Report of the
Lake Erie
Forage Task Group

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Presented to:

Standing Technical Committee
Lake Erie Committe
Great Lakes Fishery Commission

1.0 Charges to the Forage Task Group in 1995-1996

The Forage Task Group (FTG) addressed four major charges from the Lake Erie Committee (LEC) during the 1995-1996 work year:

1) Prepare a brief report describing the status of forage species in 1995 for each basin of Lake Erie (section **2.0**);

2) Conduct analyses with the interagency trawling program that includes
   a) a procedure for calibration of trawls, incorporating SCANMAR results (section **3.0**),

   b) a continuation of analyses with trawl data sets to determine the most appropriate statistic for describing central tendency (section **3.2**),

   c) a summary of species CPUE statistics and biomass estimates from calibrated trawls (section **3.3**);

3) Information regarding the qualitative and quantitative aspect of planktonic and benthic organisms and their roles in the Lake Erie ecosystem is limited. This is an area in which the USFWS is interested in expanding their partnership with Lake Erie management agencies, the FTG would welcome dialogue and a planning meeting to determine informational needs, appointment of additional representatives from other organizations doing work on lower trophic levels within the Lake Erie system, and develop an efficient program (section **4.0**);

4) Evaluate hydroacoustics techniques as a method for producing a basinwide assessment of the distribution and abundance of rainbow smelt in the Eastern Basin of Lake Erie (section **5.0**);

The bracketed numbers printed above in bold face, indicate the subsection where progress is reported for a particular charge in this document.

2.0 Status of Forage Species

2.1 Forage Fish

2.1.1 Eastern Basin (by L. Witzel, D. Einhouse, C. Murray)

Prey fishes known to comprise important components of piscivore diets in eastern Lake Erie include rainbow smelt, alewife, gizzard shad, white perch, spottail, and emerald shiners. Relative contributions of these species to the diets of fish predators varies with annual fluctuations in abundance.

The status of prey fish in the eastern basin of Lake Erie has been determined annually by independent bottom trawl assessments conducted in the fall by the Ontario Ministry of Natural Resources (OMNR), New York State Department of Environmental Conservation (NYSDEC), and Pennsylvania Fish and Boat Commission (PFBC). NYSDEC has also conducted a summer (July) trawl survey of deep water stations (< 36 m) since 1987. All indices of abundance from agency trawl surveys are reported below as geometric mean catch per trawl hour (GMCPTH).

Smelt are the most abundant prey fish species available to predators in the offshore waters of eastern Lake Erie. Smelt typically comprise 90 percent or more of index trawl catches (by number) and are generally the dominant food item found in the diets of salmonines and walleye.

Fall trawl assessments indicate that recruitment of YOY smelt in 1995 was relatively poor (Table 2.1.1-1). OMNR and PFBC trawl data show that 1995 produced one of the weakest year classes in the history of these surveys (Figure 2.1.1-1). Conversely, the comparatively short time series of the NYSDEC trawl survey suggests that spawning success was moderately successful in 1995, second only to 1992.

Relative abundance of YAO smelt increased in 1995 from record low levels observed in 1994 (Figure 2.1.1-2). All agency surveys show that catches of YAO smelt were below their long term average (Table 2.1.1-1). Eastern basin catches of YAO smelt were largely made up of the 1994 year class. However, the moderately poor showing of this year class as yearlings (in 1995) does not contribute much support to claims that this cohort was underestimated (as age 0) by OMNR surveys in 1994.

Average size of YOY smelt in the OMNR index trawl catches (October data) increased in 1995 (60.3 mm FL; Figure 2.1.1-3). Historically, mean size of YOY smelt reached a record low level in 1988 (54.0 mm FL), increased to 67.8 mm the following year, and has remained between 60 and 70 mm ever since, except in 1994 (58.2 mm FL). Size of yearling smelt in eastern Lake Erie has increased (even years) and decreased (odd years) on alternate years (Figure 2.1.1-3). This pattern continued in 1995 (94.2 mm FL) with a moderate decrease from 1994 (101.6 mm FL). The overall trend is one toward decreased size of yearlings. The smallest yearlings were observed in 1993 (93.6 mm FL).

Clupeids typically make up less than three percent (by number) of index trawl catches in the offshore waters of Long Point Bay, and indices of their abundance may not accurately reflect recruitment. All agencies observed poor recruitment of YOY alewife and gizzard shad in 1995; these YOY species were below long term average abundance (Table 2.1.1-1).

Agency trawl surveys indicate that recruitment of YOY emerald shiner was moderate in 1995; this cohort appeared to be above historic average abundance (Table 2.1.1-1). All but one eastern basin fall trawl survey showed a small or moderate increase in abundance of YAO emerald shiner from 1994 to 1995, but adult shiners appeared to be less available in 1995 compared to their average abundance during the last 10 years (Table 2.1.1-1).

All agencies observed increased or above long term average recruitment of YOY spottail shiner in 1995 (Table 2.1.1-1). Indicators of YAO spottail shiner abundance were mixed. OMNR surveys indicate YAO spottail shiner were less available in 1995 compared to 1994 (Table 2.1.1-1). Whereas surveys by PFBC and NYSDEC demonstrated a modest increase and no change, respectively from 1994 to 1995 (Table 2.1.1-1).

Widely conflicting trends in abundance indices of clupeids and shiners between surveys (nearshore vs offshore) and among agencies may be attributable to large variations in catches associated with widely clumped distributions of these species. Furthermore, temporal and spatial variations may be confounded by differential effects exerted on fish distributions by zebra mussels. For instance, increased water clarity may render bottom trawls increasingly less effective in the nearshore , relative to offshore areas of the lake.

Recruitment of YOY white perch was extremely poor throughout the eastern basin in 1995 (Table 2.1.1-1). All agencies reported a decline in availability of age 0 white perch; this decrease was most pronounced in the PFBC trawl survey (Table 2.1.1-1).

In summary, the relative abundance of prey fish in the eastern basin appeared to improve somewhat in 1995, but overall prey supply remained well below historic levels. Poor recruitment by smelt, clupeids and white perch in 1995 will likely force a continuation of forage pressure on the 1994 year class of smelt, the predominate cohort available to offshore predators in 1996.

2.1.2 Central Basin (by C. Murray and J. Tyson)

Fall assessment bottom trawls are conducted by the Ohio Department of Natural Resources (ODNR) and Pennsylvania Fish and Boat Commission (PFBC) in the central basin of Lake Erie during late September and October of each year. As in 1994, decreasing abundances of forage fish in the central basin were indicated by both agencies (Table 2.1.2-1). PFBC trawls showed increases in trout-perch and spottail shiner abundances, over long-term averages, but ODNR trawls did not show increases in either of these species. PFBC also showed relatively large increases in yearling and older spottail shiners, as well. Clupeid abundances appear far below long-term averages. Rainbow smelt remain the most important component of the forage base (by number) in the central basin . Assessment trawls of both agencies indicated declines in YOY smelt as well. Yearling and older smelt abundances in the central basin were at or near long-term averages for both agencies, probably due to the moderately successful 1994 year-class.

Mean fall lengths of clupeids and rainbow smelt in the central basin decreased, relative to 1994, while mean lengths of *Notropis* spp. increased slightly over 1994. None of the more notable forage species have shown any trends in mean fall length over time. Growth rates of the age 1 and age 2 walleye in the central basin have also remained at or near long-term averages, while mean fall lengths of age 1 yellow perch appear to be increasing slightly.

2.1.3 **Western Basin** (by J. Tyson and S. Nepszy)

Relative abundance and growth of young-of-year forage fishes in the western basin in 1995 were assessed from fall bottom trawl surveys conducted by ODNR and OMNR. Gears used for collection of the 1995 data were similar, but gear configurations differed between organizations, therefore the data could not be pooled. Although gear configurations were different, each series showed remarkably similar trends in relative abundances.

For both agencies, most index values (arithmetic mean catch per hour trawling) of relative abundance were below long-term averages (Table 2.1.3-1). Age-0 emerald and spottail shiners, and trout perch were the only exception. Both ODNR and OMNR data indicated that age-0 trout perch relative abundances were up over 1994 and ODNR data indicated that abundances in 1995 were greater than their long-term average abundance. The two *Notropis* species showed increases over 1994 relative abundances, and relative abundances that were similar to or slightly below long-term averages. Age-0 yellow perch abundances were well below long-term averages for ODNR and OMNR data from early fall, while OMNR data indicated age-0 yellow perch abundances were relatively high in August. This may indicate that age-0 yellow perch experienced relatively high mortality rates from mid-summer to early/late fall. Relative abundances of age-0 gizzard shad, alewives, rainbow smelt, freshwater drum, and white perch were well below long-term averages. Relative abundances of age-1 and older emerald shiners, spottail shiners, and rainbow smelt showed increases over 1994, but were also well below long-term averages. Although there appear to be modest increases in relative abundance estimates for *Notropis* spp., because of the relatively low contribution that shiners have to total forage base in western Lake Erie, total forage abundances appear to be overall quite low. Similar trends are reflected in the interagency trawl data from August.

Growth rates of age-1 and older walleye in 1995 were similar to those observed in 1994, and decreased slightly since 1990 indicating relatively low abundances in 1995. Low clupeid abundances in trawls were confirmed by walleye diet data. A broad range of clupeid lengths (64-209 mm) were consumed by walleye in the fall indicating that clupeid abundances were probably again quite low. Increased relative abundances of emerald shiners in the bottom trawls may be confirmed by the data from walleye diets collected by ODNR. Mean percent occurrence of emerald shiners in age-1 and older walleye increased this year as compared to previous years, which may be indicative of both low clupeid abundances, and higher emerald shiner abundances.

Mean lengths of age-0 predator and forage species collected in ODNR bottom trawls were at or near long-term averages. There were no trends evident in growth for any of the forage species indicating that forage prey abundance has probably remained relatively constant over the past several years.

2.2 Predator Diets

2.2.1 Walleye

(by L. Sztramko, M. Bur, M. Kershner, and J. Tyson)

Walleye stomachs were examined for food contents by ODNR, OMNR, NBS, and Ohio State University (OSU) in the western basin; by ODNR, OSU, and OMNR in the central basin; and by NYSDEC and OMNR in the eastern basin. ODNR samples were obtained from index gill nets (kegged and bottom sets) fished at random and fixed (historic) sites across a range of depths during October. NBS samples were obtained from bottom trawls at fixed stations during May and August-October. OMNR samples were obtained from fish, primarily age 3 and older, harvested by anglers during June-August. NYSDEC samples were from the summer angling fishery. Only stomachs from age-1 and older walleye were examined by ODNR and NBS. Figures 2.2.1-1 to 2.2.1.-3 show the mean percent volume of the major identifiable food groups found in walleye stomachs for each basin since the mid to late 80's. Mean percent volume was calculated by NBS and OMNR as the mean percent displacement volume of stomach contents. Mean percent volume was calculated by ODNR and OSU as the ingested volumes derived by calculating a mean total length from backbone, standard, or total lengths and then applying a year and species specific length-weight regression to each prey item found in the stomach to obtain weight estimates.

Walleye in the western basin of Lake Erie were found to have a diverse intake of prey fish that included clupeids (mostly gizzard shad), smelt, yellow perch, *Morone* spp. (mostly white perch) and emerald and spottail shiners (Figure 2.2.1-1). Gizzard shad have been the primary prey species for age-1 and older walleye within the western basin (ODNR and NBS data) during the late summer and fall, when age-0 clupeids become available to walleye as prey. Western basin diet data from NBS indicates that benthic macroinvertebrates (mainly amphipods, chironomids, and Ephemeroptera) are consumed by walleye during the early summer. Zooplankton also show up in the diets of walleye during the spring (NBS data), but typically the volume contributed is quite low. Yellow perch have been a minor component of western basin walleye diets.

In the central basin, walleye diet as assessed by ODNR-Sandusky and OMNR were quite different (Figure 2.2.1-2). ODNR-Sandusky data indicated that walleye consumed almost exclusively clupeids in the west-central basin, whereas in OMNR samples, smelt was the principal prey fish and clupeids were relatively insignificant, except in 1992. ODNR-Fairport data also indicated that smelt and *Notropis* spp. were the principle prey in walleye diets throughout the summer and fall (Figure 2.2.1-3). This discrepancy may be attributed to differences in sampling gear (size selectivity), methods, season, daytime (day vs night), and where walleye were collected in the central basin in relation to north-south and east-west gradients in prey fish abundance. The walleye diet information provided by the ODNR-Sandusky was collected in the west-central basin, from Huron to Avon Point, OH, while the data provided by ODNR-Fairport was collected from Cleveland to Ashtabula, OH. Yellow perch were also a minor component of the walleye's diet throughout in the central basin in the last 5 to 10 years.

In the eastern basin walleye consumed almost exclusively smelt (OMNR and NYSDEC data) (Figure 2.2.1-4). Both agencies also indicated that a small percentage of the summer diet of walleye was comprised of benthic macroinvertebrates (particularly Ephemeroptera from NYSDEC) when emerging Ephemeroptera densities are typically at their highest. *Morone* spp., *Notropis* spp., and clupeids were also present in eastern walleye diets as indicated by OMNR data.

2.2.2 White Perch and Yellow Perch

White perch and yellow perch were examined for food contents by NBS in the western basin and by OMNR in Long Point Bay, Lake Erie. Long Point Bay samples were obtained from index gill nets fished for 24-h periods, weekly from May to October since 1986. Western Basin samples were from bottom trawls fished at a few index stations during May and August-October, since 1989. Mean percent volume was calculated as the mean percent displacement volume of stomach contents. At the time of writing, OMNR results for 1995 were not available.

Western Basin (by M. Bur and B. Ickes)

The diet of yellow perch in the western basin from 1989 to 1995 consisted mostly of benthic macroinvertebrates (Figure 2.2.2-1). Mollusks were an important food, usually comprising between 20 and 25 of the mean percent volume. Zebra mussels were present in the diet of yellow perch in all five years, usually between 6 and 17 mean percent volume. Amphipods comprised as much as 28% of the diet. Chironomids, which historically (1970's and 80's) were a major component of yellow perch diets, made up less than 10 percent of the stomach volume, while Hexagenia made up 5-12 % of the stomach volume in 1994 and 1995. Zooplankton was a minor component in 1990-92 (< 12%), and a major one in 1989 (36 %) and 1993 (46 %) and 1995 (50%). The relative contribution of prey fish in the diet of yellow perch has remained relatively constant over time.

The main food of white perch was zooplankton (*Daphnia* spp. and *Bythotrephes cederstroemi*) and macrozoobenthos (chironomids and amphipods). *Bythotrephes cederstroemi* were found in white perch stomachs from all years except 1991 and comprised up to 31 % of the mean percent volume (Figure 2.2.2-1). Amphipods made up from 1 to 16 % of the diet in a particular year. Chironomids accounted for 6 to 22 % of the food volume, while Hexagenia appeared in higher volumes in 1995 than in previous years. Fish were not an important food item in most years, except in 1990 when they contributed 50 % of the mean percent volume. Mollusks were not as important a food item in white perch as they were to yellow perch. Zebra mussels usually comprised less than 3 % of the food volume in white perch stomachs.

2.2.3 Lake Erie Food Web Study, 1995

A partnership study involving Environment Canada, The Lake Erie Fish Packers and Processors Association and the Ontario Ministry of Natural Resources was conducted between June 26 and October 26, 1995. Approximately 1700 fish stomachs were examined from walleye, smallmouth bass, yellow perch, white perch, channel catfish, salmonids, coregonids, white bass, burbot, and freshwater drum. Although originally intended to cover the whole lake, the majority of samples were from the western and central basins.

Walleye stomach contents are shown in Figures 2.2.3-1 and 2.2.3-2. Generally clupeids and smelt are the major component of walleye diet with smelt assuming a greater role moving from west to east. OMNR data indicated that yellow perch were consumed by yearling walleye (<15" total length) in July and August in the western basin. Yellow perch were not present in the diets of larger walleye or any walleye from later in the year.

2.2.4 Walleye/ Yellow Perch Interactions Western and Central Basin

(by J. Tyson)

In a cooperative study between the Ohio Department of Natural Resources and the Ohio State University, walleye stomachs from the western and central basins of Lake Erie were examined on a monthly basis, as well. Walleye were collected monthly using bottom trawls from ODNR stations in both Sandusky and Fairport. Approximately 1500 walleye stomachs were examined in 1995 by Mark Kershner at the Ohio State University, with several hundred being included in the following figures. Seasonal diets of age-1 and older walleye were quite diverse, but similar to the data collected by OMNR Partnership Gill Net surveys (Figure 2.2.4-1). In the western basin, spottail shiners comprised a large portion of the diet early in the year, while later in the year, gizzard shad were the major component of walleye stomachs. Western basin walleye did consume yellow perch in May and June, but seldom consumed them later in the year. In the central basin, spottail shiners and rainbow smelt were important in the diet throughout the year, while gizzard shad became more important later in the year, as age-0 clupeids became vulnerable to walleye predation. Yellow perch, again were present in the diets of walleye, but, they were present mainly in July walleye diets. Other species that showed up in the diets of walleye were *Morone* spp., emerald shiners, freshwater drum, walleye, and trout perch.

3.0 Interagency Trawling

An ad-hoc task group, called the Interagency Index Trawl Group (ITG) was formed in 1992 to: 1) review the interagency index trawl program in western Lake Erie and recommend standardized trawling methods for measuring fish community indices, and; 2) lead in the calibration of agency index trawling gear using SCANMAR acoustical instrumentation. Upon their termination in March 1993, the ITG recommended that work on interagency trawling issues be continued by the FTG on four matters. Progress on these charges are reported below

3.1 Calibration of Bottom Trawls (by J. Tyson and K. Muth)

Interagency Testing of the Bottom and Midwater Trawl in Lake Erie

Introduction

Historically, several natural resource agencies have participated in assessment of Lake Erie predator and forage fish populations using bottom and midwater trawls. Information obtained from annual assessments by these agencies are frequently compared or combined to examine trends in abundance. But, because of differences in both gears used and gear configuration, comparison or combination of these abundance estimates may not be totally valid. In this cooperative study, four state (MDNR, NYSDEC, ODNR, and PFBC) , one provincial (OMNR) and one federal (U.S. NBS) natural resource agencies participated in an interagency effort to quantify the fishing characteristics of each agency's trawls. This was done in order to standardize trawling procedures and to develop correction factors that would adjust for differences in total volume sampled for among the various trawls. Ohio and Ontario have participated in an annual interagency trawling program conducted in August of each year since 1987. This information is currently being used by Mark Kershner (a Ph.D. student at Ohio State University) to generate western basin abundance and biomass estimates. Mark is currently generating volumetric estimates for Ohio and Ontario trawling series based upon trawl opening estimates from the 1992 SCANMAR exercises. For this series of SCANMAR tests, a more specific and structured experimental design was used, with all boats getting estimates of trawl opening in the same waters, with similar weather, and using each agencies standard tow configuration. We had hoped to generate more accurate estimates of the trawl opening, during the deployment and retrieval stages, and during the actual fishing stage.

Western Basin Methods

The Lake Erie Biological Station of the National Biological Service had access to the SCANMAR hydroacoustic gear that was required for conducting these tests and assumed the lead role in conducting this project. Ken Muth, of NBS, was the principle planner and coordinator of the effort. For convenience, field trials were conducted in two areas, one in the eastern basin, and the other in the western basin. Agencies in the western basin tested bottom trawls off-shore of

Cedar Point, Ohio in the 9-11 m depth stratum on July 10-13. Agencies in the eastern and central basins of Lake Erie conducted testing of both bottom and midwater trawls in off-shore waters of Erie, Pennsylvania on July 19-20. First, we will address the results from agencies involved in the western basin trawl session (MDNR, NBS, ODNR, OMNR), with results from the eastern basin SCANMAR series following.

The SCANMAR equipment consisted of an onboard receiver, a towed transducer, and three transmitters or sensors. The headrope sensor was mounted just behind the headrope, centered on the top of the trawl. It measured the gape height or vertical opening of the trawl. The wing sensors were mounted to the headrope at the ends of the wings of the trawl to measure the largest horizontal opening, or wing spread of the trawl. Data were logged electronically aboard ship via a serial communication link to a portable PC. Acoustic signals were processed at five second intervals. Data logging began soon after the trawl doors entered the water when possible, or after the bridle had spooled out.

The size and construction of index bottom trawls used by each agency in the western basin trawling series were similar (Table 3.1-1) but trawl configurations differed for each agency. Each test run consisted of a single 10 minute tow. The opening of the trawl (vertical gape and wing spread) fluctuated throughout the entire sequence of steps of each test, but was considerably more erratic during deployment and retrieval. For the most part, size and shape of the trawl opening, while different among the various trawls tested, had stabilized within about three minutes from when data logging commenced. Based upon these observations, I divided each test run into two segments: 1) an initial deployment stage (first three minutes of logged data) and; 2) a fishing stage. Designation of a third stage, characterizing the retrieval portion of each trawl test was not possible because the transducer had to be removed from the cable before the trawl was completely hauled aboard ship. I assumed trawl opening size during net retrieval was the same as during net deployment. I used a conservative estimate of the surface area fished defined as trawl surface area - 2 standard errors to describe the net opening during these periods. I used the mean to describe the surface area sampled during the fishing stage of each trawl test. Possible effects attributable to herding (by sweeplines and doors) were not considered.

Because tow speeds varied between organizations, total distance that the standard ten minute tow was fished varied between organizations. From estimates of tow speed, I generate a distance sampled by each boat during the actual ten minutes that the trawl was assumed to be on the bottom and stable. Therefore, based upon actual distance sampled and surface area during stage two, or the stable stage, I computed an estimate of volume filtered when the trawl was on the bottom. During the standard ten minutes while the trawl was on the bottom the mean estimate of surface area was used as the estimate of surface area fished.

Volumes sampled during net deployment and retrieval were difficult to quantify because deployment and retrieval proceeded at different rates depending upon the winch characteristics and scope used. To compute the total volume filtered by each net during net deployment and retrieval, I had to make some broad assumptions because I lacked some of the information needed at the time of the analyses. I had actual estimates of distances towed during net deployment and retrieval for only the ODNR and OMNR boats, therefore, I generated estimates of time for deployment based on ODNR trawling series and applied these to the MDNR and NBS boats involved. Based upon these time estimates and individual tow speeds, I computed distances towed during net deployment and retrieval. Then the net surface areas for each boat during stage one, the unstable stage, were applied to the distances towed and a volume sampled was computed.

Western Basin Data Analysis &Results

Trawl mensuration data from SCANMAR testing were analyzed using SAS. The two stanzas of the data were compared to determine whether the net fished differently during the two stages. If there are significant differences, the data will be analyzed separately to determine whether there were any significant differences in the surface area and dimensions of the trawls being fished by each organization during these two stanzas. Each set of test results consisted of approximately 36 observations for stage one and 120 observations for stage two, with each observation containing measures of gape height and wing spread. Note that each 5 second reading was considered as an independent observation, which may violate rules of independence. Distribution plots of trawl opening data were not normally distributed and had several outliers. Most of these outliers we attributed to inaccurate sensor readings. I eliminated these inaccurate readings by bounding the data set by the 5th and 95th percentiles. Neither bounding the data set, or a log transformation of the data normalized the data, therefore I used a Kruskal-Wallis/Dunn's multiple comparison test to detect significant differences in the data collected by organization.

A Kruskal-Wallis test indicated that there were significant differences in the surface areas fished by each agency net during net deployment/retrieval and the stabilized stage ($p < 0.0001$). Therefore, the data from the deployment and fishing stages were analyzed separately. Experimentwise error rate for the multiple comparisons was set at 0.15, therefore significance levels for each individual test was at the 0.0125 level. A Kruskal-Wallis test indicated that there were significant differences in the surface area sampled during the two operation stages (deployment and fishing stages, respectively) among agencies. Dunn's multiple comparison procedure indicated that the surface area of the MDNR net was significantly greater than that of the ODNR, the OMNR, and the NBS nets during the deployment stage (Table 3.1-2). The surface area of the ODNR net was also significantly greater than either of the OMNR and NBS nets. During the fishing period, when the trawl was most stable, the surface area of the MDNR net was significantly greater than that of all of the other nets tested (Table 3.1-3). Surface areas of the ODNR and NBS nets were statistically similar, but significantly greater than the OMNR net.

Because differences in the surface areas of the nets appeared significant, I attempted to quantify the shape of the net openings based on gape height and wing spread. In theory, two nets could fish the same total water volume, but differ in terms of mount of area fished (horizontally) on the bottom, and (vertically) in the water column. Again, a Kruskal-Wallis test indicated significant differences in wing spread and gape height between the two operational periods, therefore these periods were analyzed separately. For both operational periods, the Kruskal-Wallis test revealed significant differences in both gape height (p=0.0001, n=334, and p=0.0001, n=334, respectively) and wing spread (p=0.0001, n=206, and n=0.0001, n=206, respectively) among agency nets. During deployment, the gape height of the nets fished by MDNR and ODNR were significantly greater than those fished by OMNR and NBS (Table 3.1-4). The OMNR net also had a significantly higher gape than the NBS net. Dunn's multiple comparison test indicated that the wing spread of the net fished by ODNR was significantly less than the other agency nets (Table 3.1-5).

Dunn's multiple comparison test indicated that the gape height was significantly greater in the ODNR net than the other agency trawls during the fishing stage (Table 3.1-6). Also, gape height of the OMNR net was significantly greater than the nets fished by the NBS and MDNR. Gape height of the NBS net was greater than that of the MDNR. As expected, wing spread was inversely related to the gape height. MDNR's net opened wider than all of the other nets; wing spread of the NBS net was the second highest, followed by the OMNR net (Table 3.1-7). ODNR's trawl had the smallest wing spread.

Again, in order to compare total volume sampled by each net I had to use some information from Ohio trawls and apply these to MDNR and NBS nets. The amount of time for deployment and retrieval varied by depth, but mean time fished during net deployment and retrieval was 1.98 minutes at 0-3 m depths, 2.10 minutes at 3-6 m depth strata, 3.14 minutes at 6-9 m depth strata, and 4.62 minutes at depths greater than 9-m. I applied these time estimates to the other agency trawls (a rough estimate at best) and tow speed estimates for each boat and made a conservative estimate of total volume filtered by each trawl for the various depth strata (Tables 3.1-8-11). Because the estimates for time of net deployment and net retrieval were based on a 3:1 scope, these would be a conservative estimate for the MDNR boat. Also computed were conversion rates standardized to the water volumes sampled by the MDNR trawl. These estimates showed that, depending on water depth, the Michigan net sampled from 1.2-1.8 times as much water as the other nets.

Eastern Basin Method and Results

Trawl tests in the eastern basin were conducted on July 19-20 at Erie, Pennsylvania for vessels from Pennsylvania Fish and Boat Commission (PFBC), New York State Department of Conservation (NYSDEC), and the National Biological Service (NBS). Testing for the Ohio Department of Natural Resources (ODNR) boat in Fairport, Ohio, were conducted July 28, at Fairport, OH. Because each agency participating in the eastern basin exercise had several different trawl types to test, testing was done differently than in the western basin. Also, because only two boats made bottom trawl tows in the eastern basin, analyses of the data will consist primarily of a characterization of both bottom and midwater trawl opening based upon gape height and wing spread.

SCANMAR equipment and setup used in the eastern basin trawling series was identical to that used in the western basin series. Bottom trawl construction and size was slightly different for all agencies in the eastern basin trawling series (Table 3.1-1). Midwater trawl construction and size also varied for each agency (Table 3.1-12). Each agency made several tows under similar conditions, along the 10-m depth contour. The measurements of wing spread, gape height, and surface area were then compared using analysis of variance to determine whether there were significant effects attributable to tow number, or whether they could statistically be combined. Data from the first three minutes during deployment were excluded from the analyses because of trawl instability, and again the data sets were bound by the 5th and 95th percentiles to eliminate outliers that we attributed to inaccurate sensor readings. Mean wing spread and gape height were then computed from these pooled data for bottom trawls. Midwater trawl samples varied as to duration, speed, direction, and towing warp. For midwater trawls, mean wing spread, gape height, and surface area are reported by tow number (Table 3.1-13).

Discussion

The western basin SCANMAR exercise indicated that the so-called 'standard trawls' used by Lake Erie agencies to assess fish stocks, while similar in size and construction, are not fished in a standard manner, and this results in quite different volumes of water sampled. Our tests showed that the nets fished by ODNR, NBS, MDNR, and OMNR sampled significantly different volumes of water. Although differences in the surface areas fished among agency nets were not large (range of 5.817-7.176 m^2) (Tables 3.1-2-7), when multiplied over the distance of a standard ten minute tow (approximately 0.70 km), the volumes of water sampled and number of fish caught could be potentially much different (Tables 3.1-8-11). Keep in mind, however, that these estimates are based on a few broad assumptions and therefore, should be considered as preliminary.

Even if we can standardize total water volumes filtered by the various trawls (Tables 3.1-8-11), there still appear to be significant differences in how these nets fish in the water column (i.e. gape height relative to wing spread) (Tables 3.1-4-7). Our results indicate that of all the nets tested, MDNR trawls probably fished the bottom more effectively because of its wide, but low net opening (Figure 3.1-1). The ODNR net had the smallest wing spread and the highest gape, and therefore probably fished the water column more effectively. The nets fished by the NBS and OMNR were intermediate in both wing spread and gape height. The various trawls we tested were similar in dimensions and construction, therefore, most of the variability in total water volume sampled can probably be attributed to gear configuration and tow speed (Table 3.1-1). In particular, the short bridle length of the ODNR net probably restricted the wing spread on this net and permitted the larger vertical gape. The MDNR net had the longest bridle length; maximum wing spread of this net was probably restricted more by the head and foot rope lengths than by bridle length. Reasons for the small wing spread on the net fished by OMNR, which used a double warp, are unclear, but may be a function of door weight or tow speed. Nonetheless, these differences in how the different trawls fish could translate into some rather large differences between agencies in estimates of species abundance and composition, based on spatial distributions of pelagic versus benthic fishes. SCANMAR results in the central basin indicated that several tows need to be made in various weather and bottom conditions to get a representative sample of the range of trawl dimensions. Trawl tows made in the same day by agencies in the eastern basin showed relatively low coefficients of variation for each tow (<10%), but tows could not statistically be combined. Nonetheless, we combined them to get a representative estimate of trawl dimension variability. Midwater trawls appeared to be slightly more variable in their fishing dimension than the bottom trawls.

3.2 Central Tendency Statistics

Resource management agencies on Lake Erie typically report the relative abundance of selected fish species from index trawls as an arithmetic mean or geometric mean catch per unit effort (catch per trawl hour). B. Haas has been leading a charge to determine the most appropriate statistic for describing relative abundance. He has written a computer program that simulates trawl catches of fish from populations of known size and distribution characteristics. The arithmetic mean, geometric mean, and median are generated from multiple trawl catch simulations. These statistics are then evaluated on the basis of how close they approximate the known (true) population size. Both B. Haas and D. Einhouse have also consulted statisticians at MSU and NYSU for advise on the matter. Development and application of the trawl catch simulation program is also continuing and no results were available for this report.

3.3 Summary of Species CPUE Statistics (by J. Tyson)

Interagency trawling in August has been conducted in Ohio, Michigan, and Ontario waters of the western basin of Lake Erie from 1987-1995. This interagency trawling series was developed to more precisely measure basin-wide fish community indices including growth and abundance of forage species. Information collected during interagency trawling surveys include species specific length and abundance data. A total of 80-100 standardized tows per year are conducted in Ohio, Michigan, and Ontario waters of Lake Erie's western basin. Tows are stratified into four depth strata (0-3 m, 3-6 m 6-9 m, and >9 m).

Historically, indices as computed from standard bottom trawling have been reported as relative indices, meaning they are not based upon a volumetric estimate. Therefore, interagency trawl data could only be compared on a qualitative basis. In 1992, the Interagency Trawling Group charged the Forage Task Group with development of standardized trawling procedures and calibration of agency trawls such that the indices could be combined and quantitatively analyzed. Preliminary calibration work was done in 1992 by several Lake Erie agencies using SCANMAR acoustic equipment to assess the dimensions of the bottom trawls being used.

Mark Kershner has developed a program that uses the information from SCANMAR trials in 1992, and total trawling distance, and catches from the interagency trawling. Using this program, Mark is able to assign a volume sampled to each tow. The estimate of volume sampled by each tow in conjunction with the species specific abundance estimates of each tow allow for computation of a species-specific quantitative abundance estimate (in # /m^3) for each tow. Additionally, using the volumetric estimate of abundance in conjunction with the length data from the interagency trawls, Mark generated a species-specific biomass estimate (in g /m^3) for each tow. These estimates were then extrapolated by depth strata to the entire western basin of Lake Erie.

Estimates of total prey abundance and biomass available to piscivores were plotted across years (Figure 3.3-1). Annual trends in forage biomass across years are similar between Ohio and Ontario, also both abundance and biomass appear consistently higher in Ohio waters. Estimates of total prey abundance appears to be decreasing, with total abundance in 1995 being the lowest on record. Trends in biomass are similar, although not quite as pronounced as trends in abundance. Estimates of forage group specific (clupeids, soft-rayed, and spiny-rayed forage) abundance and biomass estimates were also computed for the western basin (Figure 3.3-2). These estimates show large declines in both abundance and biomass of spiny-rayed forage, while modest increases in clupeid abundance in the 1990's. The data from 1995 again was the one of lowest on record for spiny-rayed and clupeid abundance and biomass, indicating that 1995 was probably a poor growth year for most piscivores in the western basin.

Last year, Mark examined the effects of depth on total prey abundance and biomass estimates and determined that the two shallow depth strata (0-3 m and 3-6 m) could be pooled, and that the two deeper depth strata (6-9 m and >9 m) could also be pooled. The trawling program has recently been completed and will be distributed to task group members in the near future. This trawling program currently uses trawl dimension information from the 1992 SCANMAR series, but hopefully we will be able to refine these estimates further and update the volumetric estimates in the future. Also, in the near future, we hope to use the trawling program to compare growth data among areas within the western basin, and examine the effects of water transparency, temperature, and dissolved oxygen on catch rates, and shifts in community composition.

4.0 Results of the Lake Erie Lower Trophic Level Survey of Lake Erie Agencies and Institutions (by Tom Czapla)

A survey letter was sent to 46 contact names at federal, state/provincial and university/college institutions to determine existing information regarding historic or present populations of zooplankton, phytoplankton or benthos. A total of 22 responses were returned (47.8%); one reported no collections made in Lake Erie by their institution (Table 4.0-1). Two others submitted a list of their or their associates publications as a bibliography. The other respondents sent detailed information regarding projects they were presently conducting or participated in the past listing a total of 84 projects (Table 4.0-2).

Currently, five contacts indicated ongoing monitoring efforts or other studies in the lower trophic levels which were being conducted:

Contact	Project Title
Einhouse	Forage Task Group Zooplankton Monitoring
Klarer	Phytoplankton of Old Woman Creek National Estuary Research Reserve
McDermott	Lake Erie Trophic Transfer
Reynoldson	Long term monitoring of Lake Erie benthos
Stewart	Student sampling

One result from this survey is an extensive reference list of publications regarding lower trophic level surveys, monitoring and/or studies which were conducted in Lake Erie. This bibliography is currently being computerized and annotated for potential use by the FTG.

In addition, specific site information is being processed for a historic component or use as attribute data in a geographic information system.

5.0 Fisheries Acoustic Survey of Eastern Lake Erie

(by D. Einhouse, L. Witzel and L. Rudstam)

5.1 Introduction

Since 1993, the Forage Task Group has pursued a charge to evaluate acoustic techniques as an additional assessment approach for eastern basin smelt stocks. This effort was undertaken with the knowledge that acoustic techniques offer potential benefits of high sampling power and high precision in estimating limnetic fish abundance. Obstacles for applying acoustic techniques are usually identified as the high initial investment for equipment, the need for specialized expertise, poor species discrimination and applications restricted to limnetic species. Our ongoing efforts have proceeded to evaluate a Lake Erie acoustic survey application for smelt relative to these perceived benefits and obstacles.

Many of the questions about the merit of acoustic surveys as a smelt assessment tool on Lake Erie have been addressed in evaluations prior to 1995 (Witzel et al. 1995). However, a few outstanding issues remained for this report. Beginning in 1995, the remaining objectives for this acoustic survey evaluation have been: 1.) replicate the mid-summer acoustic survey that has been underway since 1993; 2) validate our acoustic abundance and target strength estimates by duplicating a transect with a modern split beam sonar; 3.) increase mid-water trawl samples with improved sampling gear, and; 4.) conduct an October acoustic survey of smelt distribution and abundance .

5.2 Methods

The 1995 mid-summer, fisheries acoustic survey of Lake Erie's eastern basin was conducted from July 21 to 29, 1995. The location of nighttime acoustic transects completed during this survey is shown in Figure 5.2-1. Acoustic data acquisition was conducted aboard the New York State Department of Environmental Conservation's research vessel **Argo.** In Canadian waters, nighttime, midwater trawl collections and temperature profiles were conducted concurrently with acoustic data acquisition by the Ontario Ministry of Natural Resource's research vessel, **Keenosay**. Nighttime mid-water trawling was generally conducted in the vicinity of high fish densities as indicated by acoustic data. A daytime bottom trawl survey in New York waters was conducted immediately preceding the acoustic survey and provided supplemental observations on fish species composition.

A limited autumn acoustic survey was also conducted from October 12 to 14, 1996, and repeated the three easternmost transects of the July survey (4235, 58600, 59080). This more limited autumn survey did not include any accompanying mid-water trawl collections.

The New York State Department of Environmental Conservation owns a 15 year old single beam echosounder (Simrad EY-M, 7024 transducer) that has been available for this acoustic survey evaluation. This 70-kHz single beam acoustic system was used for both summer and fall surveys. Signal calibration was conducted at the beginning and end of the summer survey period by suspending a known target in the sound beam. Voltage responses from these two calibration events suggest the echosounder was stable throughout the summer survey. A calibration sphere of known target strength was not available for the fall cruise but calibration with a ping pong ball suggested that the acoustic system did not drift. However, a comparison of calibration efforts from 1993 to 1995 produced a range of measured response of 1.7 dB. This was more than expected and may have been due to difficulty in centering the calibration sphere on the transducer beam. Data acquisition occurred at a vessel speed of 6.0 knots with a transducer affixed to a towed body 1-m below the lake surface. Acoustic signals were collected at 40logR TVG (Time Varied Gain) and recorded on digital-audio tape for subsequent processing in the lab.

The Hydro Acoustic Data Analysis System (HADAS) developed by Lindem (1990) was used to digitize and convert signals to fish densities by a deconvolution algorithm for single fish echoes. This signal processing computer card and software has been borrowed annually from Dr. Lars Rudstam at Cornell University. Processed data describing fish density by target strength (TS) were stratified vertically by four thermal zones (epilimnion, thermocline, upper and lower hypolimnion) and horizontally by three bottom depth contours (15-25 m, 25-35 m, >35 m) for more conventional analysis with SAS programs. Fish echos were also segregated into three groups based on target strength (TS) ranges. Small, young-of-the-year (YOY) forage fish (-56 to -53 dB), large, yearling-and-older (YAO) forage fish (-52 to -43 dB), and large fish (> -43 dB) were grouped to TS ranges for analysis.

5.3 Results

The 1995 acoustic surveys were wrought with problems that prevented full attainment of the outlined methods. The Simrad EY-M echosounder was sent to the manufacturer for routine service prior to the mid-summer assessment, but was not fully operational when returned for the survey. A ping rate too rapid for some surveyed depths resulted in voided observations for the deeper (>55 m) portions of the basin. Also, some data were also lost when one tape became misplaced during the signal processing task that occurred subsequent to the mid-summer survey. Finally, the autumn cruise was abbreviated due to poor weather. Nevertheless, enough usable data were collected to characterize the 1995 pelagic forage fish resource relative to the previous two years.

The July, 1995 mid-water trawl tows that accompanied the acoustic survey effectively sampled the pelagic forage fish community for the first time in the three year investigation. Smelt ranked as the dominant pelagic species in each of three thermal strata sampled by the mid-water trawl, but were essentially the only pelagic, forage fish found in the thermocline and hypolimnion layers of the water column (Table 5.3-1). Young-of-the-year (YOY) smelt were most abundant in the epilimnion layer, while yearling-and-older (YAO) smelt represented the age groups primarily found in the thermocline and hypolimnion.

Daytime bottom trawling in hypolimnion waters was also conducted only one week prior to the July acoustic survey as part of another independent assessment that occurred in New York waters. This bottom trawl survey found predominantly yearling-and-older (YAO) smelt sampled from bottom, hypolimnion waters. Three years of mid-water and bottom trawl collections have consistently described YAO smelt as essentially the only pelagic forage fish species residing in coldwater habitat during this July survey (Table 5.3-1).

Mid-summer acoustic density estimates of YOY- and YAO-sized forage fish along transects in 1994 and 1995 are depicted in Figures 5.3-1 and 5.3-2. During each summer, the Dunkirk vicinity had particularly high densities of forage fish, while the middle of the eastern basin and the easternmost transect had the lowest densities. Mean density estimates of YAO-sized forage fish in cold water habitat were expanded to the total surface area encompassed by each depth stratum to provide estimates of total coldwater forage fish abundance (Table 5.3-2). This estimate of YAO-sized fish abundance in coldwater habitat over the last three years has been ascribed as the acoustic survey's YAO smelt index. This 1995, mid-summer, YAO smelt index (1.06 billion) was 2.7 times higher than the 1994 estimate (388 million). However, the accuracy of these indices as absolute measures of YAO smelt abundance remain in doubt because of the wide overlap in TS distributions with smaller fish. Also, mid-water trawl samples usually found YAO smelt as the most abundant fish in the epilimnion stratum, which was excluded from our definition of smelt habitat. Our definitions of a YAO smelt target strength range (-52 to -43 dB), and smelt habitat (thermocline and hypolimnion), are very likely underestimating absolute levels of abundance. As such, abundance estimates in this report remain best viewed as indicators of relative abundance.

The limited October acoustic survey produced a YAO smelt density estimate of 1.36 billion fish. We recalculated the mid-summer densities for only the transects that were replicated in the autumn survey and produced a mid-summer estimate of 1.30 billion YAO smelt (Figure 5.3-3). These very similar estimates, regardless of thermal habitat, were calculated from transects 59080, 58920, and 4235 for both summer and fall surveys (Figure 5.3-3). Mid-water trawl collections did not accompany the October survey. However, independent daytime bottom trawl collections suggested that some fraction of the YOY and small yearling forage fish may have recruited to the -52 to -43 TS range.

5.4 Discussion

The 1995 acoustic survey results found considerably higher densities of YAO smelt present during the mid-summer period relative to the previous two years. However, this resource was largely concentrated along the New York waters of the eastern basin near Dunkirk. A more limited fall survey focused on the eastern half of the basin, including the Dunkirk vicinity, and found YAO smelt densities to be very similar to those estimated during the summer survey . However, some confounding problems for interpreting the fall survey data are that forage fish age/size groupings become less distinguishable from TS distributions as there is increasing overlap in the length frequency distributions of the YOY and YAO cohorts. As such, accompanying mid-water trawl collections are perhaps more imperative as an element of any future fall acoustic surveys.

Finally, we believe the three year (1993-1995) evaluation of acoustic techniques has now fully addressed this charge to the Forage Task Group. This 3-year trial demonstrated that acoustic methods do offer high sampling power as entire eastern basin surveys were completed in one week. Also, this high sampling power produced smelt abundance estimates with precision exceeding ongoing trawl surveys, and without the inherent distributional bias of independent bottom trawl surveys from three agencies. The acoustic surveys also demonstrated that the potential limitation of species discrimination is not an impediment in eastern Lake Erie as smelt represent over 90 percent of the species encountered in offshore areas. Also, the potential constraint of specialized expertise has not emerged as an issue because Dr. Lars Rudstam is a technical expert in acoustic methods and is a member of the Forage Task Group. Other members of the FTG continue to gain fundamental skills in acoustic surveys as our experience now spans 3 years. However, the impediment of attaining modern equipment is an ongoing problem. The equipment used for this 3-year investigation, although functional, remains old and is no longer manufactured. This 70-kHz system also has a detection threshold perilously close to the detection limits for YOY smelt. As such, if acoustic surveys are to become an ongoing, annual assessment tool used by the FTG, obtaining new equipment ranks as the greatest operational need to conduct these surveys. Secondly, it has also become apparent that specialized geostatistical methods are probably most appropriate for fish abundance estimation with acoustic data and this specialized statistical expertise not available within the FTG. An ongoing survey would need development of a survey design with accompanying spatial statistical methods for analysis.

6.0 References

Lindem, T. 1990. Hydro Acoustic Data Acquisition System (HADAS) Instructional Manual. Lindem Data Acquisition, Oslo.

Witzel, L., M. Bur, T. Czapla, D. Einhouse, R. Haas, C. Murray, K. Muth, S. Nepszy, L., Sztramko, M. Thomas, and J. Tyson. 1995. Report of the Forage Task Group. 1995 Report to the Lake Erie Committee and the Great Lakes Fishery Commission 38 pp.

Table 2.1.1-1 Indices of relative abundance of six forage fish species in Eastern Lake Erie from bottom trawls conducted by Ontario, New York and Pennsylvania in 1995 and 1994. Indices are reported for the age-groups young-of-the-year (YOY) and yearling-and-older (YAO). A long term average is reported in some cases

Species	Trawl Survey	YOY			YAO		
		1995	1994	LT Avg	1995	1994	LT Avg
Smelt	ON-DW	67.7	265	403	30.6	4.4	74.1
	NY-Su				6861	2091	7178
	NY-Fa	683	232		128	5.4	
	PA-Fa	58	3598	3281	88	40.4	1436
Emerald Shiner	ON-DW	2.2	2.4	1.9	1	0.5	4
	ON-OB	1.3	2.2	1.1	1.3	1.4	1.2
	NY-Fa	29.3	0		6.9	0.1	
	Pa-Fa	0.9	1.1	66.8	0	3.8	31.2
Spottail Shiner	ON-OB	54.6	110	31.1	6.7	8.9	3.3
	ON-IB	7.6	3.2	8			0.9
	NY-Fa	4	1.2		1.7	1.7	
	PA-Fa	1.7	0	1.1	2.9	0	7.9
Alewife	ON-DW	0.5	0.6	3.7			
	ON-OB	0.7	1	1.6			
	NY-Fa	2.6	0.2		0.6	0.1	
	PA-Fa	0	0	9.9	0	0	24.8
Gizzard Shad	ON-DW	<0.1	0.5	1.7			
	ON-OB	1.1	2.4	2.2			
	NY-Fa	0.4	0.3		0	0	
	PA-Fa	0	0	33.2	0	0	0.7
White Perch	ON-DW	0.5	1.23	1.1			
	ON-OB	0.5	7.1	2.3			
	NY-Fa	5.9	9.4		0.8	0.7	
	PA-Fa	5.4	138	523	0	0	42.7

Ontario Ministry of Natural Resources Trawl Surveys

ON-DW	Trawling is conducted weekly during September and October at 4 fixed stations in the offshore waters of Outer Long Point Bay using a 10-m trawl with a 13-mm mesh cod end liner. Indices are reported as GMCPTH and LT Avg is for the period 1984 to 1994.
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. Indices are reported as GMCPTH and LT Avg is for the period 1980 to 1994.
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. Indices are reported as GMCPTH and LT Avg is for the period 1980 to 1994.
ON-EB	A systematic survey of Ontario's Eastern Basin waters conducted during September using 10-m trawl with a 13-mm mesh cod-end. Indices are reported as GMCPTH and LT Avg is for the period 1991 to 1994.

New York Department of Environment Conservation Trawl Surveys

NY-Su	Trawling is conducted at 14 stations in stratified waters (< 36 m) during July using a 10-m trawl with a 9.5-mm mesh cod end liner. Indices are reported as arithmetic mean catch per trawl hour and LT Avg is for the period 1987 to 1994.
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 GMCPTH and a LT Avg is not reported for this survey, which started in 1991.

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 GMCPTH and LT Avg is for the period 1984 to 1994.

Table 2.1.2-1 Indices of relative abundance of forage species in the central basin of Lake Erie from bottom trawl surveys conducted by Ohio and Pennsylvania in 1994 and 1995. Indices are reported for age groups young-of-the-year (YOY) and yearling and older (YOA). A long-term average (LT Avg.) is reported in some cases.

Species	Trawl Survey	YOY			YAO		
		1994	1995	LT Avg	1994	1995	LT Avg
Alewife	ODNR-Fa	1	1	20	—	—	—
	PFBC-Fa	0	0	50	0	0	14
G. Shad	ODNR-Fa	2	4	12	—	—	—
	PFBC-Fa	1	0	127	0	0	< 0.5
Smelt	ODNR-Fa	139	117	543	8	43	52
	PFBC-Fa	1100	241	6627	2	1049	1051
E. Shiner	ODNR-Fa	27	26	191	9	83	266
	PFBC-Fa	0	48	104	1	21	81
S. Shiner	ODNR-Fa	0	1	33	0	3	24
	PFBC-Fa	0	20	2	0	40	5
T. Perch	ODNR-Fa	4	11	50	—	—	—
	PFBC-Fa	2	65	7	5	135	98
W. Perch	ODNR-Fa	369	14	615	—	—	—
	PFBC-Fa	109	101	1176	—	—	—
Y. Perch	ODNR-Fa	28	5	28	—	—	—
	PFBC-Fa	263	125	97	—	—	—
Drum	ODNR-Fa	33	3	18	—	—	—
	PFBC-Fa	--	--	–	—	—	—

ODNR-Fa Trawling is conducted in October at offshore stations in Ohio waters of the central basin of Lake Erie using a 10-m bottom trawl with 13-mm mesh cod end liner. Indices are reported as GMCPTH. LT Avg. is for the period from 1976-1994.

PFBC-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 GMCPTH and LT Avg is for the period 1984 to 1994.

Table 2.1.3-1 Indices of relative abundance of forage species in western Lake Erie from bottom trawl surveys conducted by Ontario and Ohio in 1994 and 1995. Indices are reported for the age groups young-of-the-year (YOY) and yearling and older (YOA). A long-term average (LT Avg.) is reported in some cases.

Species	Trawl Survey	YOY			YAO		
		1994	1995	LT Avg	1994	1995	LT Avg
Alewife	ODNR-Fa	0	0	262	—	—	—
	OMNR-Su	17	12	522	—	—	—
	OMNR-IA	—	—	—	—	—	—
G. Shad	ODNR-Fa	3	18	75	—	—	—
	OMNR-Su	51	9	302	—	—	—
	OMNR-IA	—	—	—	—	—	—
Smelt	ODNR-Fa	0	0	95	0	2	3
	OMNR-Su	251	1	90	—	—	—
	OMNR-IA	0	5	114	—	—	—
E. Shiner	ODNR-Fa	0	42	125	0	3	3
	OMNR-Su	0	16	8	—	—	—
	OMNR-IA	—	—	—	—	—	—
S. Shiner	ODNR-Fa	0	24	52	0	9	23
	OMNR-Su	0	2	7	—	—	—
	OMNR-IA	—	—	—	—	—	—
T. Perch	ODNR-Fa	0	129	120	—	—	—
	OMNR-Su	0	2	57	—	—	—
	OMNR-IA	—	—	—	—	—	—
W. Perch	ODNR-Fa	5223	435	1402	—	—	—
	OMNR-Su	2175	28	2907	—	—	—
	OMNR-IA	1824	612	4734	—	—	—
Y. Perch	ODNR-Fa	207	219	587	—	—	—
	OMNR-Su	1771	203	522	—	—	—
	OMNR-IA	950	1300	781	—	—	—
Drum	ODNR-Fa	150	27	446	—	—	—
	OMNR-Su	0	1	10	—	—	—
	OMNR-IA	1	<0.5	54	—	—	—

ODNR-Fa	Trawling is conducted at offshore stations in October in Ohio waters of the western basin of Lake Erie using a 10-m bottom trawl with 13-mm mesh cod end liner. Indices are reported as AMCPTH. LT Avg. is for the period from 1976-1994.
OMNR-Su	Trawling is conducted at 10 fixed sites every two weeks from July to September in Ontario waters of the western basin of Lake Erie using a 10-m bottom trawl with 13-mm mesh cod end liner. Indices are reported as AMCPTH. LT Avg. is for period from 1990-1994.
OMNR-IA	Trawling is conducted at fixed sites during August in Michigan and Ontario waters of the western basin of Lake Erie using a 10-m bottom trawl with 13-mm cod end liner. Indices are reported as AMCPHT. LT Avg. is for period from 1977-1994.

Table 3.1-1 Trawl specifications and configurations for trawls used in western basin SCANMAR trawling session.

Agency	Headrope Length	Footrope Length	Warp Type	Bridal Length	Door Size	Tow Speed	Scope
MDNR	10.3 m	11.8 m	Single	45.7 m	1.3 x 0.68 m	3.89 km/h	9:1
NBS	10.3 m	11.8 m	Single	20.7 m	1.1 x 0.51 m	3.70 km/h	3:1
ODNR-S[a]	10.3 m	11.8 m	Single	15.2 m	1.3 x 0.68 m	2.87 km/h	3:1
OMNR	10.3 m	11.8 m	Double	------	1.2 x 0.72 m	3.70 km/h	6:1
NYSDEC	9.7 m	11.6 m	Double	------	1.0 x 0.71 m	5.00 km/h	3:1
PFBC	10.1 m	12.6 m	Double	------	-------------[b]	5.56 km/h	3:1
ODNR-F[a]	10.6 m	------[b]	Double	------	0.9 x 0.90 m	2.41 km/h	3:1

[a] ODNR-S = ODNR-Sandusky and ODNR-F = ODNR-Fairport

[b] Not available at the time of analyses

Table 3.1-2 Mean, standard deviation, and median surface areas of nets during the deployment period during SCANMAR exercise in the western basin (values in m^2)

Agency	Mean	std	Median**	N
MDNR	14.16	2.79	15.68^A	32
ODNR-S	7.865	0.99	8.015^B	31
OMNR	4.856	0.52	5.190^C	33
NBS	3.643	1.78	4.181^C	30

**Values with different letters indicate significant differences using Dunn's multiple comparison test

Table 3.1-3 Mean, standard deviation, and median surface areas of nets during the fishing period during SCANMAR exercise in the western basin (values in m^2)

Agency	Mean	std	Median	N
MDNR	7.314	0.23	7.25^A	84
ODNR-S	6.804	0.36	6.83^B	71
NBS	6.671	0.81	6.38^B	80
OMNR	5.817	0.82	5.36^C	76

Table 3.1-4 Mean, standard deviation, and median gape height of nets from deployment period during SCANMAR exercise in the western basin (values in m)

Agency	Mean	std	Median	N
MDNR	2.742	1.22	2.41^{A}	32
ODNR-S	1.866	0.33	1.85^{A}	31
OMNR	0.927	0.10	1.00^{B}	33
NBS	0.619	0.29	0.69^{C}	30

Table 3.1-5 Mean, standard deviation, and median wing spread of nets during deployment period during SCANMAR exercise in the western basin (values in m)

Agency	Mean	std	Median	N
NBS	5.618	0.60	5.85^{A}	30
MDNR	5.738	1.35	6.56^{A}	32
OMNR	5.246	0.27	5.25^{A}	33
ODNR-S	4.252	0.27	4.38^{B}	31

Table 3.1-6 Mean, standard deviation and median gape height of nets during fishing period during SCANMAR exercise in the western basin (values in m)

Agency	Mean	std	Median	N
ODNR-S	1.538	0.08	1.56^{A}	71
OMNR	1.164	0.19	1.06^{B}	76
NBS	1.077	0.12	1.03^{C}	80
MDNR	1.020	0.03	1.00^{D}	84

Table 3.1-7 Mean, standard deviation, and median wing spread of nets during fishing period during SCANMAR exercise in the western basin (values in m)

Agency	Mean	std	Median	N
MDNR	7.170	0.08	7.19[A]	84
NBS	6.193	0.03	6.19[B]	80
OMNR	5.017	0.11	5.06[C]	76
ODNR-S	4.421	0.04	4.44[D]	71

Table 3.1-8 Total area fished by each agencies nets in a standard trawl in the 0-3 m depth strata

Agency	Deployment Area Fished	10-minute Tow Area Fished	Retrieval Area Fished	Total Area Fished	Possible Conversion
MDNR	853.8	4741.9	853.8	6449.5	1.0
NBS	184.8	4118.2	184.8	4487.8	1.4
ODNR-S	330.3	3254.6	330.3	3915.2	1.6
OMNR	216.5	3891.0	216.5	4324.0	1.5

Table 3.1-9 Total area fished by each agencies nets in a standard trawl in the 3-6 m depth strata

Agency	Deployment Area Fished	10-minute Tow Area Fished	Retrieval Area Fished	Total Area Fished	Possible Conversion
MDNR	896.5	4741.9	896.5	6534.9	1.0
NBS	194.0	4118.2	194.0	4506.2	1.4
ODNR-S	338.4	3254.6	338.4	3931.4	1.6
OMNR	302.9	3891.0	302.9	4496.8	1.4

Table 3.1-10 Total area fished by each agencies nets in a standard trawl in the 6-9 m depth strata

Agency	Deployment Area Fished	10-minute Tow Area Fished	Retrieval Area Fished	Total Area Fished	Possible Conversion
MDNR	1342.9	4741.9	1342.9	7427.7	1.0
NBS	290.6	4118.2	290.6	4699.4	1.6
ODNR-S	596.7	3254.6	596.7	4488.0	1.7
OMNR	303.3	3891.0	303.3	4497.6	1.6

Table 3.1-11 Total area fished by each agencies nets in a standard trawl in the > 9 m depth strata

Agency	Deployment Area Fished	10-minute Tow Area Fished	Retrieval Area Fished	Total Area Fished	Possible Conversion
MDNR	1970.8	4741.9	1970.8	8683.5	1.0
NBS	426.5	4118.2	426.5	4971.2	1.7
ODNR-S	832.0	3254.6	832.0	4918.6	1.8
OMNR	346.3	3891.0	346.3	4583.6	1.9

Table 3.1-12 Mean and standard deviation of wing spread, gape height, and surface area values for central and eastern basin bottom trawls tested using SCANMAR, 1995.

Agency	Wing spread	std	Gape Height	std	Surface Area	std	N
PFBC	5.44	0.44	1.08	0.13	5.84	0.36	153
NYSDEC	4.32	0.20	1.12	0.11	4.80	0.33	189
ODNR-F[a]	5.89	0.02	1.70	0.02	9.99	0.12	34

[a] ODNR-F = Ohio Department of Natural Resources in Fairport Harbor, OH

Table 3.1-13 Trawl configurations and towing conditions for midwater trawls tested by NBS and NYSDEC. Wing spread and gape height are listed in meters, while surface area is in square meters.

Agency	Gear Type	Tow	Time (min)	Comments	Wing Spread	Gape Height	Surface Area
NYSDEC	14.3 m MWT	1	30	Into Sea	6.11	1.69	10.31
	14.3 m MWT	2	18	With Sea	5.10	1.91	9.75
NBS	7.8 m MWT	1	15	1000 rpm, with sea, 250' warp	3.82	2.25	8.59
	7.8 m MWT	2	10	800 rpm, with sea, 250' warp	4.36	2.48	10.80
	7.8 m MWT	3	7	1200 rpm, with sea, 250' warp	4.27	1.67	7.15
	7.8 m MWT	4	10	1000 rpm, with sea, 200' warp	3.99	2.16	8.58
	9.1 m MWT	5	15	1100 rpm, into sea, 250' warp	5.32	3.50	18.63
	9.1 m MWT	6	10	1100 rpm, with sea, 250' warp	4.94	3.41	16.89
	9.1 m MWT	7	10	900 rpm, with sea, 250' warp	5.12	3.56	18.23
	9.1 m MWT	8	10	900 rpm, with sea, 200' warp	4.87	3.59	17.45

Table 4.0-1. List of responses from contacts in a survey of lower trophic level work being conducted or historically conducted by their institution. Type: U/C is University or College; Fed is Federal agency; S/P is state or provincial agency. ND represents no data.

Contact Name	City	State	Country	Agency/Institute	Type	Response
Berg	Hamilton	OH	US	Miami University	U/C	Yes
Brandt	Buffalo	NY	US	SUC @ Buffalo	U/C	
Brinkhurst	Sydney	BC	CAN	DFO	Fed	
Bur	Sandusky	OH	US	USFWS	Fed	Yes
Cooley	Burlington	ONT	CAN	DFO	Fed	
DePinto	Buffalo	NY	US	SUNY @ Buffalo	U/C	
Dermott	Burlington	ONT	CAN	DFO	Fed	Yes
Einhouse	Dunkirk	NY	US	NYSDEC	S/P	Yes
Haas	Mount Clemens	MI	US	MDNR	S/P	Yes
Hartig	Detroit	MI	US	Wayne State University	U/C	Yes
Head, Biology	Buffalo	NY	US	Canisius College	U/P	
Head, Biology	Niagara Falls	NY	US	Niagara University	U/C	
Head, Biology	Binghamton	NY	US	SUNY @ Binghamton	U/C	
Head, Biology	Fredonia	NY	US	SUNY @ Fredonia	U/C	
Herdendorf	Columbus	OH	US	Ohio State University	U/C	
Johannson	Burlington	ONT	CAN	DFO	Fed	
Johnson	Columbus	OH	US	Ohio State University	U/C	
Kauss	Toronto	ONT	CAN	OMEE	S/P	Yes
Kenyon	Fairview	PA	US	PFBC	S/P	
Klarer	Huron	OH	US	OWC NERR&SNP	Fed	Yes
Knight	Sandusky	OH	US	ODNR	S/P	
Kounce	Cleveland	OH	US	Case Western Reserve	U/C	
Krieger	Tiffin	OH	US	Heidleberg College	U/C	Yes
Le Feuvre	Burlington	ONT	CAN	Environ. Canada	Fed	
Leach	Wheatley	ONT	CAN	OMNR	S/P	
MacIssac	Windsor	ONT	CAN	University of Windsor	U/C	Yes
Makarewicz	Brockport	NY	US	SUC @ Brockport	U/C	Yes
Manny	Ann Arbor	MI	US	NBS	Fed	Yes
Mattisoff	Columbus	OH	US	Ohio State University	U/C	Yes
McLarty	Hamilton	ONT	CAN	OMNR	S/P	
Millard	Burlington	ONT	CAN	DFO	Fed	
Mills	Bridgeport	NY	US	Cornell University	U/C	
Munawar	Burlington	ONT	CAN	DFO	Fed	
Muth	Sandusky	OH	US	NBS	Fed	Yes
Nepszy	Wheatley	ONT	CAN	OMNR	S/P	Yes
Reynoldson	Burlington	ONT	CAN	Environ. Canada	Fed	Yes
Schloesser	Ann Arbor	MI	US	NBS	Fed	Yes
Sheror	Buffalo	NY	US	Medaille College	U/C	
Spicka	Geneseo	NY	US	SUC @ Geneseo	U/C	No Data
Stein	Columbus	OH	US	Ohio State University	U/C	Yes
Stewart	Buffalo	NY	US	SUNY @ Buffalo	U/C	Yes
Stuckey	Columbus	OH	US	Ohio State University	U/C	Yes
Sztramko	Simcoe	ONT	CAN	OMNR	S/P	
Thomas	Mount Clemens	MI	US	MDNR	S/P	
Werner	Syracuse	NY	US	ESF @ SUNY @ Syracuse	U/P	
Witzel	Port Dover	ONT	CAN	OMNR	S/P	Yes

Table 4.0-2: List of lower level trophic studies conducted in Lake Erie

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
Berg	Assessing the fitness and genetic variability of Lake Erie unionids following encrustation by zebra mussels	7/93	WB: Put-in-Bay, Kelley's Island	B (inshore)	SCUBA	Qualitative diver collection		No live unionids found
Berg	Fitness of native unionid bivalves when encrusted by zebra mussels	summer 1990	WB: Put-in-Bay, Kelley's Island	B (inshore)	SCUBA	Qualitative diver collection	raw data sheets	CJFAS 50:13-19
Bur		5,6,8,10/78	WB	B	Peterson, Eckman dredges		raw data sheets	JGLR 8:672-675
Bur		6/92 - 10/92	WB	P, Z	4.2 beta & S-P trap (153 um)		not worked up yet	
Bur		5/93	WB, far west	Z	0.5 m net & S-P trap (153 um)		not worked up yet	
Einhouse	Forage Task Group zooplankton sampling program	5-9, 1985-present	EB	Z	0.5 m (#10, 20) vertical tows	4 fixed stations, 10 samples a year	spreadsheet	
Hartig	Factors contributing to Fragilaria crotonensis pulses in Pigeon Bay, Lake Erie	1983-1984	Pigeon Bay	P (inshore)	whole water samples	Discrete samples; one station	data sheets	3 Journal publications
Hass	Great Lakes plankton populations near historical and potential walleye spawning rivers.	4/90 - 6/94	Maumee R., OH; Huron R., MI	P	whole water samples		spreadsheet	DJ performance reports; completion report in 1999
Hass	Great Lakes plankton populations near historical and potential walleye spawning rivers.	4/90 - 6/94	Maumee R., OH; Huron R., MI	Z	0.5 m (153 um) vertical tows		spreadsheet	DJ performance reports; completion report in 1999
Kauss	Long term sensing sites	S,S,F 1993	WB (2); CB (2); EB (3)	P, B (inshore)	whole water samples; ponar	single index stations	raw data files	
Kauss	An environmental assessment of western Lake Erie sediments and benthic communities	5,9/1991	WB Det. R to Pelee Island	B	Ponar seived at 600 um	16 stations (3 reps) 96 total	appended to report	Consultants report to Ministry
Kauss	Great Lakes embayments and harbors investigation Program Phase 1: Lake Erie Harbors	8/88 & 10/89	9 harbors along the north shore	B	Ponar seived at 600 um	13 samples taken in harbors	appended to report	Consultants report to Ministry
Klarer	Feeding habits of selected Lake Erie fish	4-10/87-89	CB nearshore	P	Vertical tows; S-P trap	triplicate samples monthly	raw data sheets	Bur & Klarer 1991
Klarer	Phytoplankton of Old Woman Creek NERR	1980 to present	Old Woman Creek NERR	P	whole water samples		raw data sheets	
Klarer	Zooplankton in Old Woman Creek NERR	5-9/90	Old Woman Creek NERR	P	samples poured thru plankton net	triplicate samples twice monthly		Havens, et al.
Krieger	Zooplankton dynamics in a Great Lakes coastal marsh	10/83 - 10/84	Old Woman Creek NERR	Z	samples poured thru plankton net	about 171 samples	raw data sheets	JGLR 17:255-269
Krieger	Macroinvertebrate communities of OWC-NERR	F/89 - F/90	Old Woman Creek NERR	B	Eckman & core	62 of 291 analyzed	raw data sheets & computer	OWC Tech Rept #9
Krieger	Benthic macroinvertebrates as indicators of environmental degradation in the southern nearshore zone of the central basin of Lake Erie	6/78 - 9/79	4 Ohio harbors	B (offshore, inshore)	ponar	149 samples	raw data sheets	JGLR 10:197-209
Krieger	Changes in the macroinvertebrate community of the Cleveland harbor area of Lake Erie, 1978 to 1989	10/88 - 5/89	vicinity of Cleveland harbor	B (offshore, inshore)	ponar	71 samples	raw data sheets & computer	JGLR 19:237-249
Krieger	Macroinvertebrate communities of OWC-NERR	F/91 - Su/92	Old Woman Creek NERR	B shoreline	core	104 samples	raw data sheets & computer	OWC Tech Rept expected

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
MacIssac	Filter effects of zebra mussels	1/91 - 12/92	WB Hen & Pelee Islands	Z	19 L S-P trap (41 um)	5 sites every m; 50-70 total	being processed	some published in Oecologia 92:30-39; CJFAS 48:2151
Makarewicz	Comparative study of lakes Erie, Michigan and Huron	83-87	LW	P	composite samples	10-12/year	STORET	4 Reports and Journal publications
Makarewicz	Comparative study of lakes Erie, Michigan and Huron	83-87	LW	Z	vertical tows	2-4 seasons	STORET	4 Reports and Journal publications
Makarewicz	Comparative study of lakes Erie, Michigan and Huron	87-92	LW	P	composite samples	10-12/year	STORET	Not worked up yet
Makarewicz	Comparative study of lakes Erie, Michigan and Huron	87-92	LW	Z	vertical tows	2-4 seasons	STORET	Not worked up yet
Manny	Changes in bottom fauna of western Lake Erie 1930-1961	6,7/1961	WB (40 stations)	B	Peterson grab	120 samples		LO 10:551
Manny	Changes in bottom fauna of western Lake Erie 1961-1982	6,7/1982	WB (40 stations)	B	Peterson & ponar grabs	120 samples		in prep: Manny et al.
Manny	Changes in bottom fauna of western Lake Erie 1982-1993	6,7/1982	WB (47 stations)	B	ponar grab	141 samples	being processed	in prep: Schlosser et al.
Mattisoff	Zebra mussel veligers	5/90-11/93 (weekly)	CB (off Cleveland intake crib	P	62 um net; 10 ft tows from bottom	5 samples @ 10' water col. intervals	CWRU Mac; CWD IBM	Cleveland Water Dept Repts
Mattisoff	Survey of benthos of western Lake Erie	5/81 - 7/83	WB	B	ponar, kb cores	4 samples/6stations over seasons	Published with paper & thesis	CJFAS 47:1970-1985 & 1996-2005
Mattisoff	Survey of benthos of western Lake Erie	6/93 - 9/94	WB	B	ponar, kb cores	resurvey of some stations		
McDermott	Great Lake Institute, Univ. Toronto Brinkhurst, Herrington, Hamilton	W,Sp, Su 1963-65	WB, CB, EB	B	Franklin dredge	Grid, 24 cruises, 1175 samples	raw data (Dr. Bartow, U Toronto)	CJFAS Tech Rept #1635
McDermott	Great Lakes Biolimnology Lab. Nanticoke Waste Heat Project	Su 1974; Sp	Nanticoke area Long Point Bay	B (inshore)	Ponar	Grid, 96 samples	file - raw data, Burlington	incomplete raw data lists
McDermott	Lake Erie benthic survey	10/79	WB, CB, EB	B	Shipek 153 um screened	Mecator 10 km grid (CJFAS 1976) 159 sites-samples	raw data sheets - GLLFAS, burlington	Tech Rept
McDermott	Lake Erie Trophic Transfer (LETT)	7/92 & 6/93	WB, CB, EB	B	mini ponar; box core 177um	CCIW historic sites/transects 37 samples 1992/rep-ed 1993	raw data sheets - GLLFAS, burlington	unanalyzed
McDermott	Zebra Mussel Project	4-10/1990-92	EB at Welland Canal	B	area suctions & diver air lifts, 0.25 um screen	one site	raw data sheets - GLLFAS, burlington	1990 analyzed & publ. in Zebra Mussels 1993. ED: Nalepa & Schlosser
McDermott	Lake Erie Biomonitoring	5-10/1993	EB (2 Long Point), CB (2-Rondeau), WB (2)	B, Z	mini ponar, 0.25 screen	OMNR & LETT sites 108 samples	raw data sheets - GLLFAS, burlington	unanalyzed
Nepsy	Zooplankton abundance and composition on western Lake Erie	5-11/1988-93	WB, CB	Z	vertical tow 1 m from bottom, #20 net	fixed sites: 156 - 237 samples annually	computer files	
Nepsy	Distribution and abundance of benthic invertebrates on western Lake Erie reefs	5-11/1991-93 (3x annually)	WB: Sunken Chicken & Chickenolee Reefs	B	ponar N,S,E,W of reef; air lifts on reef (triplicate samples)	72 ponars; 54 lifts annually	computer files	

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
Reynoldson	Long term monitoring of Lake Erie benthos	1984 - present	WB (2); CB (1); EB (1)	B	box core	5 reps/site; 250 um mesh	Lotus	
Reynoldson	Reference statis	1991 - 1993 (1 visit)	WB, CB, EB	B (Chemistry)	box core	5 reps/site; 250 um mesh	Lotus	
Schlosser	Benthos of western Lake Erie	6/1993	WB	B	ponar	47 stations with 3 samples	IBM files	manuscripts for Journals
Stein	Genetics and ecology of an invading species: Bythotrphes cederstroemi in western Lake Erie	7,10/86 & 5-11/1987-89	WB: Put-in-Bay, Bass Islands; CB: near Cleveland		1, 0.75, & 0.5 m, 0.5, 0.5 mm & 112 um nets	weekly samples at night		Berg, D.L. 1991 OSU, Ph.D. dissertation
Stein	Trophic interactions in a large lake ecosystem: ontogeny of fish diet, zooplankton summer dynamics, and phytoplankton succession	6-8/1988-1989	WB (443353N824756W; 413867N824644W)	P, Z	0.5 m, 112 um; integrated tube 5 cm diam.	weekly duplicate samples		Wu, L. 1991 OSU, Ph.D. dissertation
Stein	Pursuing mechanisms regulating walleye recruitment in the Maumee and Sandusky Rivers	4-6/1993	WB	Z	vertical tows 153 um	twice weekly; 25-30 samples/site; 3 sites	computer files	Mion, J. OSU, MA Thesis (ongoing)
Stewart	Student sampling	since the 1970's	EB	P, Z	qualitative	<20 m vertical tow		class projects
Witzel	Nanticoke Environmental Study: Bottom fauna survey of Long Point Bay in the nearshore region, 1969	4/1969	EB: Long Point Bay	B (inshore)	artificial substrates	2 samples at 8 stations for 6 weeks	in report	Osmond, D.S. 1969. OMNR
Witzel	Nanticoke Environmental Study: Bottom fauna survey of Long Point Bay in the nearshore region, 1969-1971	5-10/1969-1971	EB: Long Point Bay	B (inshore)	artificial substrates (8x8x6" wire cages filled w/ 2" crushed limestone)	2 samples at 8 stations for 6 weeks	in report	Osmond, D.S. 1973 In: Nanticoke, a pre-operational Report, Vol.8.
Witzel	Nanticoke Environmental Study: Bottom fauna survey of Long Point Bay in the vicinity of Nanticoke, 1969-1974	4-11/1972-1974	EB: Long Point Bay	B (inshore)	artificial substrates (8x8x6" wire cages filled w/ 2" crushed limestone)	2 samples at 9 stations for 6 weeks	in report	McLarty & Craig 1975, OMNR West-Central Region, Stoney Creek
Witzel	Nanticoke Environmental Study: Bottom fauna survey of Long Point Bay in the vicinity of Nanticoke, 1975-1977	4-11/1975-1977	EB: Long Point Bay	B (inshore)	artificial substrates (8x8x6" wire cages filled w/ 2" crushed limestone)	2 samples for 6 weeks	in report	McLarty & Yerex 1978, OMNR
Witzel	Phytoplankton conditions in Nanticoke area of Lake Erie 1975-1978	Ice free season 1975-1978	EB: Long Point Bay	P (inshore)	1 L Composite in euphotic zone (2x secchi depth)	10-13 stattions, 1 m deep biweekly samples	in report	Hopkins 1981 OMNR
Witzel	Phytoplankton conditions in Nanticoke area of Lake Erie 1969-1978		EB: Long Point Bay	P (inshore)	Mcihalski 1972; Hopkins 1975; 1979	Michalski 1972; Hopkins 1975; 1979	in report	Hopkins & Lea 1979 OMNR Report Nov. 1979
Witzel	A ten year study of the phytoplankton biomass and composition in the Nanticoke region of Long Point Bay, Lake Erie	Ice free season 1968-1978	EB: Long Point Bay	P (inshore)	1L narrow necked bottle in photic zone	8-13 stations sampled bi- or tri weekly	in report	Hopkins & Lea 1982 JGLR 8:428-438
Witzel	A fifteen year study of the phytoplankton biomass and composition in the Nanticoke region of Long Point Bay, Lake Erie	Ice free season 1968-1983	EB: Long Point Bay	P (inshore)	1L narrow necked bottle in photic zone	7 stations	in report	Hopkins & Lea 1985 OMNR
Witzel	Report on the Nanticoke zooplankton study for the years 1969, 1970 &1971	Sp-F/1969-1971	EB: Long Point Bay	Z (inshore)	10 L Juday trap w/ #20 mesh (76 um)	8 stations @ 2 week intervals (deep & shallow)	in report	Monroe 1973 In: Nanticoke, a pre-operational Report Vol. 6
Witzel	Nanticoke zooplankton project, 1969-1978, Summary Report	Ice free season 1968-1978	EB: Long Point Bay	Z (inshore)	10 L Juday trap w/ #20 mesh (76 um)	8 stations, biweekly at 3 dephs	in report	Monroe & Standke 1980 OMNR

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
Witzel	Zooplankton monitoring study of the Nanticoke area of Lake Erie, 1979-1983	Ice-free season 1979-1983	EB: Long Point Bay	Z (inshore)	10 L Juday trap w/ #20 mesh (76 um)	biweekly	in report	Carter & Sardella 1984 Waterloo Research Inst. Project #403-24, 119 p.
Witzel	Zooplankton of the Nanticoke area of Lake Erie from grid samples collected in 1983 with a summary of the years 1981-1983	7, 8, 11/1983	EB: Long Point Bay	Z (inshore)	27 L S-P trap w/ #25 mesh (64 um)	4 stations along 2 km transect & one station	in report	Carter & Sardella 1984 Waterloo Research Inst. Project #403-24, 66 p.
Witzel	Zooplankton of the Nanticoke area of Lake Erie from grid samples collected in 1981	6, 8, 11/1981	EB: Long Point Bay	Z (inshore)	27 L S-P trap w/ #10 (158 um) & #25 mesh (64 um)	4 stations taken monthly on 10 transects (2 km)	in report	Carter 1982 Waterloo Research Inst. Project #104-08, 42 p.
Witzel	Zooplankton of the Nanticoke area of Lake Erie from grid samples collected in 1982	6, 8/1982	EB: Long Point Bay	Z (inshore)	27 L S-P trap w/ #25 mesh (64 um)	4 stations taken monthly on 11 transects	in report	Carter 1983 Waterloo Research Inst. Project #205-24, 40 p.
Witzel	Effects of tempering elimination at Nanticoke, TGS	5,8,11/1980 & 3/1981	EB: Long Point Bay	P, Z, B (inshore)	0.5 m conical net (363 um) for P	monthly studies	in report	Wiancko, Dixon & Gillies 1982 OMNR Rept #NA59-07250-3
Witzel	The influence of industrialization on the aquatic environment of Long Point Bay, Lake Erie in the vicinity of Nanticoke, 1963-1983	1968-1983	EB: Long Point Bay	P, Z, B	various, listed in report	various, listed in report	in report	Haymes & Dunstall 1989
Witzel	Forms of physical damage and related effects to zooplankton as a result of entrainment at Nanticoke GS, 1976	6,7/1976	EB: Long Point Bay	Z	oblique tows with #20 mesh net	3 tows at 7 sites	some data in report	Standke & Monroe 1981 JGLR 7:136-143
Witzel	Distribution of some common benthic invertebrates in nearshore Lake Erie, with emphasis on depth and type of substratum	5-8/1972-1973	EB: Long Point Bay	B (inshore)	double Shipek grab	2 samples from each station on 2 km grid		Barton 1988 JGLR 14:34-43
Witzel	Recent changes in the nearshore phytoplankton of Lake Erie's western basin at Kingsville, Ontario	1968-1983	WB	P (inshore)		weekly water collections 450 m from shore at 3 m depths	some data in report	Nicholls, Stranden & Hopkins 1980 JGLR 6:146-153
Witzel	Seasonal distribution and abundance of crustacean zooplankton in Lake Erie, 1970	4-12/1970	LW	Z	40 cm diam, vertical nets, 64 um	10 synoptic cruises, 4 week intervals, 30 stations		Watson 1976 JGLRBC 33:612-621
Witzel	The bottom fauna of western Lake Erie, 1951-1952		WB	B				Wood 1963 Proc. 6th Conf GL Res: 258-265
Witzel	Changes in the bottom fauna of western Lake Erie from 1930-1961		WB	B				Carr and Hiltunen 1965 LO 10:551-569
Witzel	The July 1967 zooplankton of Lake Erie			Z				Davis 1968 Proc. 11th Conf GL Res: 61-75

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
Witzel	Bottom fauna of the western basin and nearshore Canadian waters of Lake Erie		WB					Veal& Osmond 1968 Proc. 11th Conf GL Res: 151-160
Witzel	Changes in Lakes Erie and Ontario		LW	B				Brinkhurst 1969 Bull Buffalo Soc Nat Sci 24:45-65
Witzel	Seasonal distribution, constitution and abundance of zooplankton in Lake Erie			Z				Davis 1969 JFRBC 26:2459-2476
Witzel	A lake wide study of phytoplankton biomass and its species composition in Lake Erie, April - December 1970	4-12/1970	LW	P	Van Dorn samples at 1 & 5 m depths	25 stations collected at 4 week intervals	in report	Munwar & Munwar 1976
Witzel	Relationships of phytoplankton biomass with soluble nutrients, primary production and chlorophyll a in Lake Erie, 1970	4-12/1970	LW	P	Van Dorn samples at 1 & 5 m depths	25 stations collected at 4 week intervals	in report	Munwar & Burns 1976
Witzel	Abundance, composition & distribution of crustacean zooplankton in relation to hypolimnetic oxygen depletion		WB, CB	Z				Heberger & Reynolds 1977
Witzel	Distribution of benthic macroinvertebrate communities in Lake Erie's eastern basin		EB	B				Flint & Merckel 1978 Verh. Int. Verein. Limnol. 20:240-251
Witzel	Benthic macroinvertebrate distributions in the central and western basins of Lake Erie		WB, CB	B				Britt, Pliodzinskas & Hair 1980 In: EPA-600/3-80-062: pp 294-330
Witzel	Benthic fauna from Great Lakes Institute cruises on Lake Erie - 1963, 1964, 1965	1963-1965	LW	B	Franklin-Anderson grab (0.028 m2)	various sites and depths	in report	Barton 1988 Canadian Tech Rept of Fisheries & Aquatic Sci #1635
Witzel	Report on the Nanticoke zooplankton study for the year 1973		EB: Long Point Bay	Z				Monroe 1973 OMNR, Fish & Wildlife Research
Witzel	Phytoplankton conditions in the Nanticoke area of Lake Erie, 1969-1971		EB: Long Point Bay	P				Michalski 1973 In: Nanticoke, a pre-operational Report Vol 7
Witzel	Report on the Nanticoke zooplankton study for the year 1974		EB: Long Point Bay	Z				Monroe 1973 OMNR, Fish & Wildlife Research Branch, Maple
Witzel	Phytoplankton conditions in the Nanticoke area of Lake Erie 1972-1973		EB: Long Point Bay	P				Hopkins 1975 OME, Water Resources Branch, Toronto

Contact	Project Title	Date (mm/yy)	Location	Habitat & Fauna	Collection Method		Data Storage	End Product
Witzel	Preliminary summary of findings, benthic fauna studies, Nanticoke 1972-1974		EB: Long Point Bay	B				McLarty 1975 OME, West-Central Region, Stoney Creek
Witzel	Report on the Nanticoke zooplankton study for the period 1969 to 1974		EB: Long Point Bay	Z				Monroe 1976 OMNR, Fish & Wildlife Research Branch, Maple

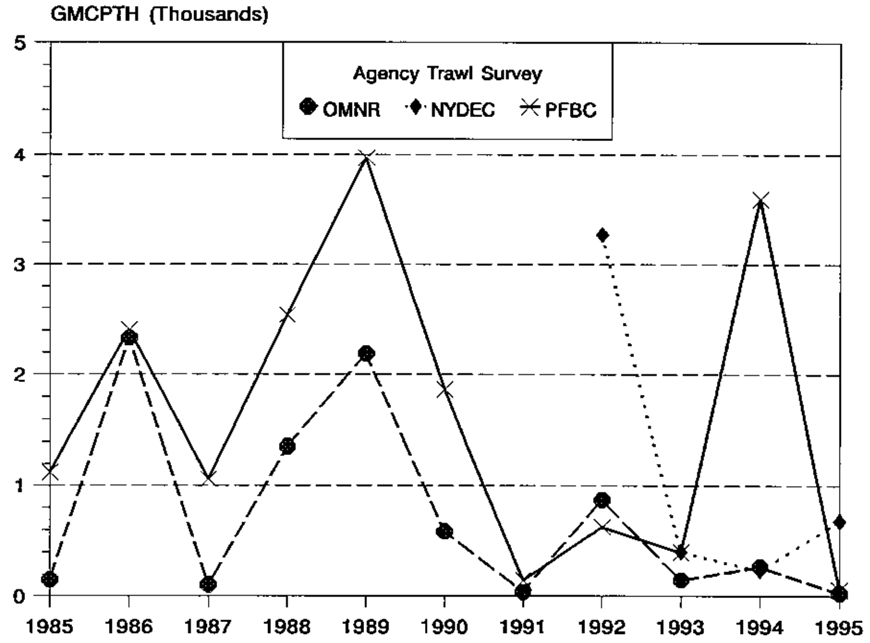


Figure 2.1.1-1: Relative abundance (GMCPTH) of young-of-the-year rainbow smelt in fall index trawl surveys of eastern Lake Erie, 1985 to 1995.

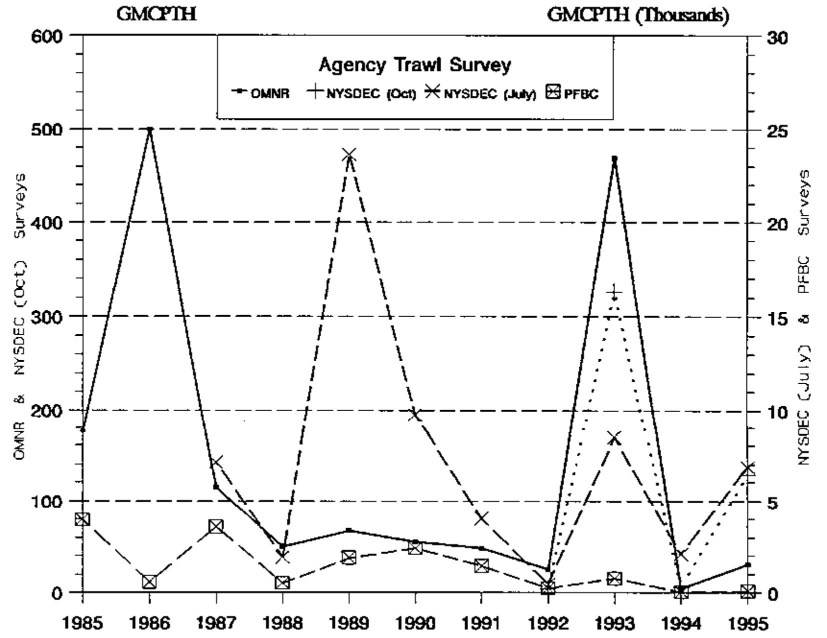


Figure 2.1.1-2: Relative abundance (GMCPTH) of yearling-and-older rainbow smelt in fall index trawl surveys of eastern Lake Erie, 1985 to 1995.

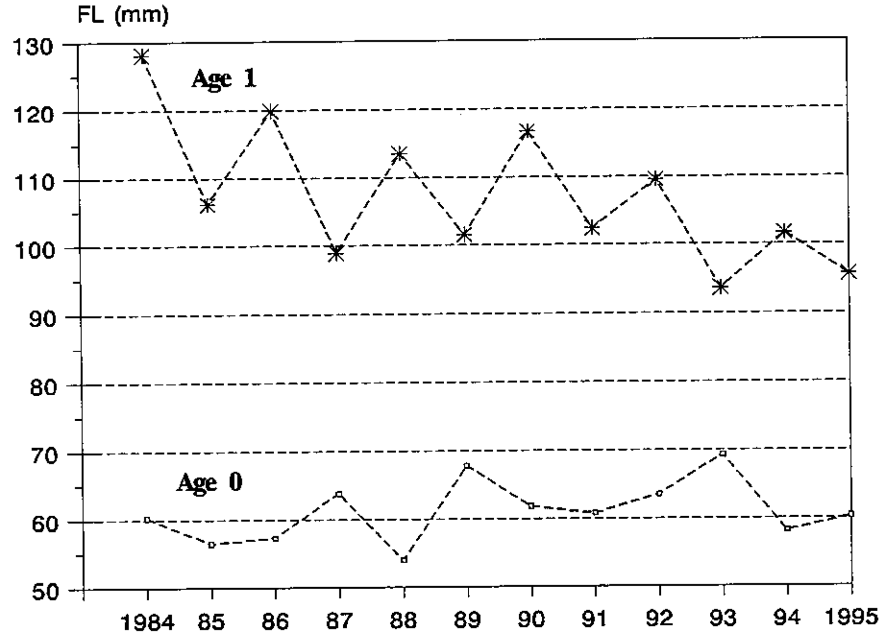
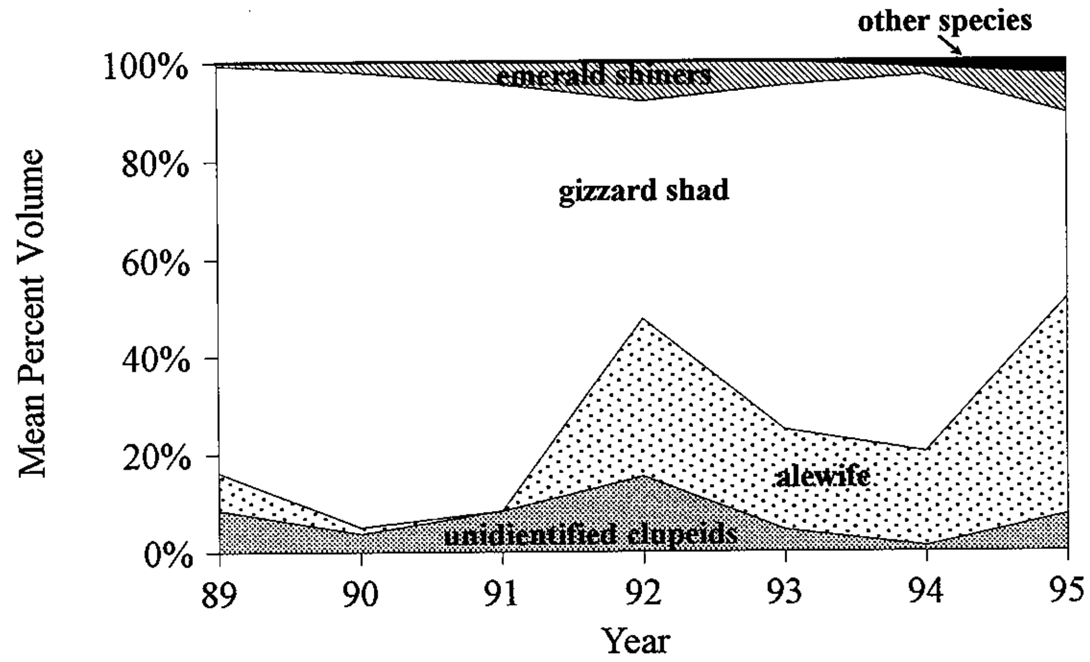
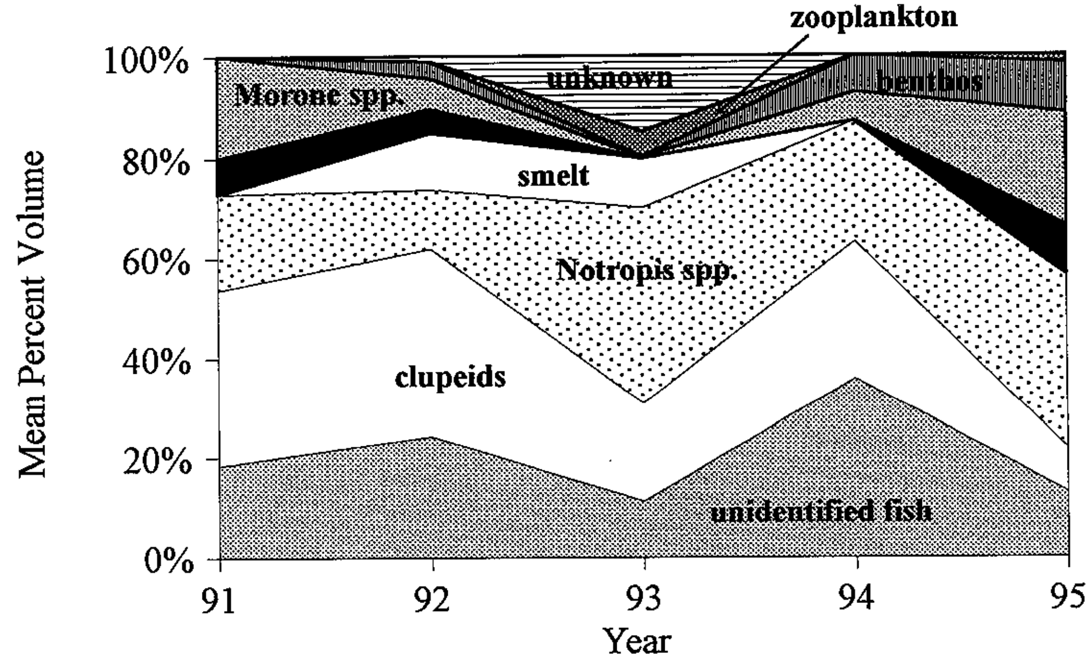


Figure 2.1.1-3: Mean fork length of Age 0 and 1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 1995.

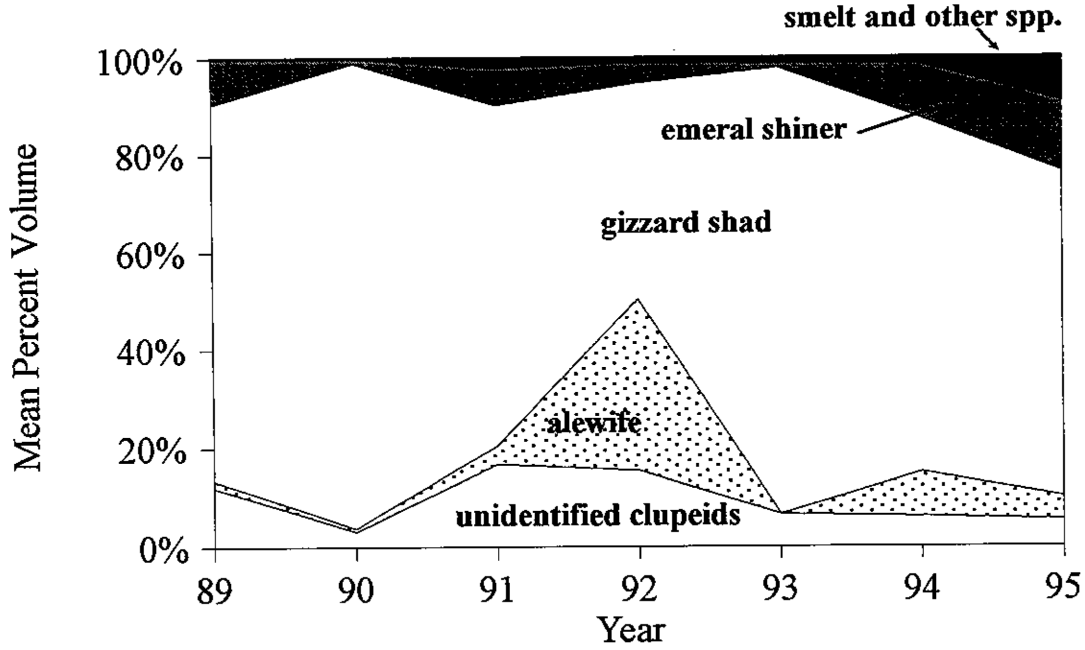


Ohio Department of Natural Resources (ODNR)



National Biological Services (NBS)

Figure 2.2.1-1 Food items identified from the stomach contents of walleye in the western basin of Lake Erie 1989-1995.


Ohio Department of Natural Resources (ODNR)

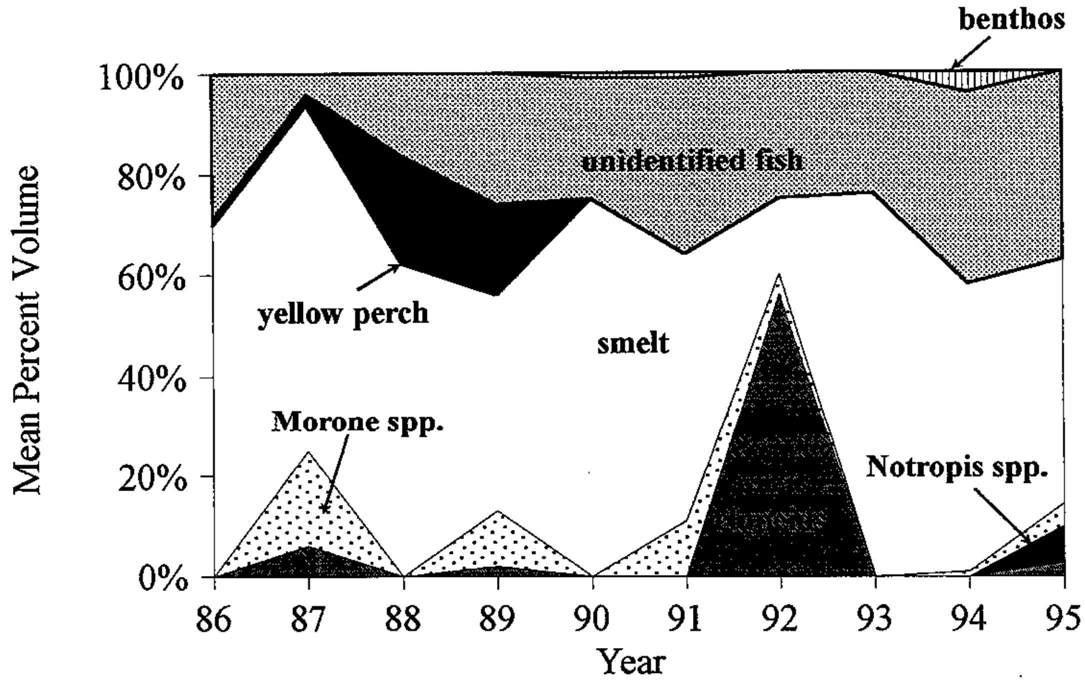

Ontario Ministry of Natural Resources (OMNR)

Figure 2.2.1-2 Food items identified from the stomach contents of walleye in the west-central basin of Lake Erie 1986-1995.

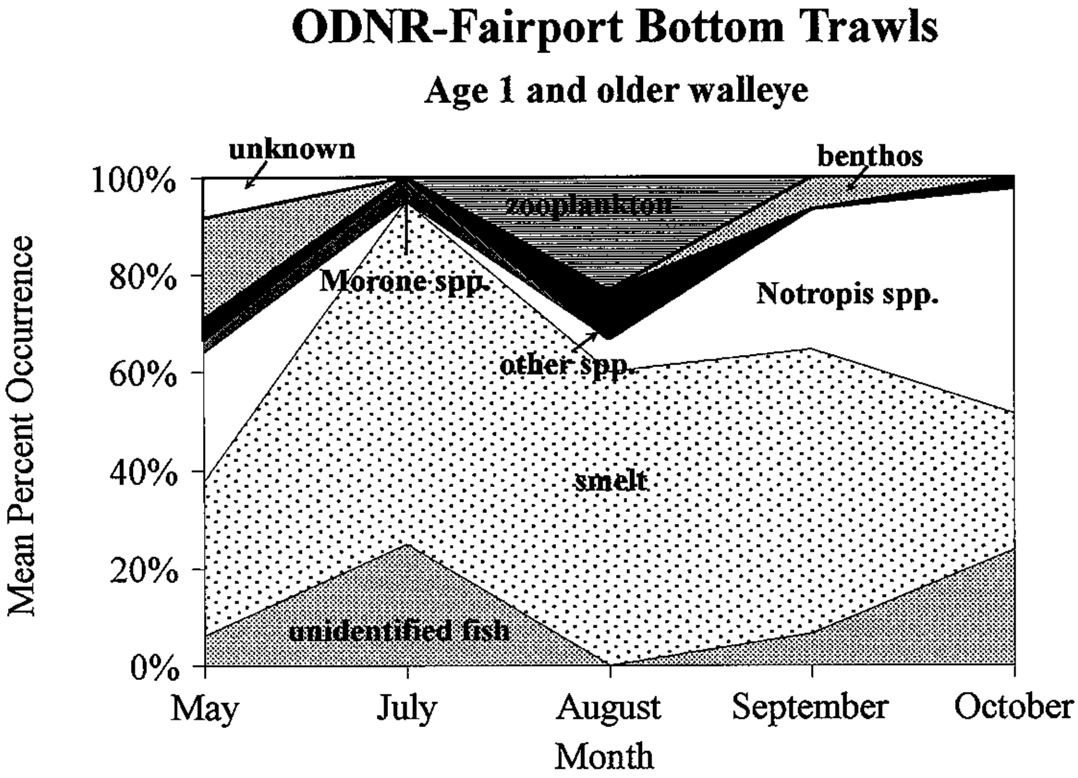


Figure 2.2.1-3 Monthly stomach contents of walleye from the central basin of Lake Erie, 1995.

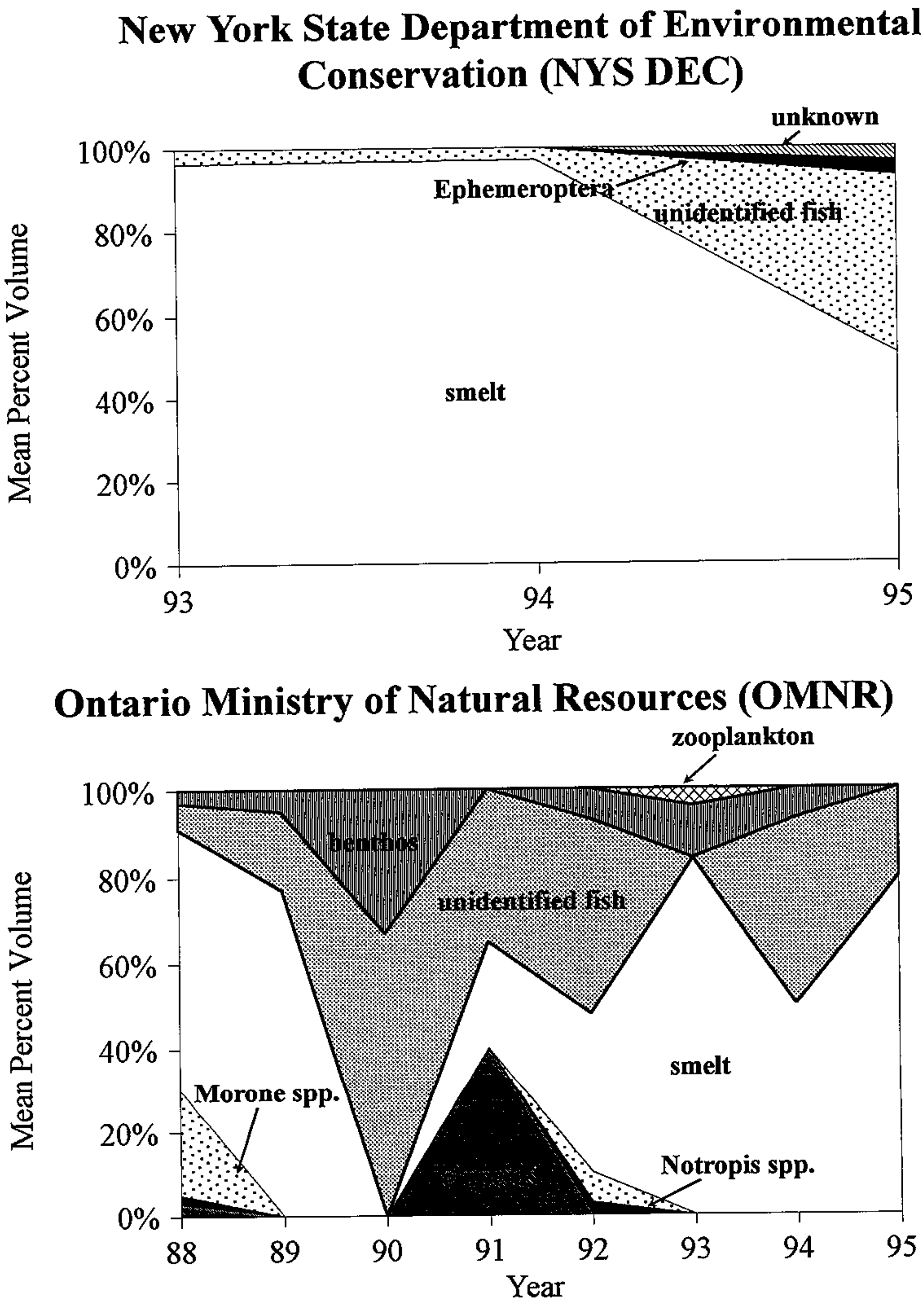
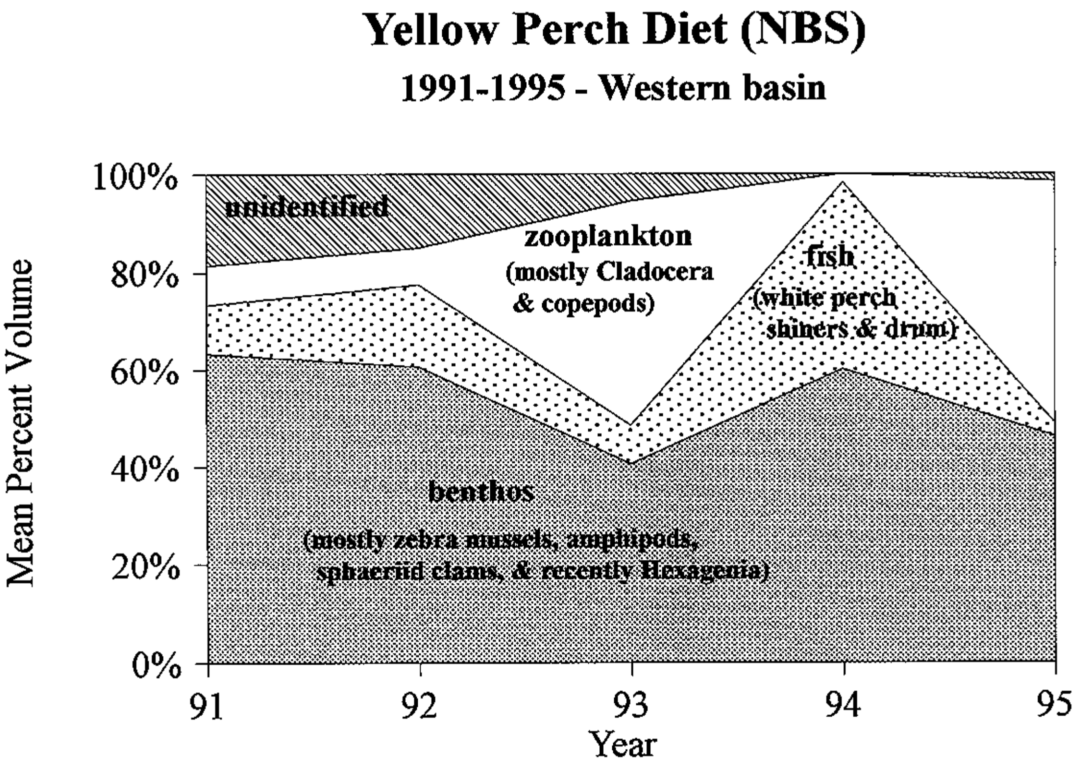


Figure 2.2.1-4 Food items identified from the stomach contents of walleye in the eastern basin of Lake Erie 1988-1995.



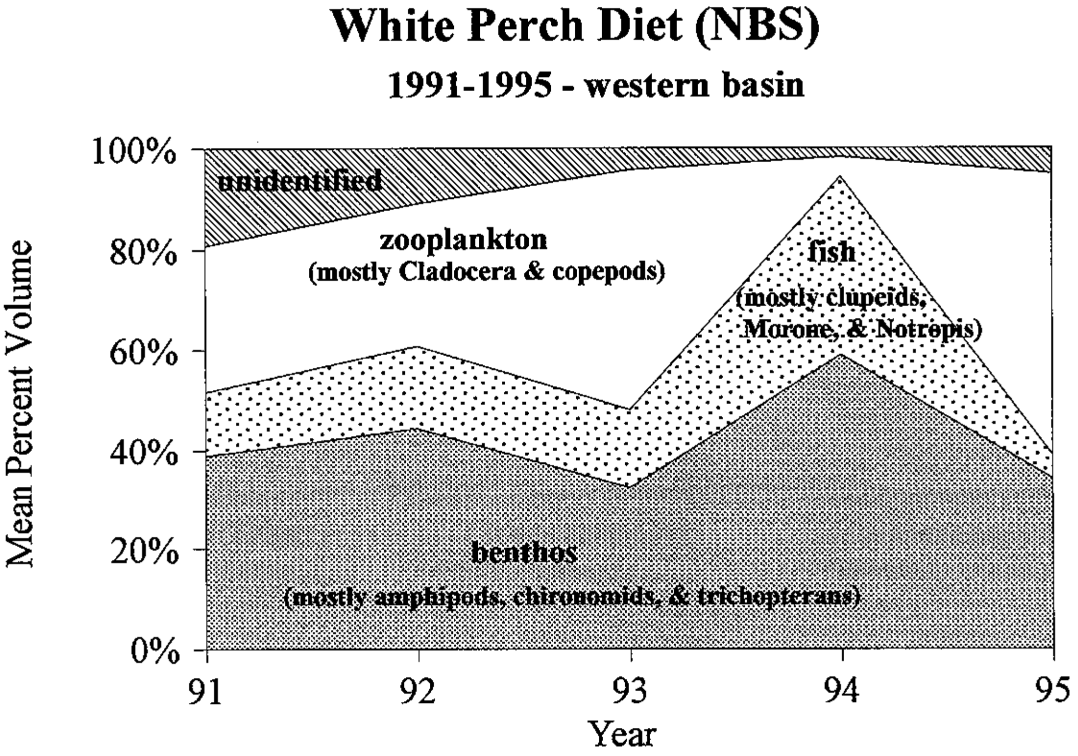


Figure 2.2.2-1 Monthly stomach contents of perch from the western and central basins of Lake Erie, 1995.

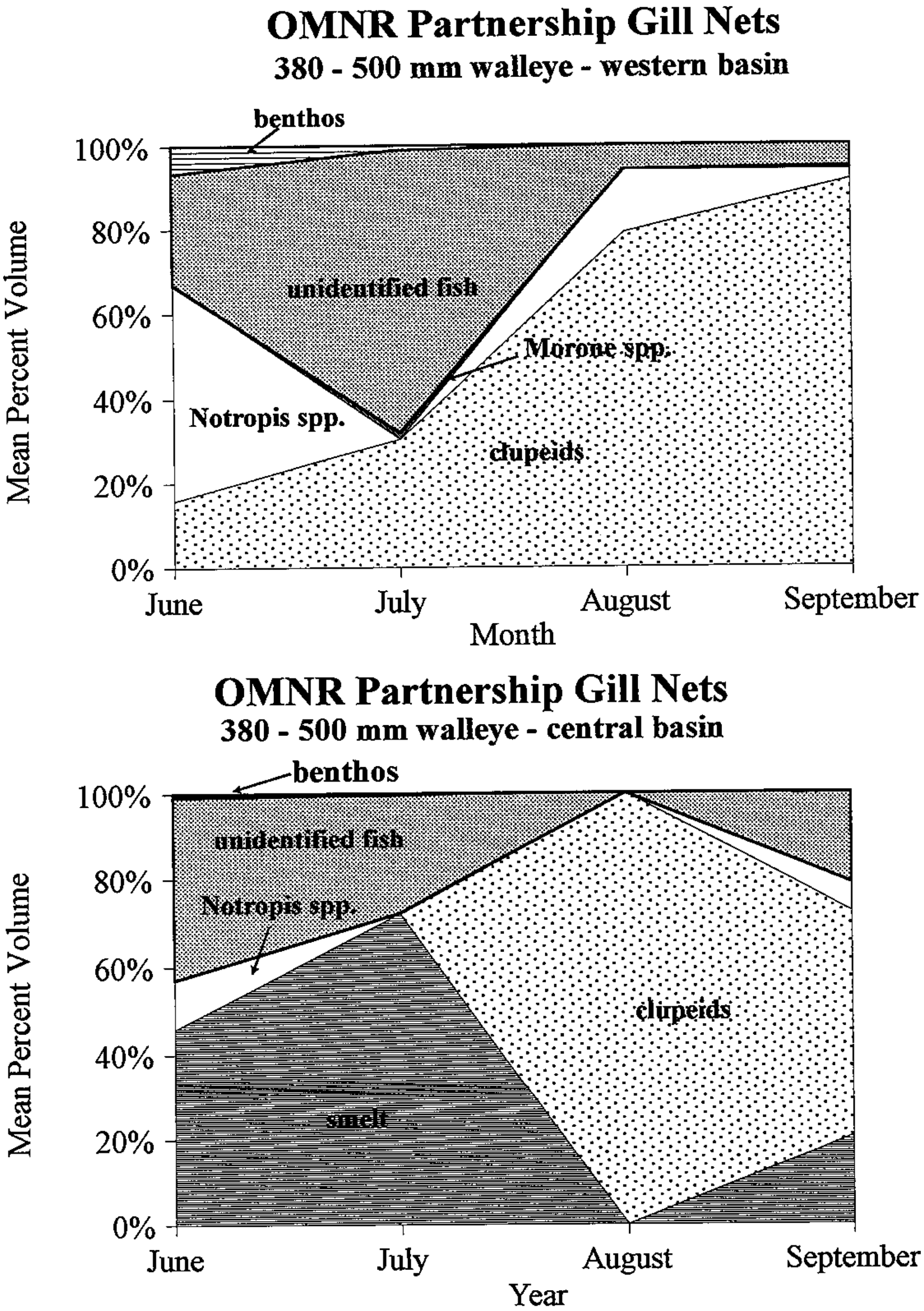
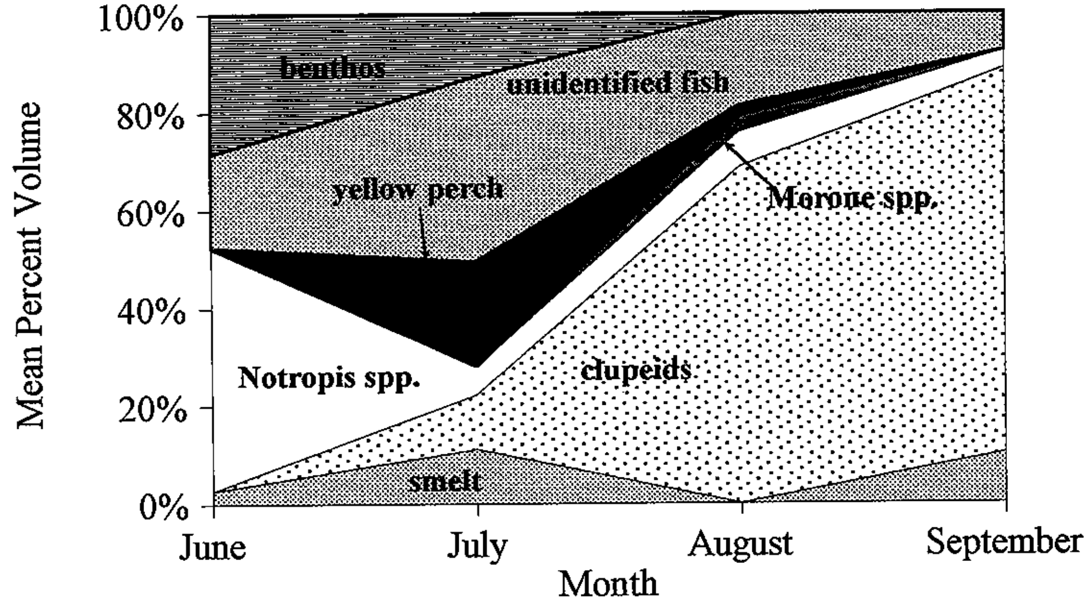


Figure 2.2.3-1 Monthly stomach contents of walleye from the western and central basins of Lake Erie, 1995.

OMNR Partnership Gill Nets

< 380 mm walleye - Western basin



OMNR Partnership Gill Nets

< 380 mm walleye central basin

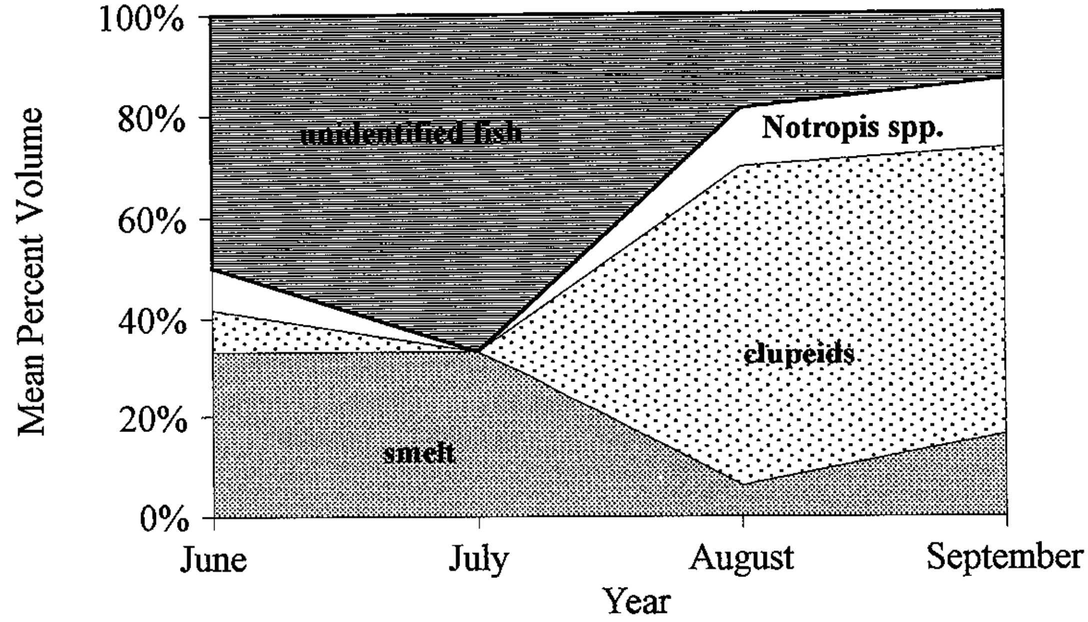
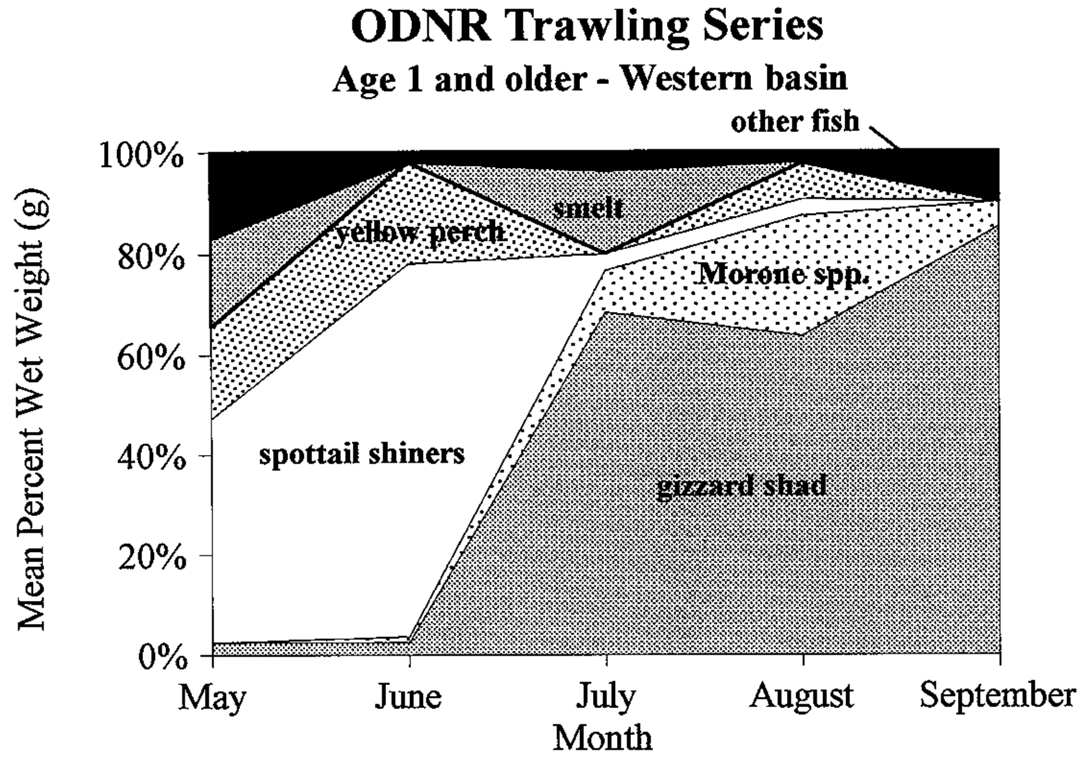
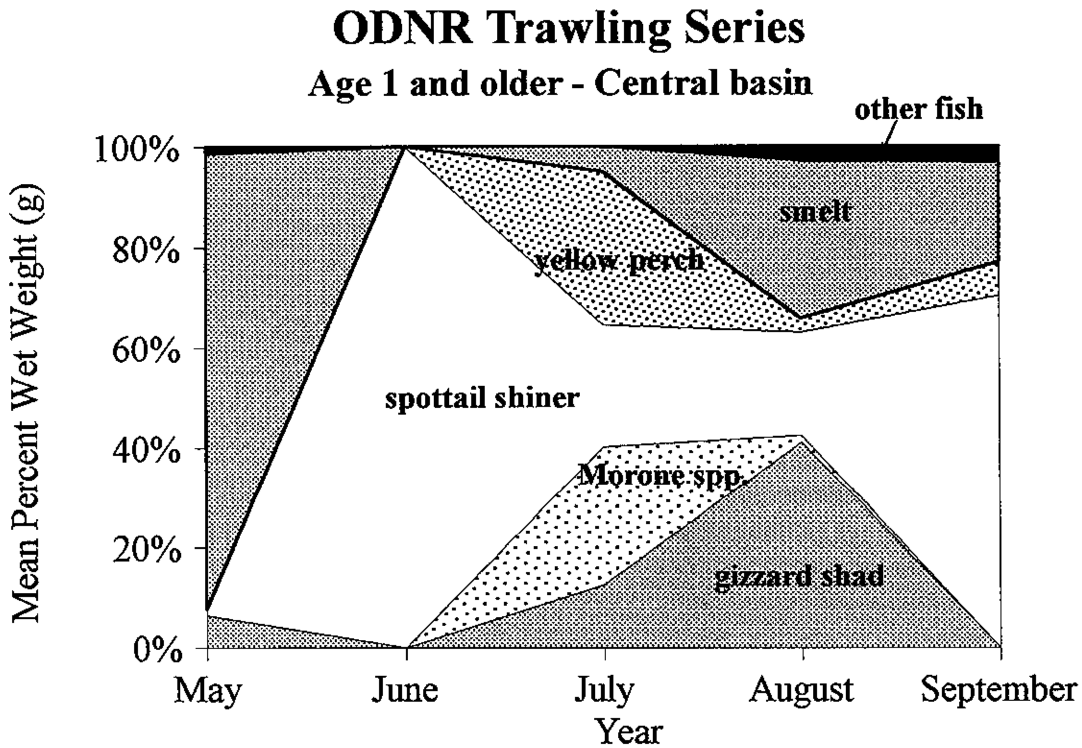


Figure 2.2.3-2 Monthly stomach contents of walleye from the western and central basins of Lake Erie, 1995.


ODNR Trawling Series

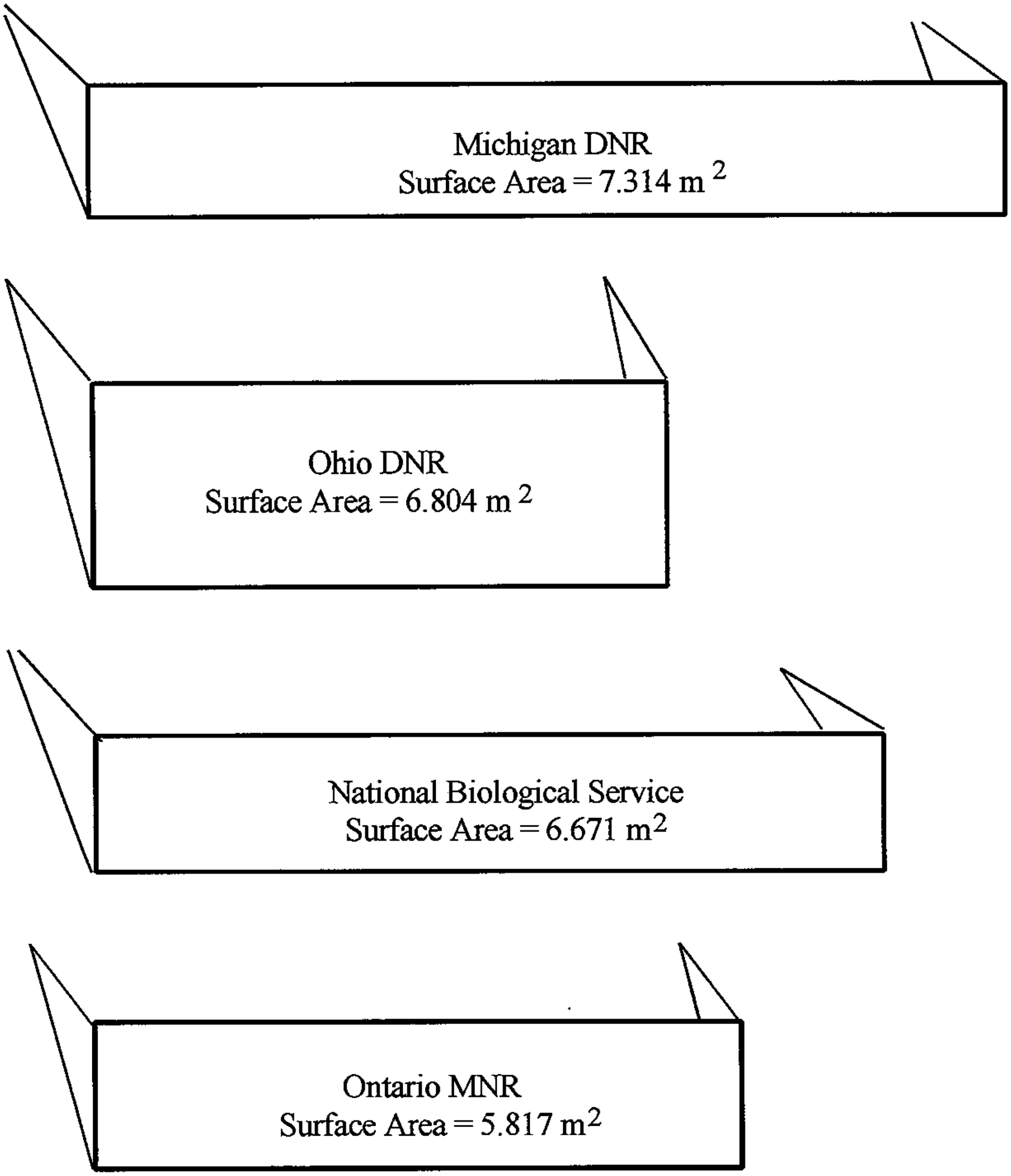
Age 1 and older - Western basin


ODNR Trawling Series

Age 1 and older - Central basin

Figure 2.2.4-1 Monthly stomach contents of walleye from the western and central basins of Lake Erie, 1995 (unpublished data from M. Kershner, OSU).

Figure 3.1.1 Graphical representation of trawl opening for each agency in the western basin trials. Gape height and wing spread measurements taken from stage two (stabilized or fishing trawls). Scale 2 cm = 1 m.



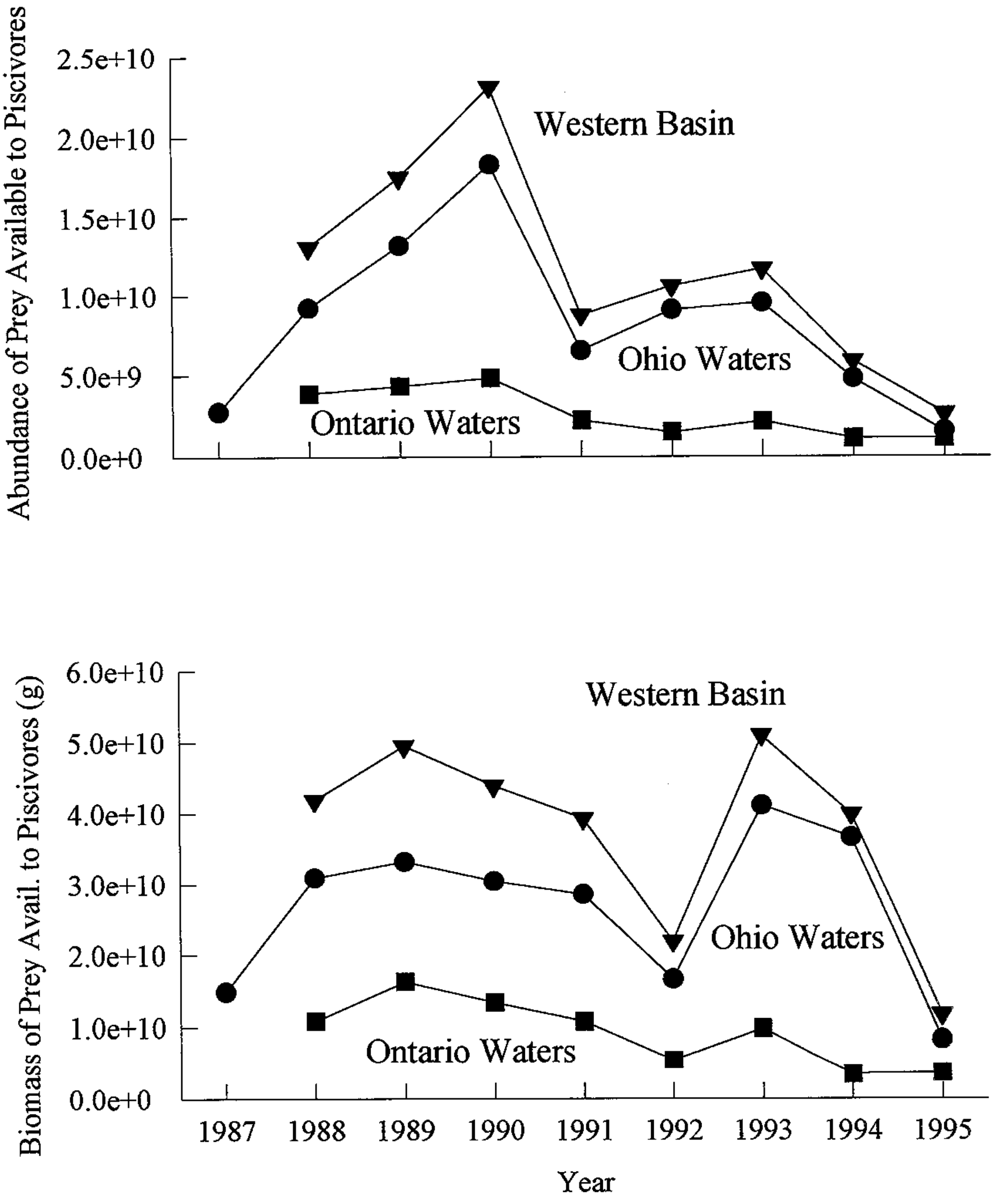


Figure 3.3-1 Estimated total prey abundance and biomass in Ontario and Ohio waters of the western basin, Lake Erie, generated from August trawls (1987-1995) (unpublished data of M. Kershner, OSU).

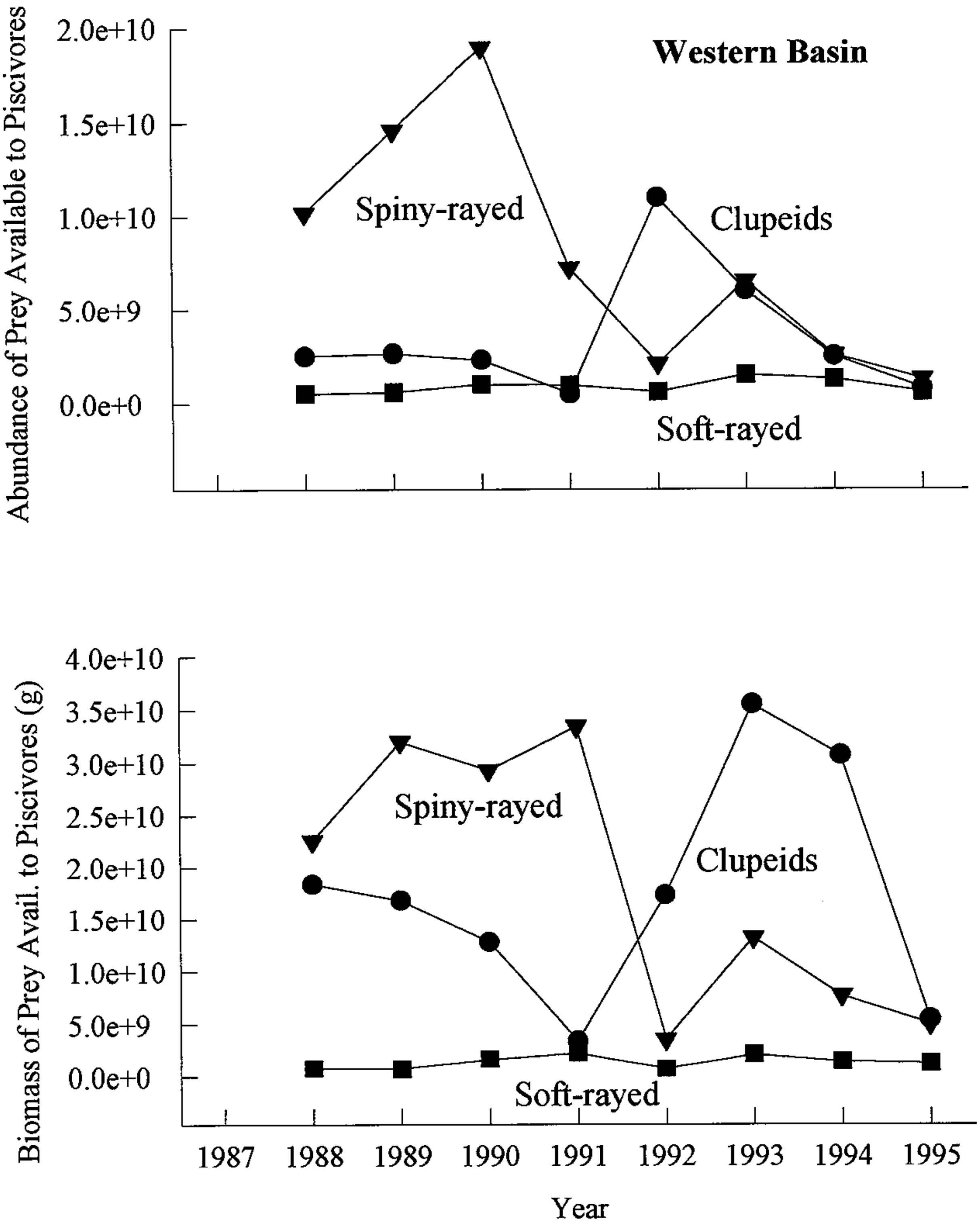


Figure 3.3-2 Estimated abundance and biomass of prey fish groups in Ontario and Ohio waters of the western basin, Lake Erie, generated from August trawls (1987-1995) (unpublished data of M. Kershner, OSU).

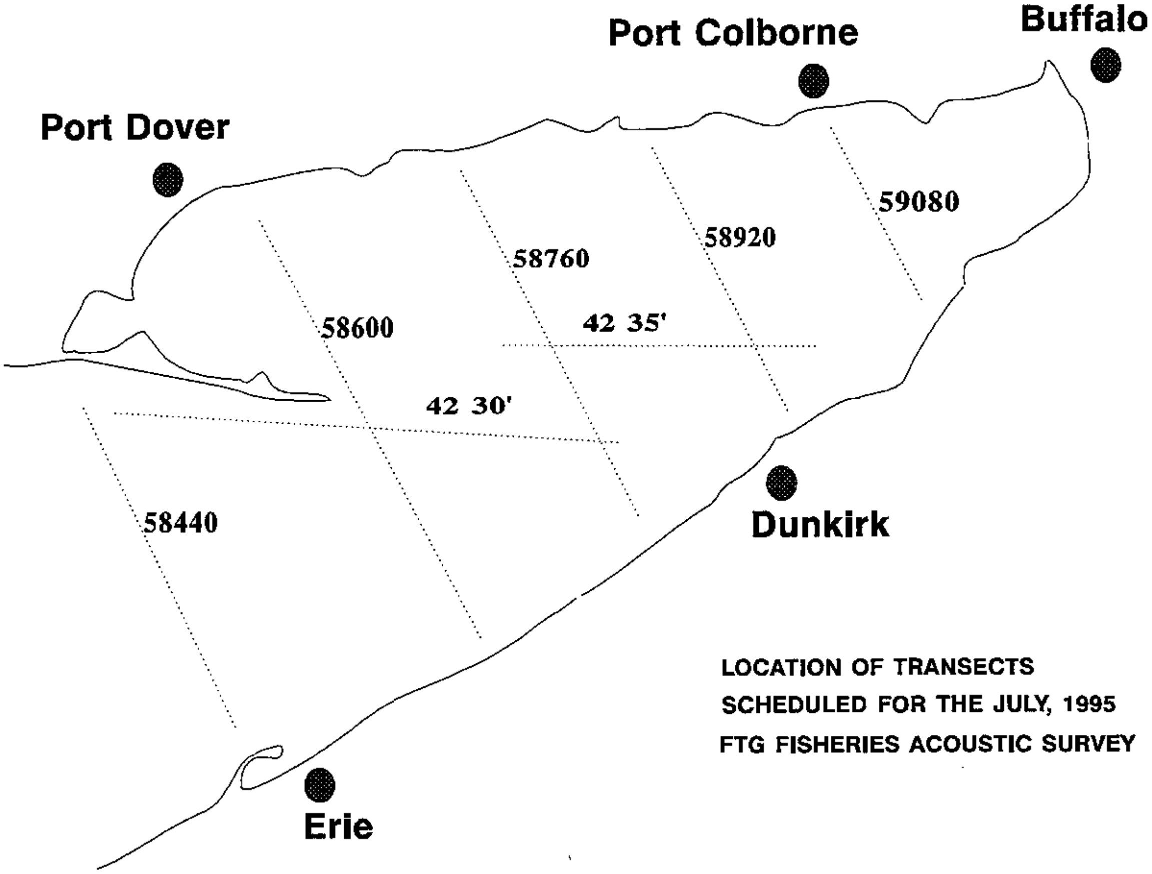


Fig 5.2-1: Locations of transects sampled during a July 1995 fisheries acoustic survey of the eastern basin , Lake Erie. An October survey replicated transects 4235, 58920, and 59080.

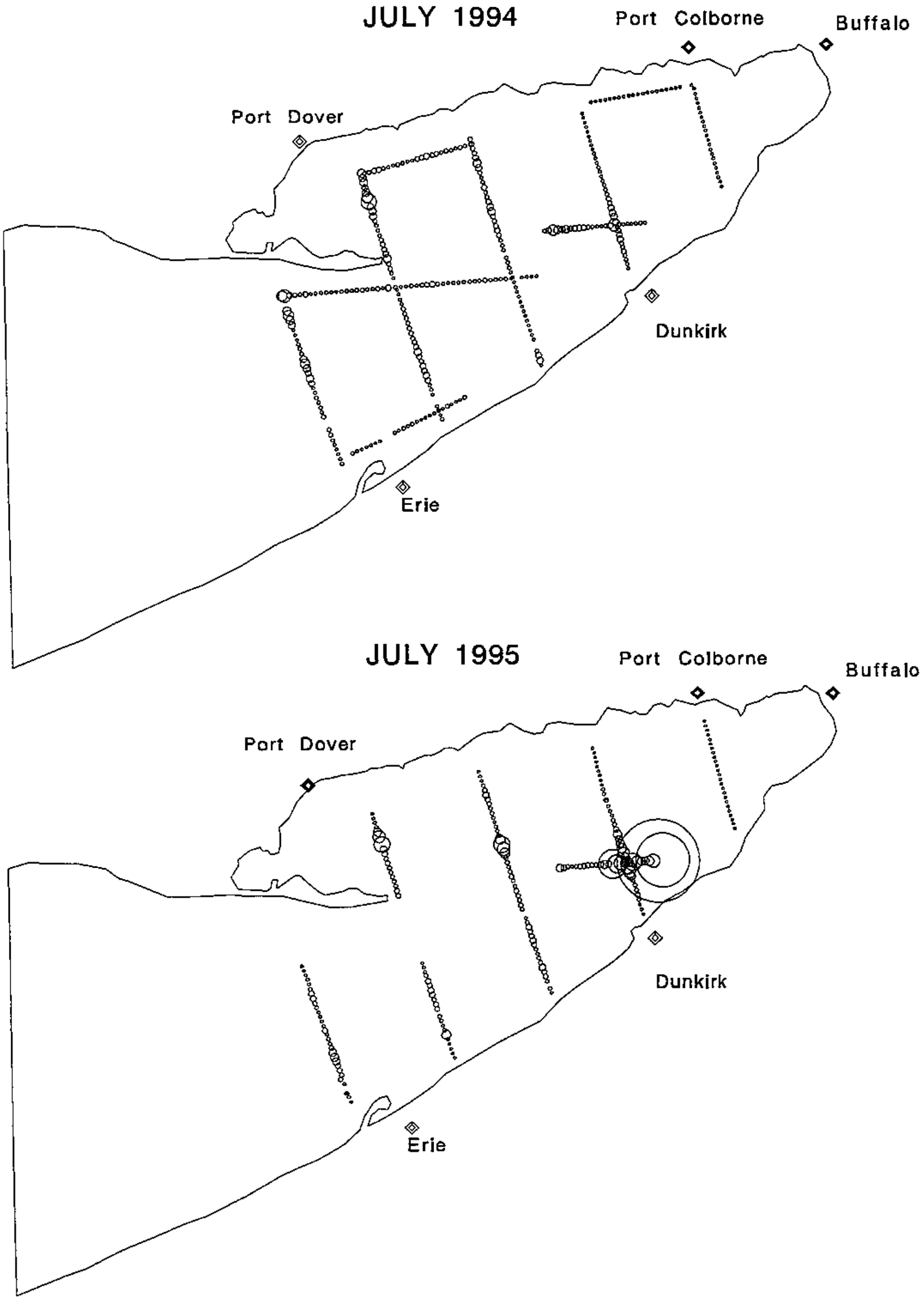


Figure 5.3-1: The distribution of yearling-and-older size (-52 to -43 dB) forage fish in cold water habitat during the July, 1994 and 1995 fisheries acoustic surveys of eastern Lake Erie.

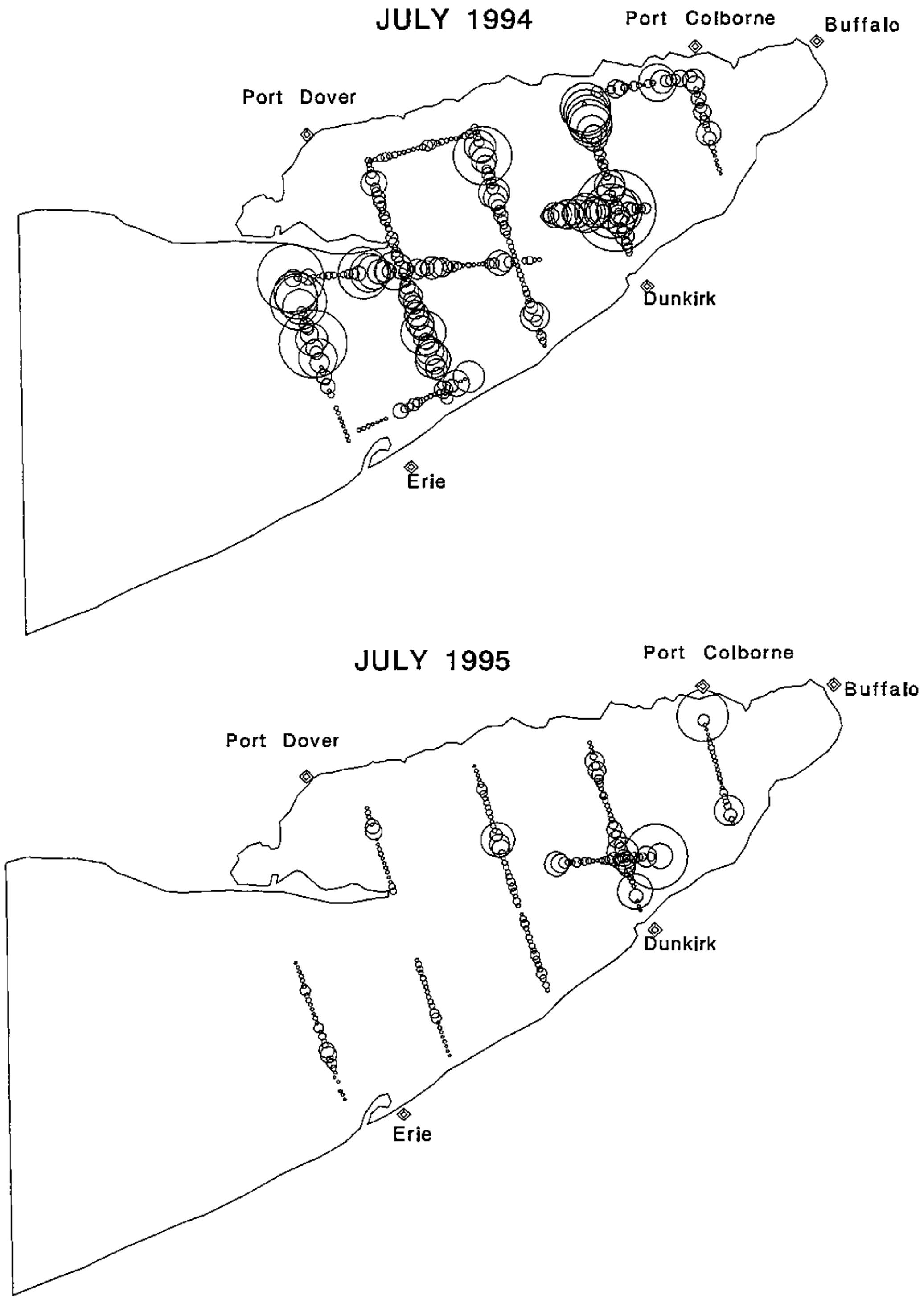


Figure 5.3-2: The distribution of young-of-the-year size (-56 to -53 dB) forage fish in cold water habitat during the July, 1994 and 1995 fisheries acoustic surveys of eastern Lake Erie.

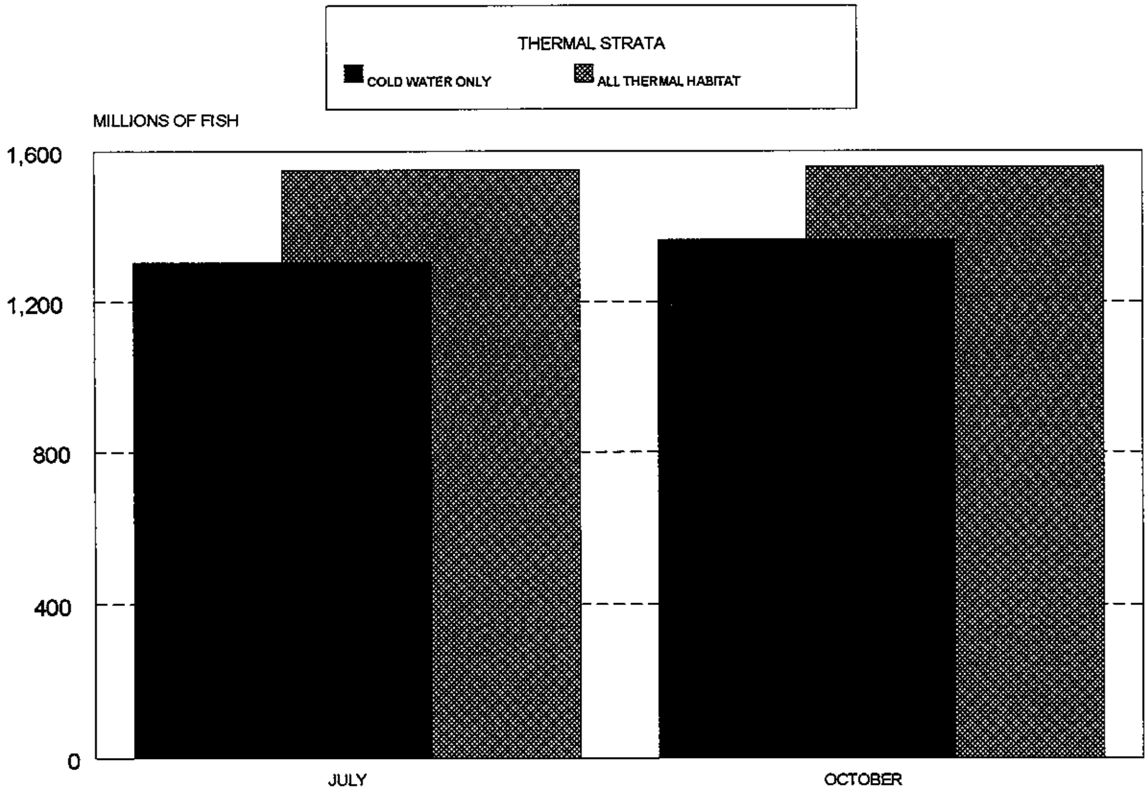


Figure 5.3-3: Estimated abundance of yearling-and-older smelt sized fish (-52 to -43 dB) expanded from eastern transects (4235, 58920, 59080) surveyed in 1995.