 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 2006 and 2005. Indices are reported as arithmetic mean number caught per hectare (NPH) for the age groups young-of-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. and 80's Avg.). Pennsylvania (PA-fa) did not conduct a fall trawl survey in 2006.

	Trawl	YOY					YAO				
Species	**Survey**	**2006**	**2005**	**00's Avg.**	**90's Avg.**	**80's Avg.**	**2006**	**2005**	**00's Avg.**	**90's Avg.**	**80's Avg.**
Smelt	ON-DW	1256.0	0.9	1640.4	485.6	1382.9	136.2	7.6	242.5	404.7	969.0
	NY-Fa	507.9	1259.6	1452.3	1450.9	NA	162.9	395.2	542.0	581.6	NA
	PA-Fa	NA	47.9	153.5	550.8	7058.1	NA	0.0	10.8	378.0	2408.6
Emerald	ON-DW	452.3	645.7	647.4	54.8	20.5	4200.3	139.0	1129.3	46.4	38.1
Shiner	ON-OB	64.8	1.1	100.1	119.4	152.3	318.4	0.1	65.9	49.9	133.5
	NY-Fa	778.5	291.4	248.2	112.4	NA	925.5	151.4	378.3	105.4	NA
	PA-Fa	NA	0.5	206.4	41.0	118.3	NA	52.5	53.4	14.5	45.6
Spottail	ON-OB	12.5	58.7	190.8	696.6	249.0	6.5	3.2	12.5	52.3	21.3
Shiner	ON-IB	0.1	1.0	2.3	111.6	291.3	0.0	0.0	0.5	2.0	9.4
	NY-Fa	0.5	0.5	8.0	19.9	NA	4.1	4.3	8.2	4.0	NA
	PA-Fa	NA	0.0	0.0	4.0	2.0	NA	0.0	0.1	7.9	12.4
Alewife	ON-DW	78.6	0.1	31.6	234.1	21.4	NA	NA	NA	NA	NA
	ON-OB	459.4	11.0	73.3	61.0	51.5	NA	NA	NA	NA	NA
	NY-Fa	30.8	27.7	130.7	52.0	NA	NA	NA	NA	NA	NA
	PA-Fa	NA	0.0	0.5	7.7	16.6	NA	NA	NA	NA	NA
Gizzard	ON-DW	1.4	1.7	13.1	7.5	15.3	NA	NA	NA	NA	NA
Shad	ON-OB	19.0	1.9	5.9	9.6	24.1	NA	NA	NA	NA	NA
	NY-Fa	14.1	3.7	13.1	4.2	NA	NA	NA	NA	NA	NA
	PA-Fa	NA	0.0	0.1	0.9	74.3	NA	NA	NA	NA	NA
White	ON-DW	0.9	0.1	3.3	2.2	5.6	NA	NA	NA	NA	NA
Perch	ON-OB	0.8	0.4	2.8	14.2	28.7	NA	NA	NA	NA	NA
	NY-Fa	91.9	99.8	42.7	29.4	NA	NA	NA	NA	NA	NA
	PA-Fa	NA	51.2	210.0	101.1	NA	NA	NA	NA	NA	NA
Trout [a]	ON-DW	0.1	0.0	0.0	0.1	0.5	1.1	0.0	0.8	0.5	1.9
Perch	NY-Fa	519.4	1317.3	881.9	410.0	NA	NA	NA	NA	NA	NA
	PA-Fa	NA	27.4	55.0	23.2	NA	NA	171.2	53.8	26.0	NA
Round [a]	ON-DW	93.3	66.9	127.1	0.2	0.0	NA	NA	NA	NA	NA
Goby	ON-OB	20.8	28.0	61.6	0.6	0.0	NA	NA	NA	NA	NA
	ON-IB	21.4	21.0	45.2	0.0	0.0	NA	NA	NA	NA	NA
	NY-Fa	626.9	438.4	410.6	1.0	0.0	219.6	268.5	197.2	0.0	0.0
	PA-Fa	NA	497.7	818.3	30.3	0.0	NA	390.2	351.0	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 NYS DEC (NY-) trawl indices for trout perch reported as "all ages" under the heading for YOY.

Ontario Ministry of Natural Resources

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; 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1999.

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; 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1998

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; 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1999.

New York State Department of Environmental Conservation Trawl Survey

NY-Fa — Trawling is conducted at 30 nearshore (15-28 m) stations during October using a 10-m trawl with a 9.5-mm mesh cod end liner. Indices are reported as NPH; 90s Avg. is for the period from 1992-1999.

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.

Table 2.3.1 Relative abundance (arithmetic mean number per hectare) of selected young-of-the-year species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 1996-2006

	year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	mean
Yellow perch	OH MU2	119.1	12.3	69.8	73.6	21.9	114.6	6.0	149.0	8.7	37.7	10.0	56.6
	OH MU3	128.4	2.6	38.1	21.0	1.3	13.6	2.5	47.5	1.9	156.2	18.9	39.2
	PA MU3	354.1	0.0	13.7	7.2	15.7	388.4	11.9	788.0	2.4	6.7	-	158.8
White perch	OH MU2	223.8	267.5	91.9	334.1	581.3	779.7	293.0	310.1	759.7	1002.5	440.4	462.2
	OH MU3	539.9	2.3	52.3	37.1	4.9	57.6	5.9	61.8	108.0	2034.5	46.1	268.1
	PA MU3	331.5	0.0	0.0	8.5	75.9	26.6	80.7	173.8	2.4	42.3	-	74.2
Rainbow	OH MU2	421.2	238.2	253.3	70.8	150.1	2.3	274.7	1753.9	352.1	10.7	94.3	329.2
smelt	OH MU3	2944.5	477.2	953.8	282.4	1070.3	0.0	218.1	2914.1	388.9	44.4	570.7	896.1
	PA MU3	5,422.1	10.3	29.9	1.8	15.3	377.4	152.9	177.6	20.9	15.9	-	622.4
Round goby	OH MU2	8.0	49.7	130.1	95.1	21.7	43.9	37.8	22.6	13.9	37.2	19.0	43.5
	OH MU3	44.5	106.4	186.7	178.2	158.2	39.6	64.7	57.5	173.9	148.1	46.3	109.5
	PA MU3	0.4	1.5	743.6	1,114.4	781.1	1,577.8	289.3	75.3	1,011.3	204.0	-	579.9
Emerald	OH MU2	15.6	160.7	4928.5	408.4	127.2	50.5	39.4	477.6	7.0	567.1	587.2	669.9
shiner	OH MU3	77.0	4.9	150.5	599.4	500.6	2.2	0.5	903.1	0.8	279.8	1115.1	330.4
	PA MU3	3.5	0.0	5.8	0.0	0.0	8.5	38.1	81.8	0.0	17.8	-	15.6
Spottail	OH MU2	13.8	14.6	1.4	5.6	0.4	5.9	1.6	0.0	0.0	0.2	0.0	4.0
shiner	OH MU3	24.9	0.1	2.7	3.9	0.0	0.7	0.2	0.5	0.0	1.1	0.2	3.1
	PA MU3	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1
Alewife	OH MU2	12.7	9.3	10.0	37.2	62.1	50.8	59.7	0.1	0.0	0.0	4.4	22.4
	OH MU3	6.3	14.1	0.1	9.2	12.4	0.0	1.1	0.0	0.0	0.0	3.6	4.3
	PA MU3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	-	0.0
Gizzard	OH MU2	77.1	12.4	33.8	104.3	117.1	60.3	24.6	402.6	0.6	12.3	32.7	79.8
shad	OH MU3	181.5	7.2	34.8	17.0	27.6	1.8	12.3	20.4	0.3	15.7	30.7	31.7
	PA MU3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	-	0.1
Trout-perch	OH MU2	1.2	0.0	0.3	5.5	1.0	2.0	1.4	2.0	20.3	0.1	0.1	3.1
	OH MU3	35.4	2.6	1.3	4.8	0.4	0.0	0.3	1.4	1.4	1.6	0.1	4.5
	PA MU3	7.1	0.0	23.1	10.0	23.0	7.8	45.6	78.0	6.7	0.3	-	20.2

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

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 1996-2006.

	year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	mean
Yellow perch	OH MU2	11.2	110.2	6.3	40.7	61.6	5.7	51.7	3.2	216.5	18.4	4.2	48.2
	OH MU3	3.9	34.0	3.7	40.0	19.3	0.4	38.3	1.2	45.2	132.3	12.5	30.1
	PA MU3	12.4	14.7	2.5	7.9	3.9	41.3	37.5	75.6	18.3	1.9	-	21.6
White perch	OH MU2	22.1	44.5	5.6	35.2	91.1	21.7	91.5	28.2	83.9	34.1	32.4	44.6
	OH MU3	4.3	37.1	0.2	14.6	38.6	0.4	176.2	12.0	27.0	20.1	38.5	33.6
	PA MU3	1.8	0.0	0.0	1.9	0.6	2.4	38.5	28.6	6.2	0.0	-	8.0
Rainbow	OH MU2	90.9	322.6	71.0	146.2	65.6	55.6	45.3	29.4	320.5	89.8	8.9	113.3
smelt	OH MU3	136.2	380.6	58.2	2115.1	150.3	3.3	320.9	370.3	1360.2	30.8	17.3	449.4
	PA MU3	29.9	26.5	1.3	0.0	75.8	0.0	6.2	22.1	9.9	2.6	-	17.4
Round	OH MU2	138.8	171.0	164.9	82.5	27.5	54.8	39.2	25.4	27.0	33.6	20.4	71.4
Goby	OH MU3	76.0	313.4	118.6	106.7	164.5	88.4	54.3	127.1	148.8	263.0	78.9	140.0
	PA MU3	0.0	0.0	113.1	55.3	126.5	55.2	238.3	59.1	767.0	206.7	-	162.1
Emerald	OH MU2	9.1	226.0	1862.1	515.8	109.2	106.3	233.9	54.9	1.5	233.6	162.7	319.6
shiner	OH MU3	25.6	2.1	22.8	502.6	830.5	0.7	133.2	432.0	0.4	479.6	451.1	261.9
	PA MU3	0.0	7.4	0.0	0.0	0.0	0.0	107.4	217.5	0.0	123.0	-	45.5
Spottail	OH MU2	18.0	17.2	28.3	5.8	8.7	3.5	6.6	1.6	5.3	0.3	1.2	8.8
shiner	OH MU3	6.5	1.8	5.0	7.2	8.6	1.1	5.9	1.0	0.2	3.8	0.7	3.8
	PA MU3	0.0	0.0	0.4	0.0	0.0	0.0	2.2	0.0	0.0	0.0	-	0.3
Alewife	OH MU2	0.0	0.0	0.0	0.0	0.6	0.0	2.9	0.0	0.0	0.0	0.0	0.3
	OH MU3	0.0	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.1
	PA MU3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.5	0.0	0.0	-	0.2
Shad	OH MU2	0.0	0.1	0.2	0.9	4.3	0.1	1.6	0.0	0.1	0.5	0.2	0.7
	OH MU3	0.1	0.1	0.1	0.3	1.2	0.0	1.7	3.0	0.2	0.2	0.1	0.6
	PA MU3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
Trout-perch	OH MU2	5.4	16.5	15.1	9.2	17.2	3.2	27.2	12.2	14.0	13.5	3.3	12.4
	OH MU3	22.4	12.8	14.8	9.3	15.3	2.2	8.5	2.9	7.7	76.2	4.8	16.1
	PA MU3	0.0	8.8	1.0	0.9	11.5	0.6	81.2	50.9	5.2	4.1	-	16.4

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

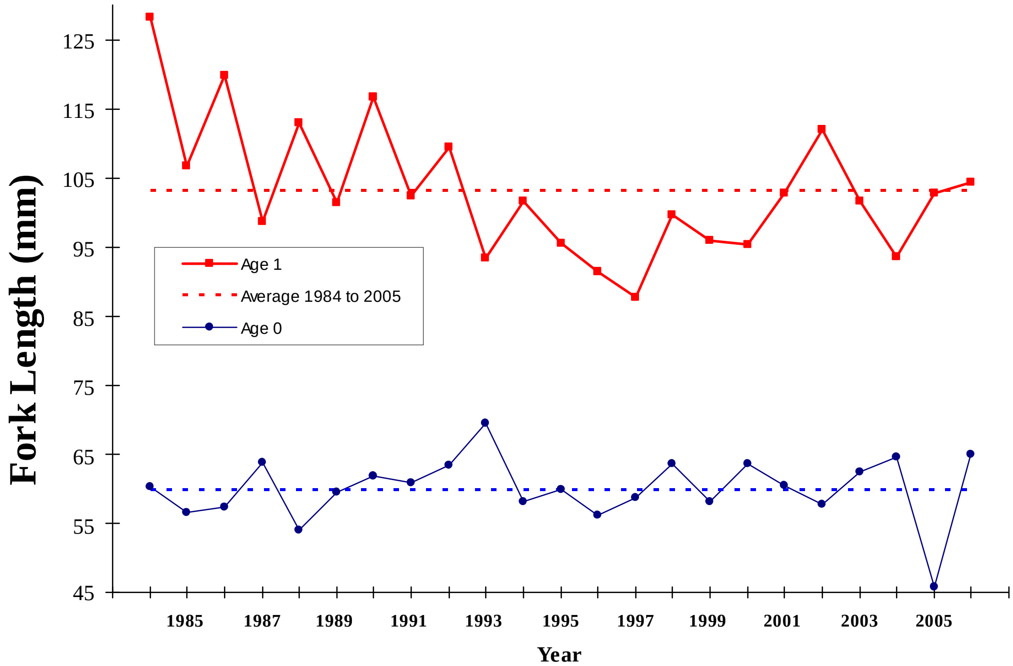

Figure 2.2.1 Mean fork length of age-0 and age-1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984-2006.

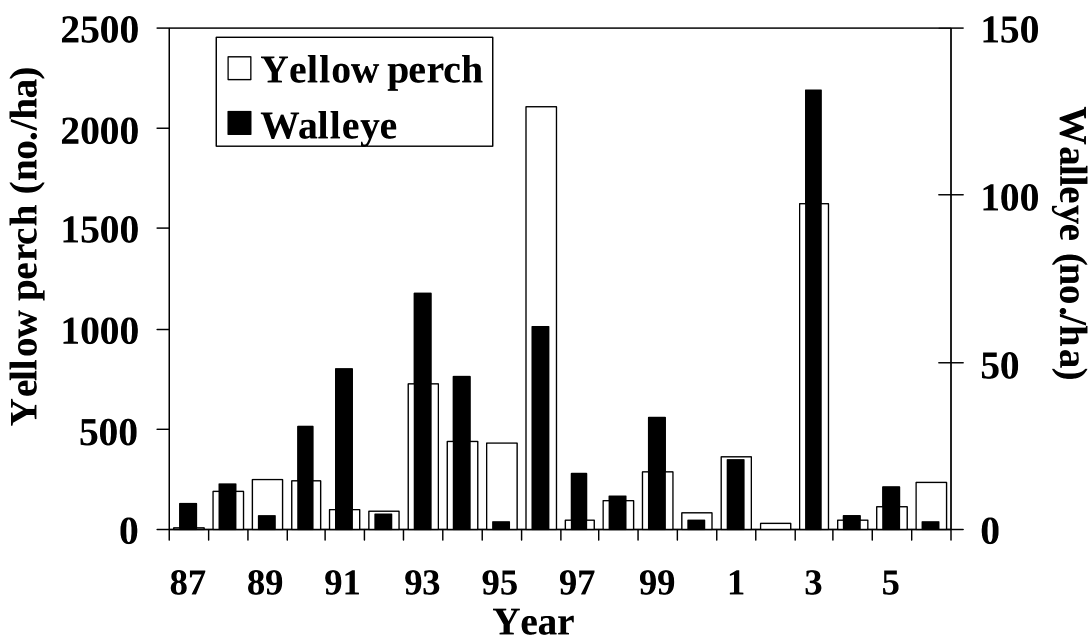

Figure 2.4.1 Density of age-0 yellow perch and walleye in the western basin of Lake Erie, August 1987-2006.

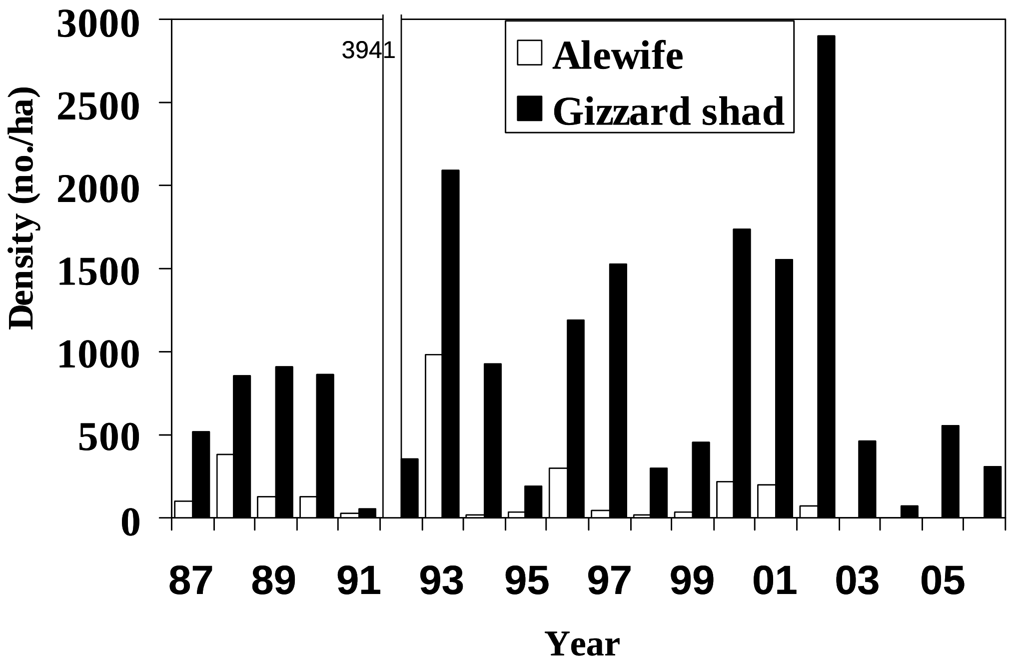

Figure 2.4.2 Density of age-0 alewife and gizzard shad in the western basin of Lake Erie, August 1987-2006.

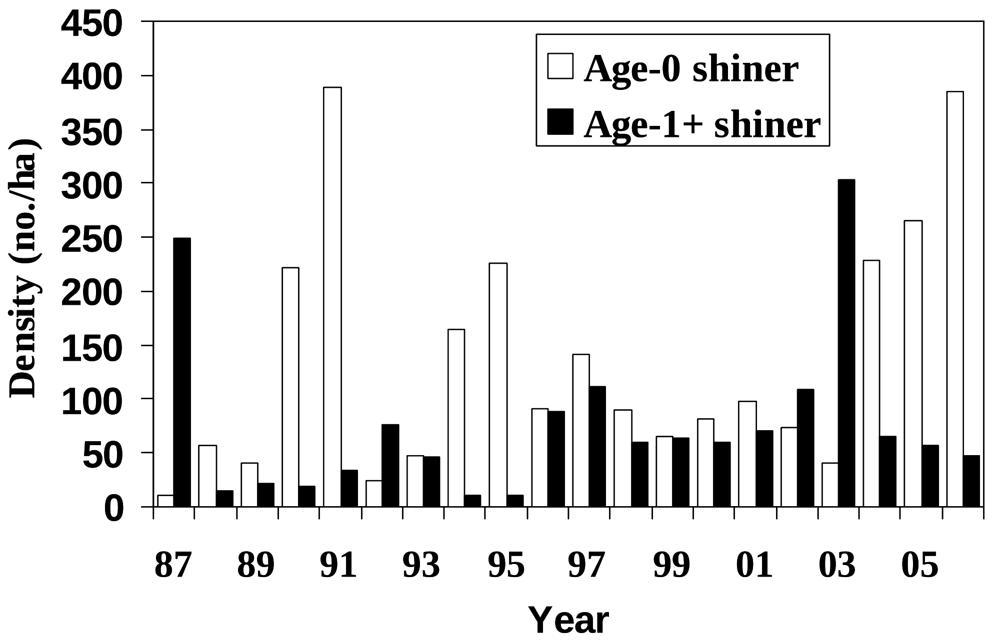

Figure 2.4.3 Density of age-0 and age-1+ shiners (*Notropis* spp.) in the western basin of Lake Erie, August 1987-2006.

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 J. Deller, M. Bur, and D. Einhouse)

The ability to measure trawl dimensions while fishing has been an integral part of trawl standardization exercises conducted by the FTG. Original efforts involved the use of USGS Great Lakes Science Center's Scanmar acoustic mensuration gear. The Scanmar equipment was used to determine actual fishing dimensions of each agency's bottom and mid-water trawls, enabling reliable determination of area and volume swept. These measurements were the basis for the trawl comparison exercise that provided fishing power correction calculations that allow for direct comparison and integration of datasets among agencies (Tyson et al. 2006). However, after 15 years of reliable service, the USGS-GLSC's Scanmar is no longer functional.

In 2001 the FTG started to compile information on current net mensuration systems. The white paper that was compiled identified several manufactures and references for product endorsements that provided very positive feedback on each systems use under field conditions. Current net mensuration systems are designed for commercial marine fisheries, where the trawl equipment is much larger than what is used for agency trawl surveys in Lake Erie. Thus, one question that consistently arises is the possible effect of the relatively large sensor size and weight on the small trawls used in management surveys. Netmind, a net mensuration system identified in the white paper as a possible replacement to the Scanmar system has been available to NYS DEC for use during regular trawl surveys and to USGS for net mensuration purposes. Netmind transducers are considerably larger and heavier than the transducers used by the Scanmar system (Table 3.1.1). Initial trawl dimensions provided by the Netmind system were vastly different from measurements provided by the earlier Scanmar exercises (Table 3.1.2), even though net design has not changed for either agency. If the current measurements are true, not sensor induced, it would decrease the current trawl survey estimates of catch per hectare relative to previous years and require more frequent assessment of net dimensions to maintain the precision of trawl surveys over time.

In 2006 MDNR used the side-scan and BioSonics trawl measurement technique discussed in 2006 Forage Task Group Report, to compare trawl dimensions with and without Netmind sensors. The results of this exercise verified the experience of NYS DEC and USGS in that trawl dimensions did change when Netmind sensors were attached (Table 3.1.2). These results confirm that the presence of Netmind sensors has a measurable effect on the small (7.9-11.6 m) trawls used by each agency for forage abundance and YOY surveys. In each instance, the presence of Netmind sensors caused the wing spread to increase which would result in changing the area swept of each trawl relative to previous survey years. A similar exercise conducted by MDNR found the side-scan and

BioSonics measures of net dimensions were almost identical to the dimensions measured by the Scanmar equipment. Based on the outcome of these exercises, the Forage Task Group is suspending the past request for funding to purchase a shared mensuration system and will further investigate the use of side-scan sonar and hydroacoustics to measure trawl dimensions. This should enable the FTG to maintain the ability to compare and integrate data sets among agencies.

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. 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 70 trawls were used in the analyses in 2006 (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 (see summary below), 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 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, total trawling 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 2006, reaching its lowest level since 2002 (Figure 3.2.2). Total forage biomass decreased as well, reaching its lowest level since 1998 (Figure 3.2.3). Reductions in white perch recruitment in 2006 and associated decrease in the spiny-rayed group was responsible for much of this decrease . Soft-rayed abundance increased slightly in 2006, and biomass decreased by 25% relative to 2005. Clupeid species decreased in abundance by one third the 2005 levels, and biomass responded similarly. Relative biomass of clupeid, soft-rayed, and spiny-rayed species was 12.7%, 10.5%, and 76.8%, and was different than the respective historic averages of 35.8%, 7.7%, and 56.5% (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 decreased biomass of clupeid and soft-rayed fish may struggle to satisfy predatory demand in Lake Erie.

Mean length of age-0 fishes in 2006 varied when compared to 2005 (Figure 3.2.4). Length of age-0 for select species include: walleye (164 mm), yellow perch (72 mm), white bass (72 mm), white perch (59 mm), and smallmouth bass (81 mm). Long-term averages for the same species are: walleye (137 mm), yellow perch (66 mm), smallmouth bass (80 mm), white bass (67 mm), and white perch (57 mm). Increases in age-0 walleye mean length likely reflects lower recruitment in 2006 than in 2005.

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 along the south shore, with gizzard shad densities loosely corresponding to the Maumee River plume. Soft-rayed fish (predominantly trout-perch and round gobies) were most abundant in the northwest portion of the basin in the outflow of the Detroit River, a pattern similar to that seen in previous years. Spiny-rayed abundance was distributed across the basin. Relative abundance of the dominant species includes: age-0 white perch (62%), gizzard shad (7%), yellow perch (5%), sand shiner (5%), and emerald shiner (4%). Total forage abundance averaged 3,671 fish/ha across the western basin, decreasing 15% from 2005 to fall slightly below the long-term average (4,648 fish/ha). Clupeid density was 166 fish/ha (average 1,028 fish/ha), soft-rayed fish density was 749 fish/ha (average 482 fish/ha), and spiny-rayed fish density was 2,755 fish/ha (average 3,137 fish/ha).

3.3 Trawl Comparison Exercise (by J. Tyson, T. Johnson, and M. Bur)

The results and analysis of the trawl comparison exercise have been published in the *North American Journal of Fisheries Management.*

Tyson, J. T., T. B. Johnson, C. T. Knight, M. T. Bur. 2006. Intercalibration of Research Survey Vessels on Lake Erie. North American Journal of Fisheries Management 26:559-570.

The FTG expects this charge to continue to provide contributions to the other task groups, especially with respect to recruitment indices. As a result of the improvements in the trawl surveys due to this charge, the FTG hopes to provide a single set of recruitment indices for use by other task groups. This will help to integrate the work of individual task groups and minimize duplication of effort. It should also keep modelers from having to pursue distributed data, allowing for more time to work on modeling issues.

Table 3.1.1 Size and weight of acoustic sensors for Scanmar and Netmind net mensuration gear. Gape = Headrope height measured off the bottom

Main Wing	Scanmar	Netmind
Length (mm)	273	400
Diameter (mm)	89	115
Weight (kg)	3.1	9.0
Secondary Wing		
Length (mm)	273	330
Diameter (mm)	92	115
Weight (kg)	2.8	7.0
Depth		
Length (mm)	194	330
Diameter (mm)	-	115
Width (mm)	232	-
Height (mm)	105	-
Weight (kg)	4.0	7.0
Gape		
Length (mm)	235	400
Diameter (mm)	-	115
Width (mm)	241	-
Height (mm)	105	-
Weight (kg)	6.1	9.0

Table 3.1.2 Trawl measurements from methods using Scanmar, Netmind, side scan sonar and hydroacoustics, and cotton twine.
Wing Spread % change = (Netmind (m) - Scanmar (m))/ Scanmar (m)
Gape = Headrope height measured off the bottom

NYS DEC 11.6 m bottom trawl	gape (m)	wing spread (m)	wing spread % change (m)
Scanmar	1.1	4.3	23.3
Netmind	*	5.3	

USGS 7.9 m bottom trawl	gape (m)	wing spread (m)	wing spread % change (m)
Scanmar	1.0	4.0	47.5
Netmind	*	5.9	
cotton twine [a]	0.9	4.3	

MDNR 11.4 m bottom trawl	gape (m)	wing spread (m)	wing spread % change (m)
Side-scan sonar without Netmind sensors	1.1	10.9	15.2
Side-scan sonar with Netmind sensors	0.8	12.5	

* Netmind sensors not able to measure gape on small experimental trawls

[a] Distance from a center-point of headrope to a center-point of footrope as well as wing spread. Distances were measured with the aid of cotton twine (1 mm in width) stretched from the headrope to the footrope and between trawl doors. Various lengths of twine were attached to the tie point, each time reducing the length of the twine by 5 cm. Ten tows were made with the trawl. Distance was determined when the string parted. The procedure was repeated (for vertical and horizontal) to develop a mean.

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

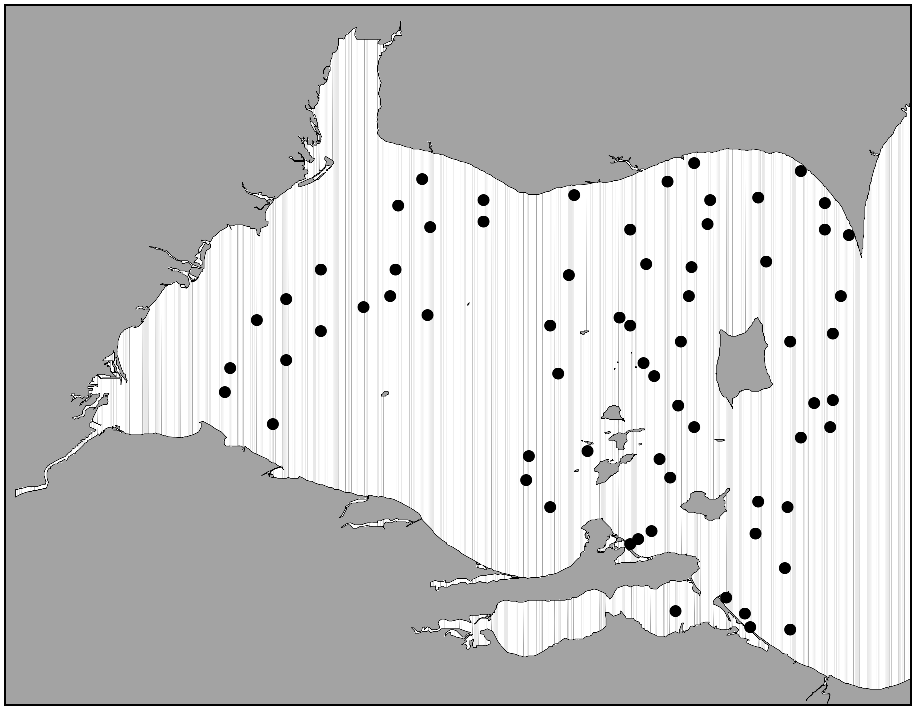

Figure 3.2.1 Trawl locations for the western basin interagency bottom trawl survey, August 2006.

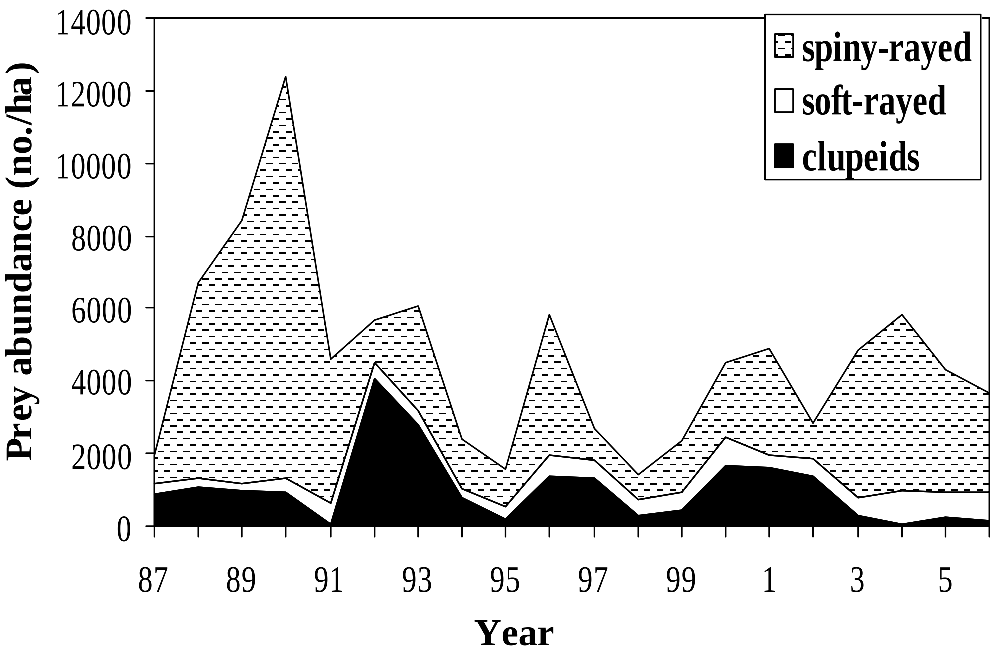

Figure 3.2.2 Mean density (no. / ha) of prey fish by functional group in western Lake Erie, August 1987-2006.

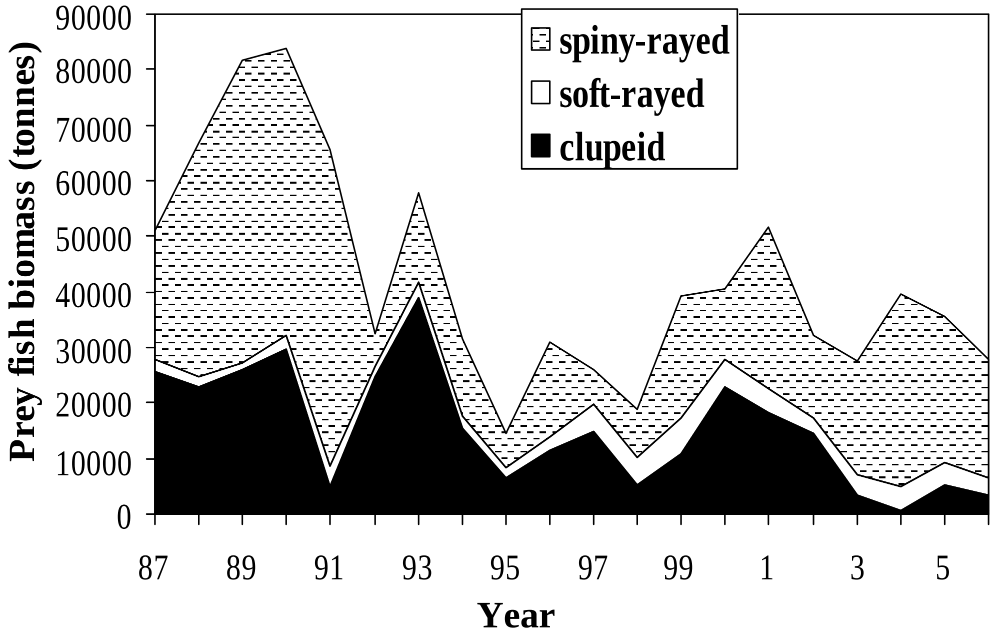

Figure 3.2.3 Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1987-2006.

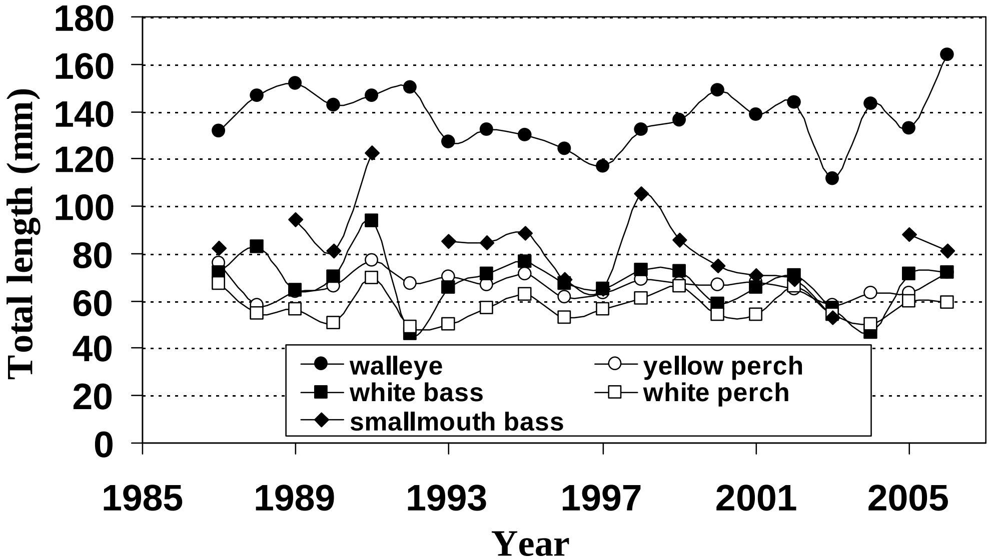

Figure 3.2.4 Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2006.

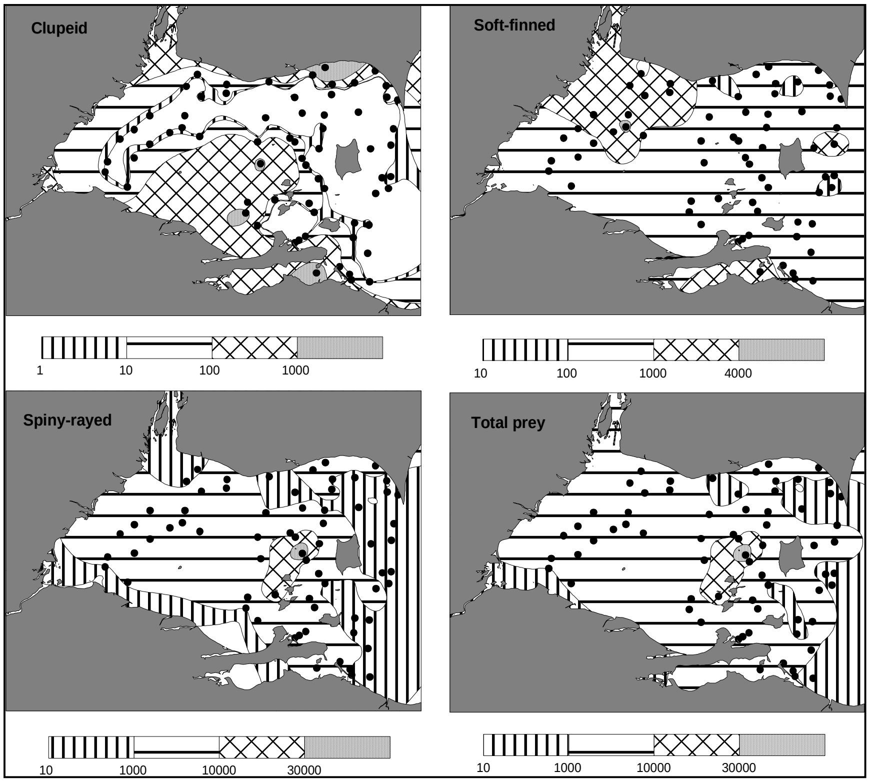

Figure 3.2.5 Spatial distribution of clupeids, soft-finned, spiny-rayed, and total forage abundance (individuals per hectare) in western Lake Erie, 2006. Black dots are locations for trawling and contour levels vary with the each functional fish group.

4.0 Acoustic Survey Program

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

Introduction

In 1993 the Forage Task Group (FTG) introduced fisheries hydroacoustic technology as a principal tool for annual assessments of pelagic forage fish stocks in eastern Lake Erie. Surveys from 1993 to 1996 were largely summertime efforts with an outdated surplus 70-kHz single beam echosounder (Simrad EY-M, 7024 transducer). Beginning in 1997, ongoing summertime acoustic survey efforts used a 120-kHz split-beam system (Simrad EY-500, ES120-7G transducer) that was jointly purchased by the Lake Erie Committee (LEC) member agencies and the Great Lakes Fishery Commission (GLFC). A two-year New York Sea Grant research project coordinated by Dr's Edward Mills and Lars Rudstam from Cornell University allowed for an expanded survey effort during the 1998 and 1999 survey years that included seasonal coverage during spring (June), summer (July) and fall (October). After 1999, only the July acoustic survey was continued as a standard, long-term measure of pelagic forage fish density and distribution in eastern Lake Erie. In 2005, a new 120-kHz split-beam system (Simrad EY60, ES120-7C transducer) was purchased for the Lake Erie acoustic program through another coordinated GLFC-LEC cost sharing arrangement.

Throughout this acoustic monitoring program, data collection has been coordinated among FTG member agencies with several research vessels (Argo, Erie Explorer, Keenosay, Musky II, and Perca) participating in various aspects of the data collection and calibration. Recent year's surveys and ongoing data analysis has been principally coordinated between the Ontario Ministry of Natural Resources (OMNR) and New York State Department of Environmental Conservation (NYS DEC).

Beyond maintaining the standardized July survey effort, the FTG has been very actively pursuing initiatives to address survey design and analysis procedures to maintain an up-to-date and defensible scientific method for the Lake Erie fisheries acoustic assessment program. Through a GLFC grant (Einhouse and Witzel 2003), Lake Erie's FTG acquired a site license for SonarData's Echoview acoustic signal processing software. This grant also supported accompanying software training for selected members of the FTG. Subsequently, the newly trained individuals led a workshop to introduce Echoview software to other biologists connected with fisheries acoustic surveys on Lake Erie. In December 2004, OMNR and NYS DEC jointly purchased a secondary site license for the Echoview software that functionally doubled the capacity for processing acoustic data. During 2005, eastern basin FTG members finalized efforts to upgrade the Lake Erie acoustic hardware system that resulted in the spring 2005 purchase of the aforementioned EY60 GPT/transducer. Progress has also been ongoing in development and refinement of post-processing applications in Echoview, SAS (SAS 1992) and Excel that integrate data flow and analysis. This ongoing process will facilitate Lake Erie's unique analytical procedures in a standard, semi-automated fashion across the extensive backlog of split-beam data. The completion of this comprehensive initiative is expected during 2007.

Two FTG members have continued to participate in a GLFC-sponsored Great Lakes Acoustic Study Group charged with preparing an array of standard operating procedures (SOP) for Great Lakes acoustic investigations. A draft SOP document titled "Standard Operating Procedures for Acoustics in the Great Lakes" has been prepared and recently distributed to the study group for review comments. This draft document is available to anyone by way of downloading from the Ohio DNR ftp site (ftp://ohiodnr.com/Wildlife/Fairport_Fish/deller/SOP_March22007_forcomment.doc) (ftp://ohiodnr.com/Wildlife/Fairport_Fish/deller/ReadMe B4SOP 4 acoustics.doc). In addition, these FTG investigators and affiliated external expert advisors have contributed to four recent publications advancing our approach to survey design (Conners 1999, Conners and Schwager 2002), abundance estimation (Rudstam et al. 2003), and comparing density estimates through a time series that employed different acoustic systems (Rudstam et al. 1999). These same investigators/advisors have continued to seek peer review and an exchange of ideas with the scientific community to validate and improve the Lake Erie acoustic program through informal discussions and participation in fisheries/academic conferences at the Great Lakes regional level (e.g. IAGLR 2004, 2005, and 2006) and national (AFS 2003, CCFR 2003) and international forums (Swedish Acoustics Workshop 2004, ICES 2002).

Methods

A comprehensive description of survey methodology and complete summary of results for the entire time series of the eastern basin Lake Erie acoustic survey is being prepared as a separate report expected to be released within a year. In general, standard survey procedures have been in-place for transect sampling of eastern Lake Erie since 1993. This midsummer, nighttime survey is typically implemented as a two vessel effort to collect acoustic signals of pelagic fish density and distribution, with accompanying mid-water trawling to characterize species composition.

In recent years' the usual contributions to this annual survey is acoustic data acquisition of fish densities and distribution by a scientific echosounder mounted on the OMNR's research vessel, *R/V Erie Explorer*, and accompanying mid-water trawl collections by the NYS DEC's *R/V Argo* to describe the fish species composition. However, during 2006 fiscal constraints within OMNR prevented the *R/V Erie Explorer* from participating in the field component of the survey. Instead, the *R/V Argo* collected acoustic data during 2006 and all companion mid-water trawl collections were suspended to re-direct efforts to acoustic data acquisition. Nearly the full compliment of planned transects were completed for the 2006 acoustic survey (Figure 4.1.1). OMNR and NYS DEC participants both remained fully engaged in data processing and analysis activities.

Some results from a representative survey year (2003) are provided in this report to illustrate some particularly useful measures acoustic surveys yield relative to indices from long term trawl surveys described in Section 2. As a cautionary note, the 2003 acoustic survey results provided in this report are best viewed as relative abundance measures to compare the precision of abundance estimates between acoustic and ongoing trawl surveys, and also to illustrate the spatial distribution of pelagic cold water forage fish, presumably YAO smelt, assessed with a standard methodology and across the entire basin.

Results

Presentation of eastern basin acoustic survey results had been suspended while the principal investigators were immersed in other initiatives pertaining largely to data processing/analysis methods, software/hardware expansion/upgrades, and EY500-EY60 GPT calibration exercise (see introduction). New standard analysis procedures are being applied to the 1997 through 2006 time series and efforts are proceeding smoothly toward an objective of reporting the entire series of split-beam acoustic data each March as an element of the annual FTG report.

At this time the representative 2003 acoustic survey year has largely been processed and is presented here to illustrate the type of information this survey is expected to contribute annually as a measure of pelagic forage fish distribution and abundance. In particular, 2003 results are provided here to demonstrate; 1) spatially explicit measures of YAO smelt along transect intervals and, 2) precision of mean density measures for YAO smelt attained by the acoustic survey, and compared with three independent bottom trawl surveys conducted by NYS DEC, PFBC and OMNR.

Figure 4.1.2 shows relative densities of yearling-and-older (YAO) pelagic forage fish along 800-m intervals of survey transects in the east basin. The distribution of pelagic cold water forage fish (ie. rainbow smelt) was very patchy throughout the basin and the frequency distribution of individual estimates was strongly skewed to the right. During the 2003 survey, highest densities of smelt were generally found mid-lake between Dunkirk and Port Maitland. Lowest densities occurred in the northern section of the same transect where the highest densities were observed and in the adjacent most easterly transect. A deep thermocline in this part of the basin restricted cold water habitat to areas further offshore. Another low fish density area was over the deepest portion of the basin, just east of Long Point.

Table 4.1.1 shows mean density indices and relative precision, expressed as proportional standard error (PSE = se/mean), for YAO smelt in 2003 by three separate agency bottom trawl surveys, and an accompanying YAO smelt index produced from the inter-agency acoustic survey. The precision of abundance estimates was greater (i.e. lower PSE) for the basinwide acoustic survey than any of the more localized agency index trawl programs. Absolute index measures from the various trawl mean values do not necessarily remain directly comparable because of unknown differences in trawl catchability associated with these independent trawling programs (see Section 3.3).

Discussion

Complete reporting of acoustic survey results has been planned for several years, but annual constraints on staff time has repeatedly postponed this more comprehensive analysis of acoustic data. However, at this time most of the hurtles related to specialized acoustic processing and analysis methodology have been resolved and the east basin investigators are just beginning to pursue analysis and reporting of 14 years of acoustic survey results.

This report provides a preview of some 2003 east basin acoustic survey data and is intended to illustrate the utility of acoustic survey methods as a smelt assessment tool. In general, acoustic survey methods promise advantages that include: (1) high sampling capability, (2) increased precision of estimates, and (3) estimation of absolute measures of population size. Results from the

2003 survey demonstrated broader sampling coverage using a standardized basin wide acoustic assessment than has otherwise been possible by separate long term trawling programs conducted by New York, Pennsylvania, and Ontario. In addition, the high sampling power of the 2003 acoustic survey produced mean density estimates that had accompanying higher estimate precision (PSE) compared to those associated with standard bottom trawl surveys. However, in the arena of absolute abundance estimation the Lake Erie investigators continue to struggle with assembling estimates that might reasonably approximate a measure of population size. Acoustic target strength ranges and species discrimination issues in warmer strata, and establishment of noise thresholds particularly in deeper, cold water strata are only a few issues that might confound estimating absolute abundance. Nevertheless, even if absolute abundance estimation remains an obstacle in the near future, it is the view of the FTG that acoustic methods have an important role as a component of forage fish assessment in Lake Erie as an index measure, because of it's high sampling power and production of spatially explicit results for achieving an improved understanding of fish distributions. This survey also is developing linkages to companion programs to assess habitat in collaboration with Lake Erie's Habitat Task Group.

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

In 2000 the Lake Erie acoustic survey was expanded to include the central basin. From 2000 through 2003 the acoustic surveys consisted of three acoustic transects, based on loran-TD lines equally spaced within the basin. Midwater trawling was conducted concurrent to the acoustic data collection. In December 2003 the FTG held a hydroacoustic workshop in Port Dover, Ontario. As a result of preliminary analysis and discussion at the workshop, a new experimental design was suggested for the central basin acoustic survey, scheduled for July of 2004 (FTG 2005). The new survey design required an additional vessel and sounding unit, and would increase the number of transects from three in previous surveys to eight. The new sample design proved to be an efficient use of available equipment and personnel and has been adopted as the standard sampling design for the central basin acoustic surveys. As in past surveys, midwater trawling from separate vessels is conducted concurrent to acoustic data collection to ground truth species composition and aid in single target detection analysis if needed.

Methods

In 2006 the central basin acoustic survey was conducted from July 17- July 21. Sample design was identical to the acoustic survey adopted in July of 2004, except only four cross basin transects could be completed due to equipment limitations. Midwater trawling was conducted on each transect and temperature profiles were collected by trawling vessels concurrent to the acoustic data collection. In 2006, acoustic data were collected aboard the *R/V Musky II* with BioSonics DT-5000 120 kHz split beam sounding units. Midwater trawling was conducted by the *R/V Keenosay* and *R/V Grandon* (Figure 4.2.1). Acoustic transects with concurrent trawling were completed between 2100 and 0530 hours and all other sampling protocols were kept similar to standard operating procedures for Great Lakes acoustics surveys.

Post processing of the 2006 and all previous years acoustic data will be done using

Echoview 3.4 software and applications in SAS 9.1 developed by FTG members to calculate density estimates. Analysis and interpretation of results is occurring in conjunction with the east basin acoustic survey in order to provide uniformity in post processing procedures, forage density and biomass estimates, and precision between the two surveys.

Results

In 2006 all four cross basin transects were completed without incident. The completed transects represent approximately 171 nautical miles of acoustic data. A total of 63 midwater trawls were completed in conjunction with the acoustic transects. Midwater trawl catches of age-0 smelt and YAO emerald shiners were highest in the area of the water column in and just above the thermocline. The thermocline ranged from 14 to 18 meters and averaged 15.6 m in Ohio waters. In Ontario waters, the thermocline was consistently higher relative to Ohio and ranged from 9 to17 meters, with a mean of 10.9 m.

Discussion

We are in the process of editing and conducting a preliminary analysis of all acoustic transects collected to date. At this time we have completed most of the pre-analysis edits in accordance with protocols established through the FTG's acoustic working group.

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 (FTG 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 (Brandt 1996). No companion trawling for species composition was conducted during the 2004 pilot survey. Since 2005, companion midwater trawling was conducted during the acoustic survey. 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 transects, extending through both Canadian and Ohio waters were selected for survey during July 18-20, 2006 (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. Due to weather constraints, Transect 3 was started on the Ohio end and cut short at the International Boundary. The other transects were completed as scheduled. Companion mid-water trawling was conducted by the ODOW's *R/V Explorer* at pre-determined sites in the Ohio waters along transects 2 and 3 to determine community composition. As this was the first attempt at using a mid-water trawl on the *Explorer*, fish collections were not consistent.

Sampling during the west basin acoustic program was performed with a BioSonics DT-X surface unit. This unit was equipped with two 6-degree 200-kHz split-beam transducers, a JRC global positioning system, and a Panasonic CF-28 laptop computer. The acoustic system was calibrated to US Navy standards at the BioSonics, Inc. Laboratory in Seattle, Washington prior to sampling and also calibrated before each survey with a tungsten carbide reference sphere of known acoustic size.

The mobile survey was initiated 0.5 h after sunset and completed before 0.5 h prior to sunrise. Transects were navigated with waypoints programmed in a Garmin GPS, and speed was maintained at 8-9 kph, (roughly 5 mph) using the GPS. Data were collected by multiplexing the transducers, with one transducer aimed down to sample from 3 m to near bottom and a second transducer aimed to the side to sample from near surface to approximately 3 m depth. Each transducer was mounted on a fixed pole located on opposite sides of the boat near the stern. The down-looking transducer was mounted 1 m below the surface and the side-looking transducer was mounted 1.5 m below the surface. Both transducers sampled at 4 pings/second with a pulse length of 0.4 msec and minimum threshold of -70 dB. The sampling environment (water temperature) was set at the temperature 3 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 10 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 3 software. Due to surface interference caused by inclement weather, 2006 side-viewing data were unusable and subsequently eliminated from analysis.

Results

Mean western basin forage fish density and biomass estimates from down-viewing data were 18,879 fish per hectare and 16.18 kg per hectare, respectively. A strong east-west gradient in mean fish density was present, with density increasing to the west (Figure 4.3.2). Biomass was similarly higher in the west, although Transect 2 was higher than Transect 1. The majority (89%) of forage fish in the survey was estimated to be 30-59 mm TL; 99% were between 20-109 mm. Mid-water trawling catches were dominated by small pelagic species, specifically YOY white perch, white bass, and gizzard shad, as well as yearling-and-older emerald shiners. Data from 2004 and 2005 will be re-analyzed to maintain continuity and long-term trends reported in the future.

Table 4.1.1 Estimated 2003 mean density for yearling-and-older (YAO) rainbow smelt and associated precision from three independent east basin bottom trawl surveys, compared with estimate precision (PSE) for the 2003 YAO smelt index of the east basin acoustic survey

Assessment Program	YAO SMELT mean density (#/ha)	SE	PSE (se/mean)
PA bottom trawl	45.8	21.7	47%
NY bottom Trawl	282.1	84.3	30%
ON offshore bottom trawl	209.8	95.2	45%
East basin Acoustic survey	597.8	81.1	14%

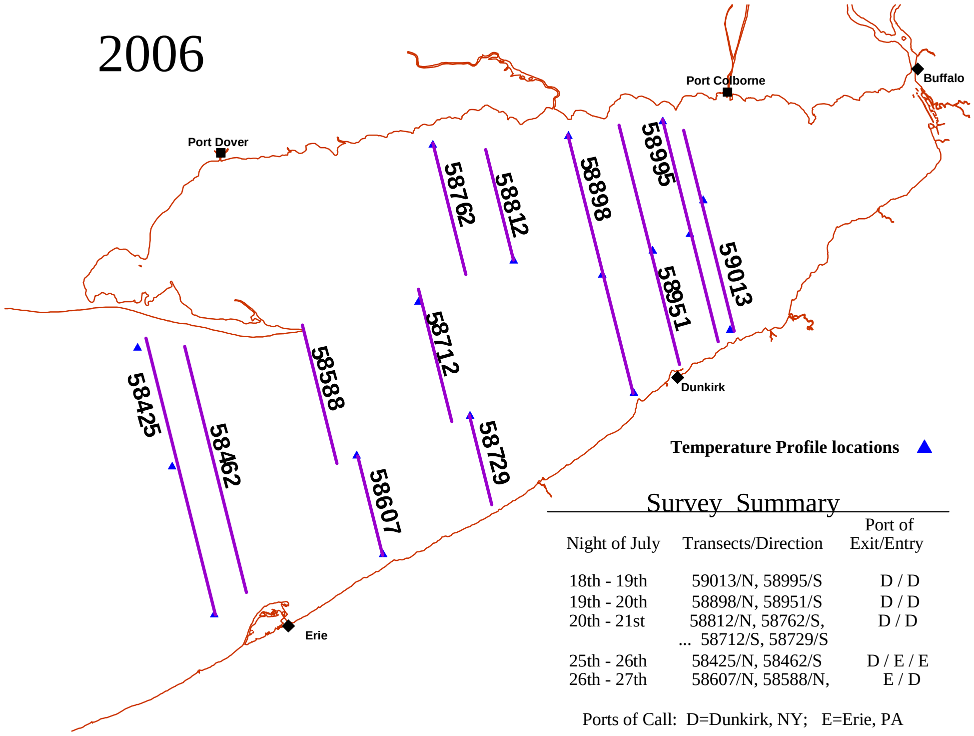

Figure 4.1.1 Transects sampled with a simrad EY60 120 kHz scientific echosounder during the July 2006 eastern Lake Erie fisheries acoustic survey.

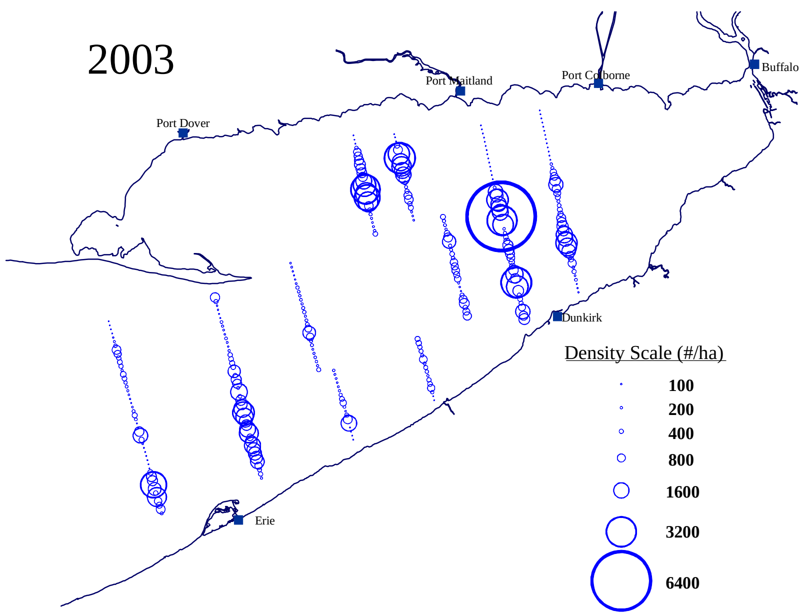

Figure 4.1.2 Relative density (No./Ha) of YAO-size forage fish in cold water habitat sampled at 800-mintervals along acoustic transects with a Simrad EY500 120 kHz scientific echosounder in eastern Lake Erie, during July, 2003.

<u>2006 Central Basin Lake Erie hydroacoustic survey</u>

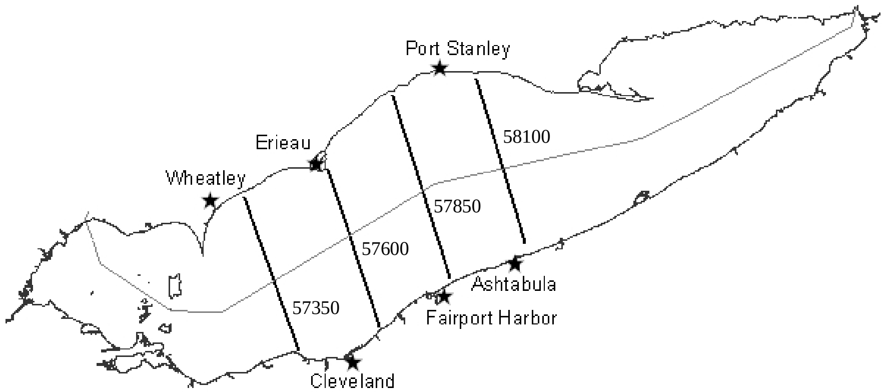

Figure 4.2.1 Four completed central basin acoustic survey transects for July 17-21, 2006. Transects were run along Loran-C TD lines. Acoustic data were collected aboard the *R/V Musky.* The *R/V Keenosay* and *R/V Grandon* conducted midwater trawling concurrent to acoustic data collection along each transect.

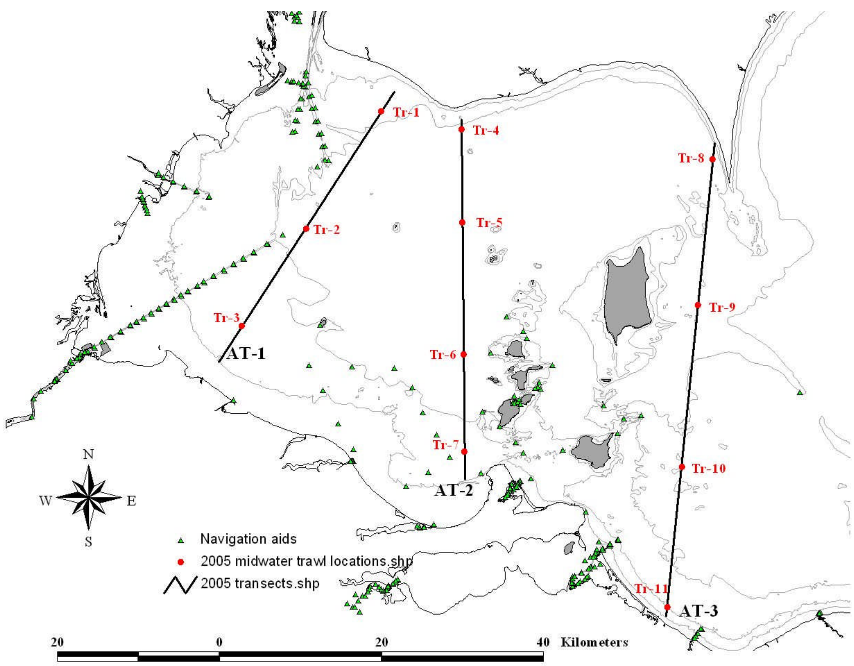

Figure 4.3.1 Three proposed acoustic survey transects and companion midwater trawling locations for the western basin July 18-20, 2006. Due to inclement weather, transect 3 was only half completed (southern half).

.

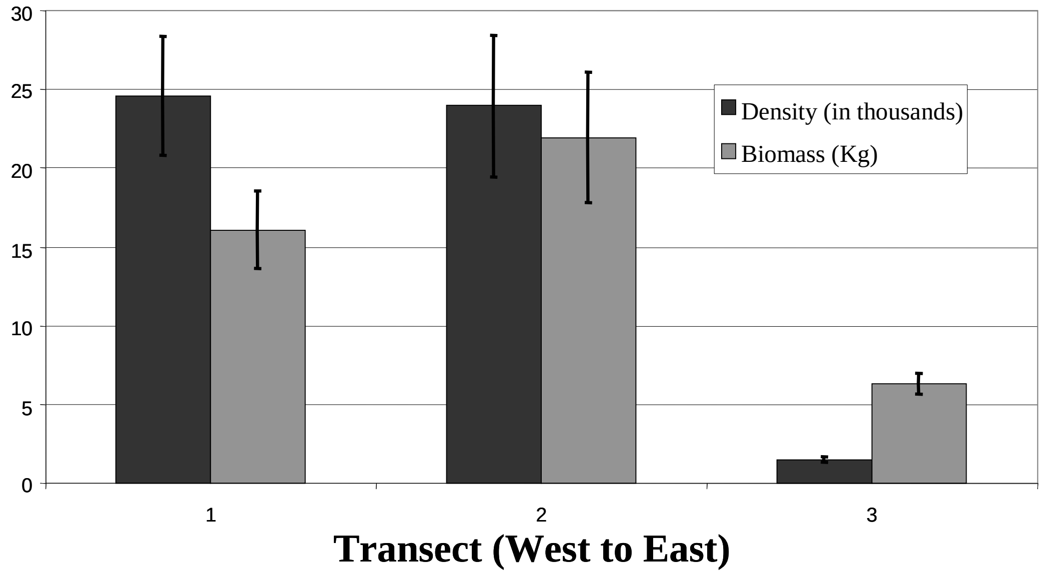

Figure 4.3.2. Mean density (in thousands) and biomass (Kg) estimates of western basin forage fish from down-viewing hydro-acoustic survey data collected July 18-20, 2006, along three transects.

5.0 Interagency Lower Trophic Level Monitoring Program

(by E. Trometer and T. Johnson)

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. The year 2006 marks the eighth year of this monitoring program. For this report, we will summarize the last eight years of data for five variables for which there is sufficient data. These variables are epilimnetic temperature, hypolimnetic or bottom dissolved oxygen, grazing pressure and planktivory 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 1 and 2 from Lake St. Clair, 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 5.0.1).

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 5.0.2). Relative to other years, 2005 was a warm year while 2006 was average.

Hypolimnetic Dissolved Oxygen

Figure 5.0.3 illustrates the mean hypolimnetic dissolved oxygen (DO) concentration (i.e. below the thermocline) for each basin of Lake Erie by year during periods when the water column was stratified. 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. Hypolimnetic DO is rarely limiting in the eastern basin due to greater water depths and cooler temperatures. Stations 19 and 20 are too shallow for the water column to stratify. In the western basin, shallow depths allow wind mixing to penetrate to the bottom, 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 in the central basin has resurfaced as an issue in the central basin. DO less than 4 mg/l was first observed in mid July and persisted until late September when fall turnover remixes the water column. Average hypolimnetic DO was lower in the central basin in 2006 than in 2005, with about ¼ of the observations being stressful to aquatic life in each year.

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 herbivorus 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 lowest in the western basin (more chlorophyll than predicted) and highest in the eastern basin. Annual grazing pressure is the most variable in the western basin. Also note the difference in chlorophyll *a* levels in each basin with an average of 6.33 µg/l in the west basin, 3.22 µg/l in the central basin, and 1.6 µg/l in the east basin.

Planktivory 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 sampled with a 63-µm net reflects a high level of predation by fish. Figure 5.0.5 reflects this planktivory index for the zooplankton communities of the three basins of Lake Erie. Zooplankton predation is deemed high, as the average size of the community is often less than this critical 0.57 mm size. Predation was high in 2000 in the western and eastern basins but not exceptionally higher in the central basin relative to other years. Planktivory was lowest in 2001 and 2003 in the central and eastern basin and in 2003 in the western basin. It increased slightly in all basins in 2004 compared to 2003.

Distribution of New Zooplankters

For this review only data from stations 3-6, 9-12, and 15-20 are included. *Bythotrephes longimanus* is found in all three basins, but is very rare in western basin stations. *Cercopagis pengoi* were first found at station 5 in July 2001 and station 9 in September 2001. In subsequent years it has also been found at stations 6, 10, 15, 16, and 18. *Daphnia lumholtzi* was first identified in this sampling in August 2001 at stations 5 and 6, and at station 9 by September 2001. It was not collected at any stations other than these 3 in subsequent years.

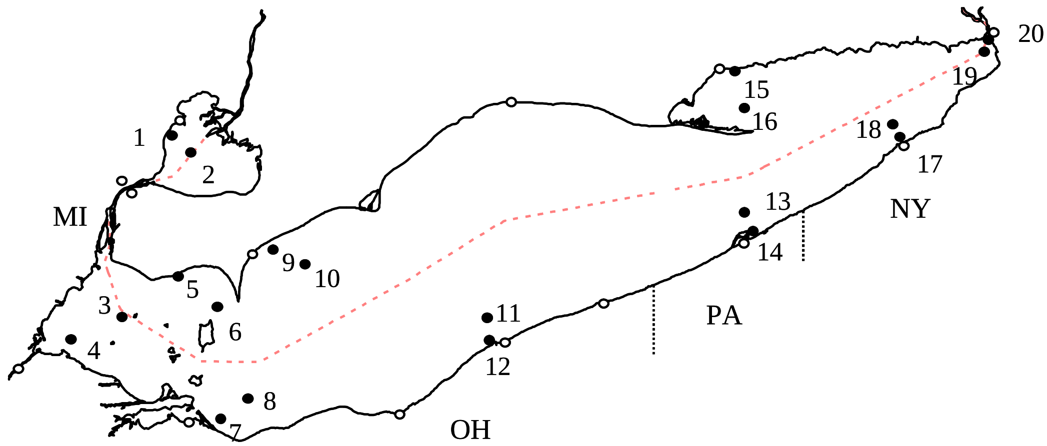

Figure 5.0.1 Lower trophic level sampling stations in Lakes Erie and St.Clair.

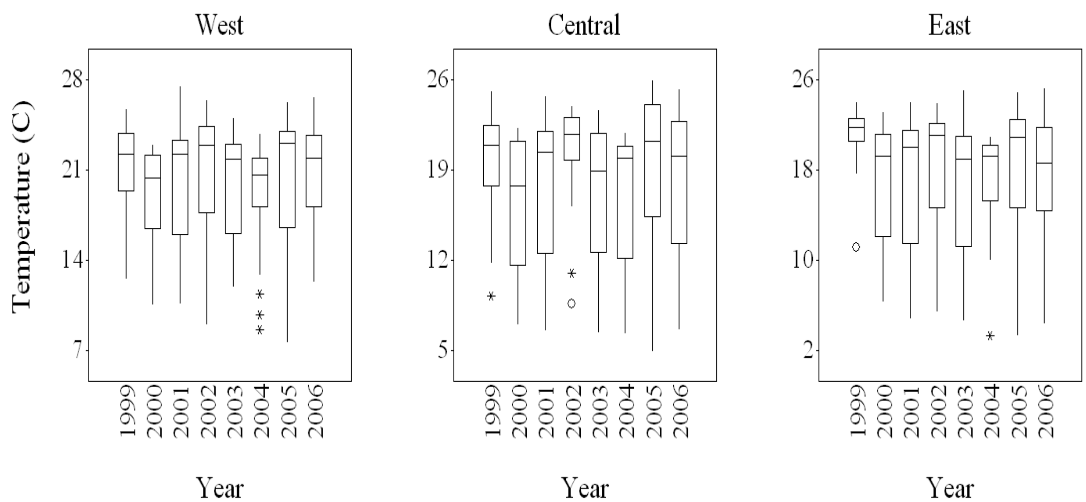

Figure 5.0.2. Epilimnetic water Temperature (C) at offshore stations by basin in Lake Erie, 1999-2006. Box plots represent median, 25th, and 75th quartile. Long-term average water temperature is 20.1 C in the western basin, 18.01 C in the central basin and 17.5 C in the eastern basin. For this analysis only data from stations 3, 6, 8, 10, 11, 13, 16, and 18 are included.

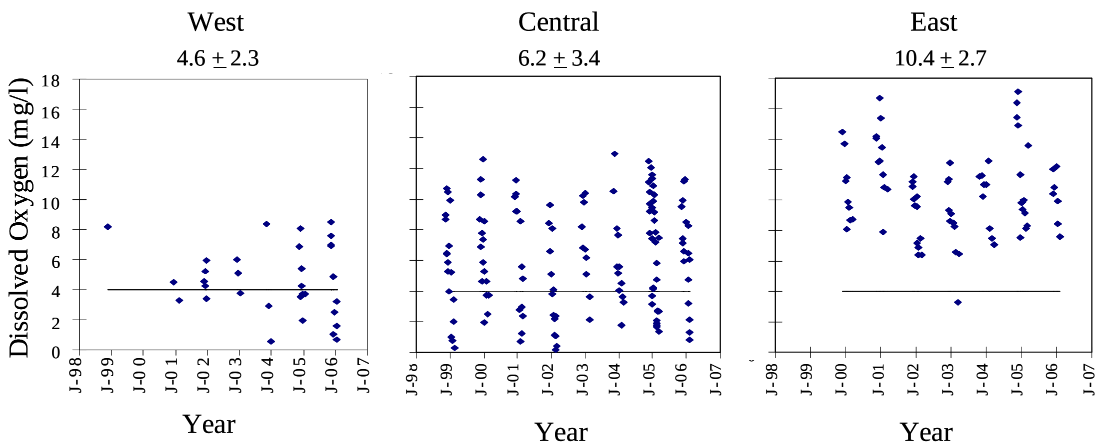

Figure 5.0.3. Mean hypolimnetic dissolved oxygen (mg/l) for each basin of Lake Erie, 1999-2006. Data are presented only when water column is stratified. The horizontal line represents 4 mg/l, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. Long-term average hypolimnetic dissolved oxygen is shown above each graph. For this analysis, only data from stations 3-16 are included.

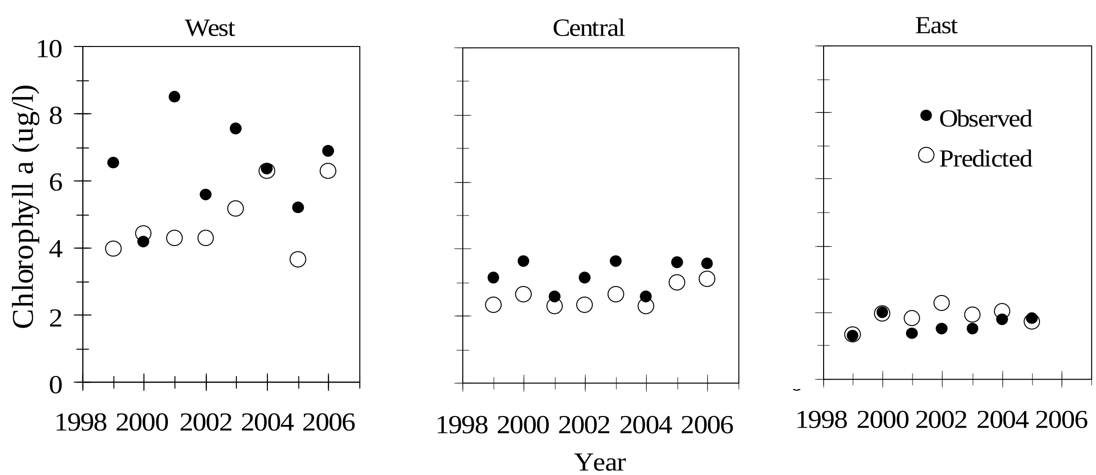

Figure 5.0.4. Observed and predicted chlorophyll *a* concentration (ug/L) in each basin of Lake Erie, 1999-2006. Chlorophyll *a* is predicted from equations presented in Mazumder 1994 for even-linked systems (those where grazing limits phytoplankton standing crop).

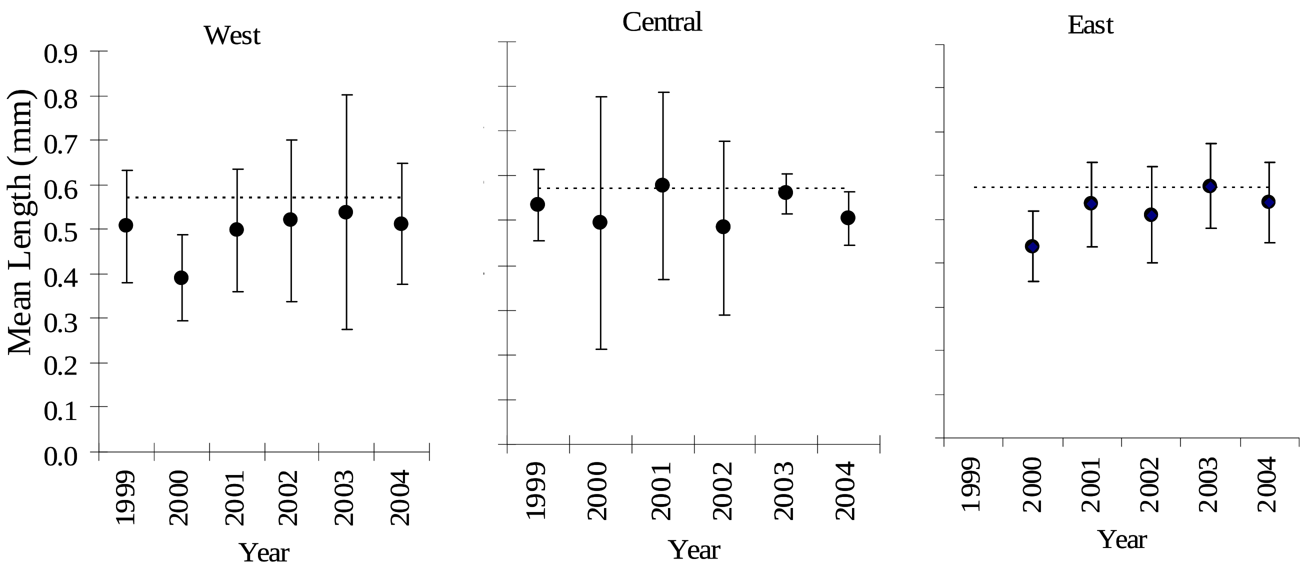

Figure 5.0.5. Mean length of the zooplankton community (± SD) sampled with a 63µm plankton net hauled through the epilimnion of each basin of Lake Erie, 1999-2004. The horizontal dashed line depicts 0.57 mm; if the mean size of the zooplankton community is less than 0.57mm, predation by fish is considered to be intense (Mills et al. 1987, Johannsson et al. 1999). For this analysis only data from stations 3-6, 9-12, and 15-20 were included.

6.0 Lakewide Round Goby Distribution (by 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 have increased in the east basin and decreased in both the central and west basins relative to 2005. Please refer to previous Forage Task Group reports for information on the yearly spread and distribution of round goby in Lake Erie prior to 2005.

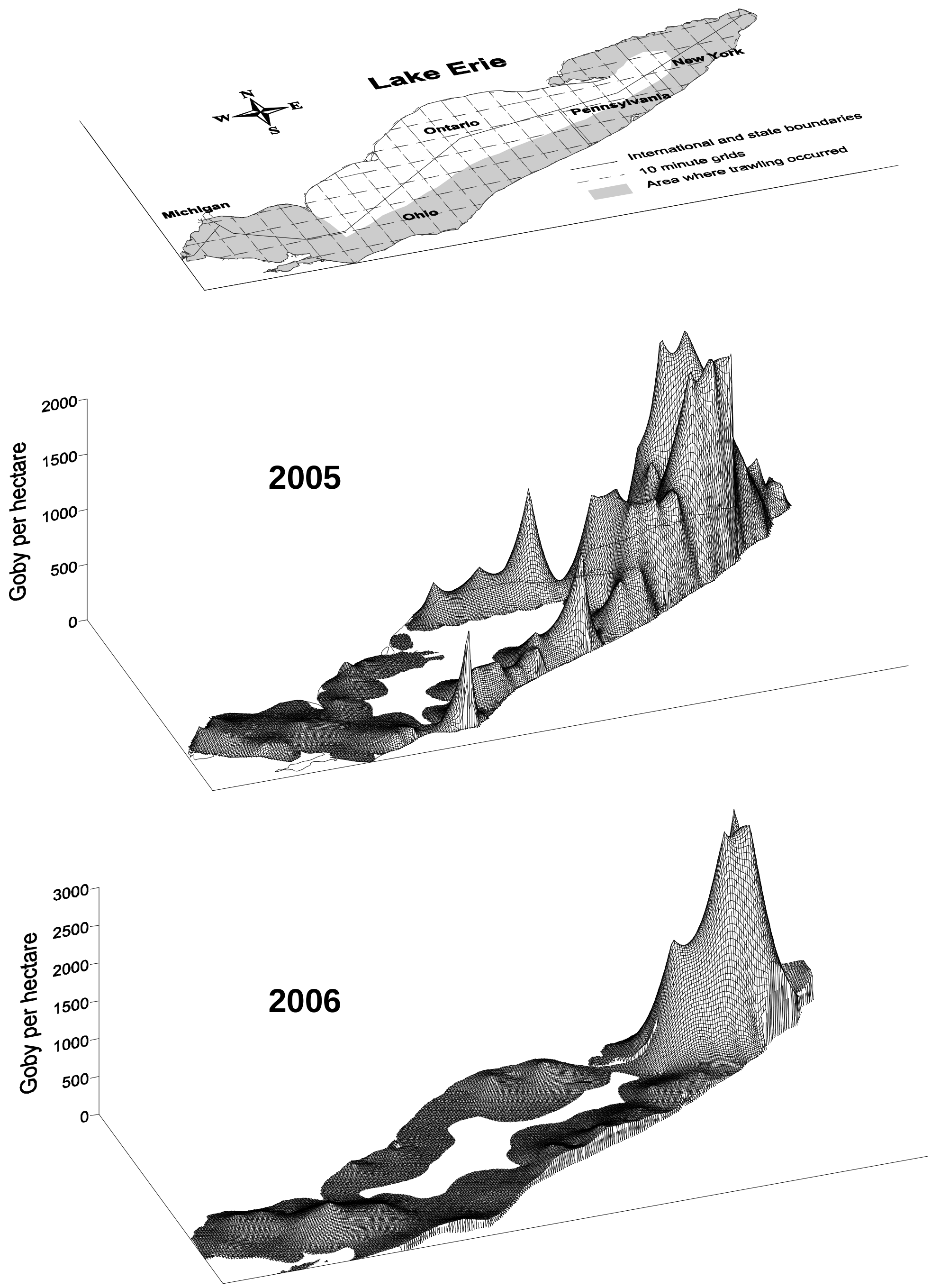

Figure 6.0.1 Two dimensional base map (upper) and three dimensional maps of round goby distribution in Lake Erie as density per hectare 2005 and 2006 estimated from bottom trawl catches. The base map shows state and provincial boundaries, the ten minute grid system used for trawl data summarization, 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.

7.0 Status of Bioenergetics Model of Predator Consumption

(J. Markham and T. Johnson)

Estimates of annual consumption by walleye were last completed by the bioenergetics sub-group in 2001. Data limitations describing critical population parameters prevented the use of other key lake predators such as lake trout, burbot, and steelhead in the analysis. Results of this analysis can be found in the 2002 Forage Task Group Report (FTG 2002).

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 data gains in previous gaps include:

- The CWTG has updated and revised the lake trout population model that estimates the adult population in Lake Erie. Population estimates were one of the limiting parameters in 2001. These improvements should allow for estimates of prey consumption by lake trout in eastern Lake Erie.
- Ageing and length-at-age relationships were recently developed from burbot collected in jurisdictional coldwater assessment surveys (Stapanian et al. 2007). Mortality of the burbot population was also estimated (Stapanian and Madenjian 2007).
- A lakewide steelhead diet study involving all inter-jurisdictional agencies was completed in 2004 (Clapsadl et al. 2005). The result of this study shows that steelhead consume a wide variety of different fish and invertebrate species but that emerald shiners and smelt provide the majority of their diets' biomass.
- Estimates of steelhead growth, longevity, and migration patterns were made from data collected in the lakewide steelhead diet study.

Despite these gains, there are still critical information that is lacking that will prevent the complete analysis of lakewide predatory demand. One of the more important information gaps is an estimate of the Lake Erie steelhead population. There is a proposed plan to tag steelhead through the Great Lakes Mass Marking Initiative, and results of this tagging are expected to provide most of the critical information that would be needed to estimate steelhead consumption demands. However, this plan is still only in its planning stage and years away from fruition. Estimates of burbot population size also remain unknown. Suggestions have been made to use the relationship of lake trout and burbot CPUE's in the coldwater netting program and apply them to the lake trout population model to estimate the burbot population, but these have not been pursued.

In order to fully estimate lakewide predatory demand, all major predators need to be included in the bioenergetics analysis. As of now, an update of the model could account for walleye and lake trout but would not include burbot or steelhead. Predatory demand by lake trout is not expected to be high given that its current population estimates are only 40% of early-1990's population estimates (CWTG 2007). However, steelhead populations remain high and estimates of total prey consumption cannot be fully understood without including these fish in the analysis.

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 Dr. Lars Rudstam (Cornell University), Dr. Dave Warner (USGS) and Dr. Patrick Kocovsky (USGS) for their continued support of hydroacoustic surveys, section 4.0; Dr. Jeffery Zhu (University of Windsor) for his efforts on the summary of species statistics, section 3.2; Jeff Tyson (ODOW) for input on trawl CPUE statistical summaries, section 3.2 and trawl comparison exercises, section 3.3; Bob Haas (MDNR) for the lake wide goby distribution figure, section 6.0; and Andy Cook (OMNR) for contributions to multiple sections of this report.

Literature Cited

Brandt, S. B. 1996. Acoustic assessment of fish abundance and distribution. Pages 385-432 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Clapsadl, M., J.L. Markham, K.A. Kayle, C. Murray, and B. Locke. 2005. An analysis of the diet of steelhead trout in Lake Erie to provide resource managers with a basic understanding of their role in lakewide predator/prey dynamics. Final Report for Project #30181-3-J225. Great Lakes Fisheries Commission, Ann Arbor, Michigan. 24 pp.

Coldwater Task Group. 2007. Report of the Lake Erie Coldwater Task Group, March 2007. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission, Ann Arbor, Michigan, USA.

Conners, M. E., 1999. Use of Adaptive Cluster Sampling Designs for Hydroacoustic Fish Surveys. MS Thesis, Cornell University, Ithaca, New York, August, 1999.

Conners, M. E. and S. J. Schwager. 2002. The use of adaptive cluster sampling for hydroacoustic surveys. ICES Journal of Marine Science 59:1314-1325

Einhouse, D. W. and L. D. Witzel, 2003. A new signal processing system for Inter-agency fisheries acoustic surveys in Lake Erie. Great Lakes Fishery Commission Completion Report, December, 2003.

Forage Task Group. 2002. Report of the Lake Erie Forage Task Group, March 2002. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery commission. Ann Arbor, Michigan, USA.

Forage Task Group. 2005. Report of the Lake Erie Forage Task Group, March 2005. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery commission. Ann Arbor, Michigan, USA.

Johannsson, O.E., C. Dumitru, and D. Graham. 1999. Estimation of zooplankton mean length for use in a index of fish community structure and its application to Lake Erie. J. Great Lakes Res. 25: 179-186.

Knight, R.L. and B. Vondracek. 1993. Changes in prey fish populations in western Lake Erie, 1969-1988, as related to walleye, *Stizostedion vitreum*, predation. Can. J. Fish. Aquat. Sci. 50: 1289-1298.

Mazumder, A. 1994. Patterns in algal biomass in dominant odd- vs. even-linked lake ecosystems. Ecology 75: 1141-1149.

Mills, E.L., D.M. Green, and A. Schiavone. 1987. Use of zooplankton size to assess the community structures of fish populations in freshwater lakes. N. Am. J. Fish. Manage. 7: 369-278.

Nicholls, K.H. and G.J. Hopkins. 1993. Recent changes in Lake Erie (north shore) phytoplankton: cumulative impacts of phosphorus loading reductions and the zebra mussel introduction. J. Great Lakes Res. 19: 637-647.

Rudstam, L.G., S. Hansson, T. Lindem, and D.W. Einhouse. 1999. Comparison of target strength distributions and fish densities obtained with split and single beam echo sounders. Fisheries Research 42:207-214.

Rudstam, S. L., S. L. Parker, D. W. Einhouse, L. D. Witzel, D. M. Warner, J. L. Stritzel, D. L. Parrish, and P. J. Sullivan. 2003. Application of in situ target –strength estimations in lakes: examples from rainbow-smelt surveys in Lakes Erie and Champlain. ICES Journal of Marine Science, 60: 500-507.

Stapanian, M.A., C.P. Madenjian, and J. Tost. 2007. Regional differences in size-at-age in the recovering burbot population in Lake Erie. Journal of Great Lakes Research – in press.

Stapanian, M.A. and C.P. Madenjian. 2007. Evidence that lake trout served as a buffer against sea lamprey predation on burbot in Lake Erie. North American Journal of Fisheries Management 27:238-245.

Tyson, J. T., T. B. Johnson, C. T. Knight, M. T. Bur. 2006. Intercalibration of Research Survey Vessels on Lake Erie. North American Journal of Fisheries Management 26:559-570.