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Status of the Lake St. Clair fish community and sport fishery, 1996-2001.

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Abstract.–Lake St. Clair is located near the geographical center of the Great Lakes and is bisected by a commercial shipping lane and an international boundary. With a large human population in close proximity, the lake provides economically and socially important recreational opportunities for the people of southeast Michigan. The fish community of the lake is an important recreational resource. Since the early 1980s, the lake underwent invasions of white perch, spiny water flea, zebra mussel, round goby, and tubenose goby. Their impact on this resource has not been well documented. Using trawls to sample fish populations and an angler diary program to collect data on recreational fishing effort and catch, this study documents the status of the fish community in the lake between 1996 and 2001. Trawl sampling revealed a diverse fish community with 62 fish species collected, including 8 exotic species, 3 threatened species, and 2 endangered species. Species richness was similar between nearshore and offshore zones, but some species occurred exclusively within one zone or the other. Trawl catches were used to create three-dimensional lakewide distribution maps for each species. The spatial distribution of each species was then categorized based on visual inspection of the maps. Ten species were found only within the Anchor Bay area of the lake. Unique habitat features or more intensive sampling in Anchor Bay could have been factors in this distribution pattern. A few temporal trends in species abundance were identified. A general trend of declining abundance for three native benthic species (Johnny darter, northern logperch, and trout-perch) was attributed to competitive interactions with the exotic round goby. Yellow perch recruitment and abundance varied across years. The 1993, 1994, and 1998 year classes were strong, while the 1992 and 1997 year classes were weak. Lake St. Clair yellow perch of all ages were near the statewide average length. Yellow perch foraged extensively on burrowing mayflies. Round gobies were the fish most frequently found in yellow perch stomachs and were the second most frequent food item in walleye stomachs. Catch rates derived from the angler diary program did not reveal any trends across years for any of the four major sport species (walleye, yellow perch, smallmouth bass, or muskellunge). Results of this study suggest that nearshore habitats, particularly in the delta area, are important for maintaining species richness and should be protected. Management efforts to protect the fisheries resources of the lake should also include steps to avoid further exotic species introductions.

Lake St. Clair is centrally located in the connecting channel between Lake Huron and Lake Erie in the Laurentian Great Lakes (Figure 1). The interface between the St. Clair River and Lake St. Clair is a unique freshwater delta system with expansive marshes. For decades, the lake supported a recreational fishery renowned for smallmouth bass, muskellunge, walleye, and yellow perch (see Appendix 1 for scientific names of fishes). These predator populations were supported by a diverse and abundant forage fish community. Since the early 1980s, the lake has experienced invasions of white perch, spiny water flea, zebra mussel, round goby, and tubenose goby. With establishment of ruffe in the Lake Superior and Lake Huron basins, colonization by this exotic may also be imminent. The short-term and long-term effects of these exotics on the species diversity of the Lake St. Clair fish community have not been documented. In addition, the current status of threatened or endangered fish species in the lake is uncertain.

Approximately 4 million people live within a 1-hour drive of Lake St. Clair. Jamsen (1985) reported that nearly 22% of all Michigan Great Lakes sport fishing effort in 1981 was spent on Lake St. Clair. In 1983 and 1984, the annual estimated fishing effort on Lake St. Clair averaged 1.9 million angler hours (Haas et al. 1985). The value of the Lake St. Clair recreational fishery to the state economy in 1983 and 1984 averaged 8.7 million dollars (based on $36.50 per 8 hour day of fishing, USDI 1989). Clearly, extensive sport fishing effort and harvest in Lake St. Clair generate important socioeconomic benefits.

While the importance of the sport fishery in these waters is high due to the fisheries resources available in the system and proximity to the metropolitan Detroit area, catch surveys on Lake St. Clair and the connecting waters are extremely expensive. As a result, unique sport fisheries for Great Lakes muskellunge and smallmouth bass have been largely unmonitored. Lake Erie stocks of walleye migrate into these waters and are subjected to different levels of exploitation than those in Lake Erie proper (Haas et al. 1988). Angler reports suggest yellow perch in Lake St. Clair experienced good recruitment through the 1980s and early 1990s, while their populations in other Great Lakes waters were in serious decline (Fielder et al. 2000; Shroyer and McComish 2000). Knowledge of why this discrepancy existed would be valuable during development of yellow perch management plans for Great Lakes waters.

Recent catch rate data for the recreational fishery on Lake St. Clair are lacking, but charter boat data indicate the fishery changed during the 1990s. Charter boat fishing records document a 60% decline in walleye catch rate in the lake since 1989 (Rakoczy 1993). Meanwhile, catch rates for other species, primarily smallmouth bass and muskellunge, have increased by 97% over the same period. Similarly, charter boat catch rates for yellow perch have increased dramatically.

This study was designed to provide a clearer picture of the species diversity and spatial distribution of the Lake St. Clair fish community. The study objectives were to: 1) Document the status of yellow perch, including food habits, and other forage fish; 2) Measure the species richness and spatial distribution of native and exotic fish species; 3) Evaluate walleye interactions with exotic species by examining walleye diet, 4) Monitor trends in catch rates for the sport fishery through a voluntary angler diary program; and 5) Use the results of this study to identify management actions or strategies to protect or enhance the fishery resource of the lake.

Methods

Study Area

Lake St. Clair has a surface area of 1,114 km^2, an average depth of 3 m, and a maximum natural depth (i.e., excluding the dredged shipping channel) of only 6.4 m (Bolsenga and Herdendorf 1993). The lake is located midway between Lake Huron and Lake Erie, sandwiched between the St. Clair River and the Detroit River (Figure 1). The St. Clair River delta, with expansive marsh areas and natural channels, is a unique geological formation. Due to shallow depths and high flow volumes, the hydraulic retention time for Lake St. Clair is short. In general, the lake is characterized by two distinct water masses. The western portion of the lake is dominated by Lake Huron water flowing through the St. Clair River channels and sweeping south to the Detroit River. The southeastern area of the lake reflects contributions of nutrients and silts from the Thames River, the primary tributary. Sampling for this study occurred throughout Lake St. Clair.

Fish Collections

To document fish distribution patterns lakewide, a 2.5-minute latitude by 2.5-minute longitude grid system was established (Figure 2) and each grid was categorized as nearshore (if the grid encompassed the shoreline) or offshore (shoreline not present in the grid). Three sectors were established based on the geography of the lake: northwest, southwest, and southeast. Three nearshore grids and two offshore grids were then randomly selected from each sector for each month from June to October. In addition, an index area was established in Anchor Bay (Grids 11, 17 or 24) to allow evaluation of temporal changes (both seasonally and across years) in species densities, yellow perch growth (as suggested by mean length at age), age structure, and diet. The index area was sampled in early June and September, annually. Each time a grid was sampled, a minimum of three replicate trawl tows were made.

Trawls were used to capture fish from June to October. All sampling took place during daylight hours. Nearshore trawling was conducted from small boats, typically in water depths of 0.6 m to 2 m. Nearshore trawling gear consisted of a 5.3-m headrope otter trawl constructed of 38.1-mm stretched mesh with a 9-mm stretched-mesh liner in the cod end. All offshore trawling was conducted from the Michigan Department of Natural Resource (MDNR) research vessel *Channel Cat* in water depths exceeding 2 m. Offshore trawling gear consisted of a 10.7-m headrope otter trawl towed with single warp and a 45.7-m bridle. The trawl was constructed of 76 mm, 38 mm, and 32 mm graded, stretched-measure mesh from gape to cod end with a 9-mm stretched-mesh liner in the cod end. Whenever possible, nearshore and offshore tows were made with the trawl on the lake bottom, underway for 10 minutes at approximately 2.0 knots. Sometimes tow duration was shortened to avoid heavy plant growth or other physical obstructions.

Trawl catches were standardized as the number of fish caught per hectare by estimating the area swept by the trawl during each tow. Area swept was calculated based on the known gape of the trawl and the linear distance between starting and ending coordinates. Trawl gape of the 10.7-m headrope trawl had been previously measured at 7 m with Scanmar gear. Trawl gape of the 5.3-m headrope trawl was visually estimated at 3 m. We used ArcView geographic information software to determine the linear distance between starting and ending locations.

Fish collected with trawls were identified and enumerated. Total weight and number for each species were recorded. For trawl tows with high forage catches (typically total forage weight exceeding 10 kg) a 25% to 40% subsample was used to estimate the total number and weight for each species in that tow. Fewer than 5% of all trawl catches were subsampled.

Biodiversity Measures

We used Shannon's diversity index (Krebs 1999) to measure the evenness of species composition in our catches. Shannon's diversity index (SDI) was calculated as

$$SDI = -\sum_{i=1}^{S} P_i \cdot \ln(P_i)$$

where P_i is the proportion of a species in relation to the total catch and *s* is the total number of species in the community. Index values were calculated for the nearshore catch, the offshore catch, and for the combined catch.

Spatial Distribution Mapping

We created three dimensional maps of the spatial distribution of most fish species sampled during this study. The species catch for an individual trawl was divided by the area swept during that trawl tow to estimate density in number per hectare. The geographical center of the trawl tow was used for mapping coordinates of the density estimate. The density estimates for each species were expanded to a 300 X 300 cell regular, rectangular array (process known as "gridding") using an inverse distance to a power algorithm (power parameter = 2.0 and smoothing parameter = 1.5). Thus, species densities were interpolated for all grids, including those without trawl sample data. Three dimensional surface (wireframe) maps were created in SURFER© version 8 mapping software. White areas in the maps (Appendices 3 to 31) correspond to cells with estimated densities of zero per hectare for a particular species.

Spatial distribution maps were categorized based on visual inspection. Categories included widespread, common, uncommon, and rare. A species was categorized as widespread if its spatial coverage exceeded 90% of the lake, common if its spatial coverage was 50% to 90% , uncommon if its spatial coverage was 10% to 50% , and rare if its spatial coverage was less than 10% of the lake area. Other special characteristics such as predominantly nearshore in distribution, or delta associated, were also noted.

Biological Measures For Select Species

Scale samples were taken from yellow perch collected in June and September of each year for age estimation. Scale samples for age estimation were collected from walleye caught from 1997 to 2001, smallmouth bass caught in 2000 and 2001, and rock bass caught in 2000. Scale impressions were made on clear acetate and viewed on a microfiche projector for age interpretation. Length-at-age (growth) for each species was compared to State of Michigan averages (Schneider et al. 2000).

In September of each year, six samples of 52 adult and 10 young-of-the-year (YOY) yellow perch were collected for diet analysis. The perch were sampled randomly, placed on ice, and immediately frozen with liquid nitrogen to stop digestion. Fish were kept frozen until processed in the laboratory.

Yellow perch were thawed in the laboratory, measured, and weighed. Fish were eviscerated, sexed, and checked for parasitic nematodes, either *Eustrongilides tubifex* or *Philometra cylindracea*, commonly referred to as redworms. Redworms are parasites of yellow perch across much of the Great Lakes. Cysts of the parasites are formed mainly in the mesenteries, liver, gonads, and body wall of yellow perch (Crites 1979).

Yellow perch viscera were weighed after removal of stomach contents. Stomach contents were weighed and preserved in ethanol. After this initial processing, yellow perch viscera and somatic tissues were frozen for later dry weight analysis. Somatic wet and dry weights were then measured after re-thawing. Subsamples of yellow perch and their excised viscera were dried at 90^{o} C for 2 days in a drying oven and weighed. Percent water content can be used as an indication of fat content. Elliot (1976) found that as food ration size increased, protein and fat increased and percent water content decreased. Percent water content of the somatic tissue was calculated by the formula:

$$\% \text{ water} = ((\text{somatic wet weight} - \text{somatic dry weight})/\text{somatic wet weight})$$

Yellow perch stomach contents were evaluated by counting the number of organisms of each taxon. The diet was analyzed for frequency of occurrence, as described by Windell and Bowen (1978), and defined as the percentage of fish with non-empty stomachs that contained at least one of a selected food item.

In order to evaluate the utilization of exotic species by a Lake St. Clair predator, the stomachs of all walleye collected from 1997 to 1999 were removed and examined for food items. Immediately upon capture, the fish were eviscerated and all stomach contents were identified to the lowest taxa possible. The diet data were analyzed for frequency of occurrence as described above.

Monitoring Angler Catch Rates

A diary program is one method of obtaining data to quantify fishery parameters. Diary programs have been used to monitor sport fisheries or fish populations in a variety of locations (Bray and Schramm 2001; Ebbers 1987; Gabelhouse and Willis 1986). We used a voluntary angler diary program to monitor catch rates of recreational anglers fishing on Lake St. Clair. Cooperating anglers recorded their fishing activity in diary booklets provided by the MDNR and Ontario Ministry of Natural Resouces (OMNR) each season. Anglers were asked to record all their fishing activity from April through the end of the open water season. Angler diary booklets were recovered from the anglers each fall. Data were keypunched into computer spreadsheets or databases. Effort was recorded as rod hours fished. Overall angler catch rates for targeted species were calculated as total number of fish caught divided by total effort.

Results

Species Diversity and Spatial Distribution

Over the 6-year study, a total of 326,013 fish were captured with 886 trawl tows. A total of 62 fish species were represented in the catch, including 8 non-native species. The most common species collected were trout-perch, spottail shiner, yellow perch, mimic shiner, and rainbow smelt (Table 1). In addition to rainbow smelt, other non-native species captured included alewife, round goby, white perch, tubenose goby, common carp, goldfish, and carp x goldfish hybrid. State-listed threatened species collected were mooneye, lake sturgeon, and eastern sand darter. State-listed endangered species collected were channel darter and river darter. Numbers of threatened and endangered fish collected were low, except for 131 lake sturgeon captured during this survey.

Species richness was similar between the nearshore and offshore zones. A total of 51 species were collected in the nearshore sampling, while 52 species were collected in offshore sampling. However, there were distinct differences in the species composition of the fish communities. Species unique to the offshore zone were lake sturgeon, quillback, longnose gar, stonecat, mooneye, blackside darter, green sunfish, hornyhead chub, northern hog sucker, and carp x goldfish hybrid. Species unique to the nearshore trawls were sand shiner, goldfish, rainbow darter, grass pickerel, river darter, Iowa darter, greenside darter, spotfin shiner, and black bullhead. Trout-perch were the most abundant species for the offshore catch, but ranked 13th in abundance in the nearshore catch. Conversely, mimic shiner was the most abundant species for the nearshore catch, but ranked 4th in the offshore catch. The SDI value for the nearshore catch (2.26) was higher than for the offshore catch (2.01).

The spatial distribution category assigned to each species is shown in Appendix 1, while the spatial distribution maps for most species are shown in Appendices 2-31. Numerically abundant species tended to exhibit widespread spatial distributions, while species with low numerical abundances in the trawl sampling were characterized by patchy or limited spatial distributions. The most recent exotic fish species to invade Lake St. Clair—the tubenose goby and the round goby—were both classified as widespread in distribution (Appendix 1), but round goby density was generally much higher across wide areas of the lake (Appendix 30). Four of the five threatened or endangered fish species collected were characterized by uncommon or rare spatial distributions. The exception was the lake sturgeon, which had a common distribution (Appendix 3). Several species categorized as rare exhibited distributions that were limited to a small portion of the lake. The spatial distribution of brook stickleback, black bullhead, northern hog sucker, spotfin shiner, hornyhead chub, green sunfish, Iowa darter, channel darter, blackside darter, and slimy sculpin, were all limited to the Anchor Bay area. The southeast area near the Thames River was the only location for sand shiner, goldfish, and river darter. All lake whitefish collected were age 0 and were found in the shallow waters of the delta.

Temporal Trends in Species Abundance

A few temporal trends in species abundance were evident at the Anchor Bay area. Rainbow smelt and yellow perch were generally more abundant in June trawls than September trawls. Largemouth bass abundance increased in the trawls from 1999 to 2001, after being absent during the first 3 years of the study. Three native benthic species (Johnny darter, northern logperch, and trout-perch) exhibited a general trend of declining abundance across the 6 years of study.

Catch rates for yellow perch were much higher in the June index trawls than in September, but no trend in June catch rates was apparent across years (Table 2). Age-specific catch rates clearly illustrate the variable recruitment experienced by yellow perch in Lake St. Clair. The 1993, 1994, and 1998 year classes were particularly strong (Table 3), while 1992 and 1997 year classes were very weak.

Biological Measures for Select Species

Overall, no clear trend in yellow perch size at age was apparent across the study period (Table 4). Yearling growth appeared to have improved from below to above the statewide average. However, older age groups were smaller than the statewide average.

A total of 1,505 yellow perch stomachs were examined for diet items. At least one food item was found in 953 of the stomachs examined. Yellow perch diets in Lake St. Clair were dominated by benthic invertebrates for most years of the study. When summed across years, the burrowing mayfly, *Hexagenia* spp., occurred in 56.3% of all non-empty stomachs examined (Table 5). Other taxa with high frequency of occurrence values included fish, chironomid larvae, gastropods, and zooplankton. While 55% of all fish found in the stomachs were too digested for positive identification, the exotic round goby accounted for 30% of all identifiable fish. Other fish species found in the stomachs included trout-perch (<1%), yellow perch (<1%), alewife (<1%), spottail shiner (<1%), northern logperch (<1%), Johnny darter (<1%), smallmouth bass (<1%), juvenile centrarchids (11%), and rock bass (2%).

Mean somatic water content (MSWC) varied across age groups, sexes, and years (Figure 3). Lowest values for MSWC were recorded for 1998 for both sexes. A general trend of decreasing MSWC from 1996 to 1998, then increasing MSWC from 1999 to 2000 was apparent for both sexes.

Visible redworm infection was recorded in 4.4% of all yellow perch viscera examined. There was no difference in infection rates between sexes. A general trend of increasing rate with increasing age was apparent. Age-0 (0%) and Age-1 (2%) fish had the lowest infection rates. Age-5 (15%) and age-7 (22%) fish had the highest infection rates.

A total of 325 walleye stomachs were examined for diet items. At least one food item was found in 183 of the stomachs examined. Exotic fish species predominated. Alewife (21.9%), round goby (12.0%), and rainbow smelt (8.2%) were the most frequently found identifiable food items (Table 6). Other identifiable fish species were relatively uncommon in the diet. More than half of the stomachs examined contained fish digested beyond recognition. *Hexagenia* spp. was the only invertebrate commonly seen in the diet.

Mean length at age for walleye from Lake St. Clair compared favorably with the state average values (Figure 4). Similarly, smallmouth bass and rock bass mean length was markedly higher for most ages than the statewide averages for those species. Thus, all these species experienced good growth during the study period.

Catch Rates from Angler Diaries

The four primary species sought by anglers participating in the angler diary program were walleye, yellow perch, smallmouth bass, and muskellunge. During the 6 years of this study, diary program participants reported results from 5,974 trips on Lake St. Clair targeting those species. In general, effort declined over the study period as angler participation declined and new angler recruitment slowed. On an annual basis, the greatest effort was directed at muskellunge, followed by walleye, yellow perch, and smallmouth bass (Table 7). Muskellunge anglers also reported the highest proportion of fish caught and released (99.1%), followed by smallmouth bass anglers (82.4%), yellow perch anglers (39.2%), and walleye anglers (13.3%). Muskie catch rates, the lowest of the four species, ranged from 0.069 to 0.117 fish per rod hour. Catch rates for walleye ranged from 0.31 to 0.47 fish per rod hour. Smallmouth bass catch rates ranged from 0.35 to 1.22 fish per rod hour. Yellow perch catch rates were the highest of the four species, ranging from 2.03 to 3.61 fish per rod hour. Catch rates for the four major species varied across the study period with no apparent trends. Yellow perch (3.61) and smallmouth bass (1.22) catch rates were highest in 2000. The best walleye (0.47) and muskellunge (0.117) catch rates were recorded in 2001.

Discussion

Species Diversity and Spatial Distribution

Our sampling during this study captured 62 fish species. This total should not be considered comprehensive. Some species, such as salmon and trout, known to be seasonally present through sport angler catches, were not collected during this study. In fact, Kelso and Minns (1996) listed 57 fish species collected by electrofishing in the St. Clair River, including 15 species we did not collect from Lake St. Clair during this study. Their absence from the sampling could be a reflection of gear types used in sampling, temporal period sampled, or true absence of the species from the lake.

Fish species richness in Lake St. Clair was high compared with other coastal areas of the

Great Lakes. Michigan Department of Natural Resources surveys in Saginaw Bay, Lake Huron during the 1990s captured a total of 38 species with offshore trawls and gill nets (Fielder et al. 2000). A 28-year time series of trawl data for Lake Erie captured a total of 41 species (Ludsin et al. 2001). A single year survey of a Lake Superior coastal wetland captured a total of 34 fish species (Brazner et al. 1998). Surveys of coastal zones in Green Bay captured a total of 54 fish species (Brazner 1997). Willis and Magnuson (2000) found that mouths of tributaries supported higher species richness than either streams or lakes. This suggests that the unique freshwater delta system at the St. Clair River-Lake St. Clair interface is likely an important factor in the high species richness documented during our study. We found that species richness was similar between nearshore and offshore zones in Lake St. Clair. However, the Shannon diversity index was higher for the nearshore zone because species evenness was higher. This suggests that protection of nearshore habitats could help maintain species richness and evenness within the lake.

All threatened or endangered species except lake sturgeon had low abundance and limited spatial distribution, suggesting continued protection for these species is necessary. Lake sturgeon abundance in Lake St. Clair was much higher than expected, prompting an additional MDNR, federal aid study in 1997 to document lake sturgeon abundance, spawning locations, age structure, movements, and exploitation. Progress of that study has been reported in several publications. Thomas and Haas (1999) reported the successful use of setlines, baited with round gobies, for capturing lake sturgeon in the St. Clair River. While lake sturgeon were widely distributed across the offshore waters of Lake St. Clair, we (Thomas and Haas 2002) identified a relatively small region of consistently high lake sturgeon densities near the Michigan portion of the St. Clair delta. Although the factors that made this area so attractive to the fish were unclear, we suggested successful rehabilitation of lake sturgeon in the St. Clair system would require continued protection of the habitat in that high density location.

Although exotic species accounted for only 13% (8/62) of the total number of species collected during this study, 4 of the 10 most numerically abundant species were exotics (rainbow smelt, alewife, round goby, and white perch). Two of those species, the rainbow smelt and alewife, have been present in the Great Lakes for at least 5 decades. The white perch colonized the St. Clair system in the early 1980s, while the round goby has only been present about 10 years (Jude et al. 1992). In comparison, exotics accounted for 21% (8/38) of the total number of fish species collected in Saginaw Bay (Fielder et al. 2000). Some other systems have been much more heavily colonized. For example, 47% (25/53) of the fish species captured in the San Francisco estuary were exotic species (Matern et al. 2002). Within Lake St. Clair and the rest of the Great Lakes, the ecological impacts of exotic fish species continue to unfold (Leach et al. 1999).

In this study, sampling effort was not evenly distributed across Lake St. Clair. This could have affected the distributions of rare species documented during this study because there may be a greater likelihood of encountering a rare species with greater sampling effort. The Anchor Bay area was sampled much more intensively than any other area of the lake and we found the highest number of species classified as rare in distribution at that location; however we do not think this number is a consequence of greater sampling effort. Six of the 10 rare species (brook stickleback, northern hog sucker, spotfin shiner, hornyhead chub, Iowa darter, and blackside darter) found in the Anchor Bay area generally inhabit lotic environments (Scott and Crossman 1973). In fact, the highest number of species classified as "rare" in distribution and limited to a single geographic area were found in Anchor Bay. The 10 species limited to Anchor Bay included 6 that are primarily lotic species. Since Anchor Bay is characterized by a large water mass flowing from the St. Clair River delta channels to the Detroit River, we view the higher occurrence of rare lotic species there as a consequence of habitat diversity rather than higher sampling effort.

A few interesting patterns were noted in the spatial distribution maps of some species. The area of highest parasitic silver lamprey densities (Appendix 3) coincided with high densities of lake sturgeon (Appendix 3), common carp (Appendix 13), white sucker (Appendix 14), quillback (Appendix 14), silver redhorse (Appendix 15), and shorthead redhorse (Appendix 16). Silver lamprey are known to specialize on large hosts such as catostomids or lake sturgeon (Cochran and Marks

1995). We suggest the spatial distribution of silver lamprey is related to the availability of large potential hosts.

The spatial distribution of the two clupeid species collected, alewife and gizzard shad, were notably different. Alewife were widespread and could be found at high densities throughout the lake. In contrast, gizzard shad, were virtually absent from Anchor Bay and only dense near the mouth of the Thames River.

Temporal Trends in Species Abundance

Temporal trends in species abundances at the Anchor Bay index site are likely a result of different factors for each of the species. Seasonal trends were apparent for rainbow smelt and yellow perch. Rainbow smelt and yellow perch abundance were both high in June and low in September. As with most fish species, these changes likely have little to do with seasonal changes in absolute abundance, but more to do with fish movement patterns and the ability of sampling gear to catch fish as their behavior changes. For smelt, warmer summer water temperatures likely force them to seek cooler temperatures in the St. Clair River or southern Lake Huron. Yellow perch may associate with submerged aquatic macrophytes in September, and be missed by trawls that are ineffective in sampling fish from dense macrophyte beds. In fact, anglers consistently reported good perch fishing in association with macrophytes in September over the course of this study (personal observation).

Trends across years were noted for several species over the course of this study. Largemouth bass abundance increased dramatically in 1999, coinciding with a drop in water levels below the long-term mean for the first time in roughly 30 years (Figure 5). Since largemouth bass prefer to spawn in shallow waters (Heidinger 1975; Nack et al. 1993), low water levels since 1999 may have stimulated improved spawning success in coastal marshes and canals which previously had been inundated with higher water levels. In contrast, there was a general decline in abundance of Johnny darter, northern logperch, and trout-perch, across the 6 years of the study. Round gobies can be aggressive competitors with small native benthic fishes (Jude et al. 1995; Dubs and Corkum 1996; French and Jude 2001; Janssen and Jude 2001); therefore, we submit that the declines in the three native species were due to competitive interactions with the exotic round goby. Declines in these three previously abundant species, raise serious concerns about the long-term persistence of less abundant benthic fishes such as the eastern sand darter, channel darter, and river darter. We anticipate that competition with round gobies will further reduce their abundance, possibly to the point of local extinction in Lake St. Clair.

Yellow perch exhibited highly variable recruitment during this study. The strong year classes produced in 1993, 1994, and 1998 in Lake St. Clair correlated with strong year classes of yellow perch in Lake Erie (Kayle et al. 2001). Similarly, 1992 and 1997 were years of poor yellow perch recruitment in both water bodies. Synchrony in year-class strength between Lake St. Clair and the more distant Saginaw Bay was less apparent. While the 1998 year class at Saginaw Bay was strong, the 1993 and 1994 year classes were among the weakest observed over the last 30 years (Fielder et al. 2000). The 1992 year class was very poor in Saginaw Bay, similar to Lake St. Clair, but the 1997 year class in Saginaw Bay was as strong as the 1998 year class. Similarities in recruitment patterns between Saginaw Bay and Lake St. Clair/Lake Erie suggest regional climatic conditions may play a key role in yellow perch reproductive success. Disparities between Saginaw Bay and Lake St. Clair/Lake Erie recruitment patterns may reflect differences in a variety of more localized factors such as egg or fry predator abundances, abundance of forage species available to buffer predation on yellow perch fingerlings by larger piscivores, or even adult perch condition.

Biological Measures for Select Species

While no trend in yellow perch size at age was clear during the 6 years of this study, results of previous studies indicate that age 2 and older yellow perch in Lake St. Clair were larger as recently as 1993 (Synnesvedt 1997). Factors behind this apparent decline in size at age are unclear. Condition, as reflected by mean somatic water content, did not follow the same pattern. Condition improved from 1996 to 1998, then declined in 1999 and 2000. Changes in the diet of Lake St. Clair yellow perch could be related to the observed changes in size at age and condition. The large burrowing mayfly *Hexagenia* spp. dominated yellow perch diet from 1996-1998. However, the frequency of occurrence of *Hexagenia* in the diet decreased in 1999 and 2000 as the proportion of fish, zooplankton, amphipods, gastropods, and chironomids increased. Recent studies have suggested that *Hexagenia* are a key benthic diet item for yellow perch, promoting faster growth rates and improved recruitment when present in sufficient numbers (Schaeffer et al. 2000; Tyson and Knight 2001).

The fish component of the yellow perch diet in Lake St. Clair has changed appreciably since 1993. In 1993, the primary fish consumed during the fall were brook stickleback, Johnny darter, and slimy sculpin. By 2000, these fish were no longer part of the yellow perch diet, which had shifted to round gobies and age-0 centrarchids (mainly bluegill and pumpkinseed). Trawl catches during this study indicated that abundances of brook stickleback, Johnny darter, and slimy sculpin had declined. We attribute the observed shift in yellow perch predation to declining abundances of those species.

Our study found that the overall redworm infection rate for yellow perch in Lake St. Clair, 4.4%, was approximately unchanged from that recorded in 1993 (Synnesvedt 1997). In comparison, Saginaw Bay yellow perch infection rates in the mid-1990s were over 50% (Fielder et al. 2000). Redworm infection can reduce yellow perch condition (Salz 1989), but the low infection rate recorded during our study suggests this was not a factor for Lake St. Clair yellow perch.

Walleye diet was dominated by three exotic species: alewife, round goby, and rainbow smelt. Alewife and rainbow smelt are pelagic species, while the round goby is a benthic species. A graduate student project examined the diets of smallmouth bass, walleye, and rock bass in Lake St. Clair during 2000 and 2001 (O'Keefe 2003). The study found that round gobies and alewives were important components of the diets for both smallmouth bass and walleye. Clearly, exotic species, including the most recent invader, the round goby, are important components in the food web of Lake St. Clair.

Catch Rates from Angler Diaries

Our data did not reveal consistent trends in catch rates for any of the four primary species (walleye, yellow perch, smallmouth bass, and muskellunge) sought by sport anglers in Lake St. Clair. However, the highest catch rate for each species was noted in 2000 or 2001, suggesting a pattern of better fishing success during those 2 years. Since angler catch rates can be influenced by a wide variety of factors, better fishing success does not necessarily represent higher fish abundance.

A carefully designed catch survey can provide fisheries managers with accurate estimates of recreational fishing effort, catch, and catch rates. Unfortunately, the extensive size of Lake St. Clair, numerous public and private access sites, and high volume of non-fishing boat traffic combine to make catch surveys of Lake St. Clair both challenging and expensive. As a result, catch survey data for the U.S. waters of Lake St. Clair have been sparse and temporally fragmented. Catch and effort data for the Lake St. Clair sport fishery was last collected with a full catch survey in 1984 (Haas et al. 1985). We elected to use a volunteer angler diary program to monitor catch rates for the major sport fish species from 1996 to 2001 as an inexpensive surrogate for creel survey data. However, we also recognize that volunteer angler diary data must be interpreted carefully. Other studies have found that participants in such programs tend to fish more frequently, belong to fishing clubs, and experience higher catch rates than the general fishing public (Prentice et al. 1995; Bray and Schramm 2001). Trends in fish abundance may not be well reflected in catch rates for avid anglers because those anglers are more persistent and effective at catching fish (Baccante 1995). Thus, actual trends in fish abundance may be masked by angler diary catch rates. Because well designed catch surveys randomly sample anglers and provide unbiased lakewide estimates of harvest, effort, and catch rates, we believe an angler diary program is not a valid substitute for full catch surveys for monitoring trends in fish abundance. We believe the greatest value of an angler diary program may lie in the maintenance of a collaborative relationship between ardent anglers and fisheries management professionals.

Management Recommendations

1. A lakewide catch survey should be conducted on Lake St. Clair on a regular basis to monitor changes in the recreational fishery related to fish population changes. With careful interpretation, catch survey data can supplement other fish population indices.
2. Nearshore habitat should be protected. This habitat is important for maintaining native species richness of the system. Areas of the St. Clair delta are probably most critical.
3. Exotic species introductions should be prevented. Such introductions pose an enormous threat to the biodiversity of Lake St. Clair and the overall integrity of the Great Lakes ecosystem.

Acknowledgments

This study was supported by funds from the Sport Fish Restoration Act. Numerous MDNR employees were instrumental in field collections. Boat captains Larry Shubel, Jack Hodge, and Roy Beasley operated the survey vessels and maintained the sampling gear. Jack also performed the majority of the angler diary data entry. Ken Koster, Fisheries Research Technician, conducted the lab work on yellow perch (dry weight and diet processing) and interpreted all scale samples for ages. Fisheries Assistants Sarah Thayer and Kevin Rathbun assisted in field collections, gear maintenance, data entry, lab processing, and scale sample preparation. Sarah Thayer provided a much appreciated critical review of the manuscript.

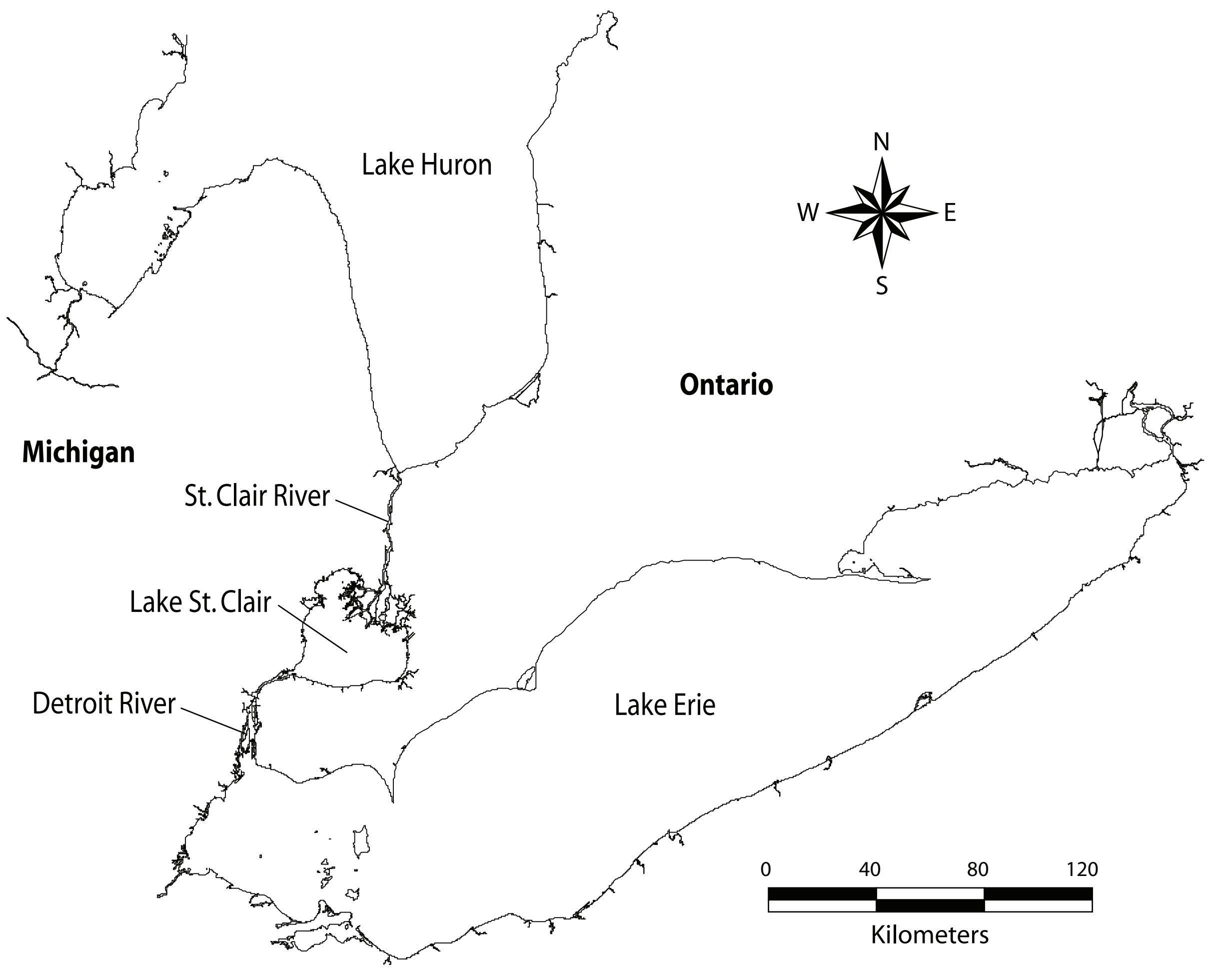

Figure 1.–Lake St. Clair is part of the connecting waterway between southern Lake Huron and western Lake Erie.

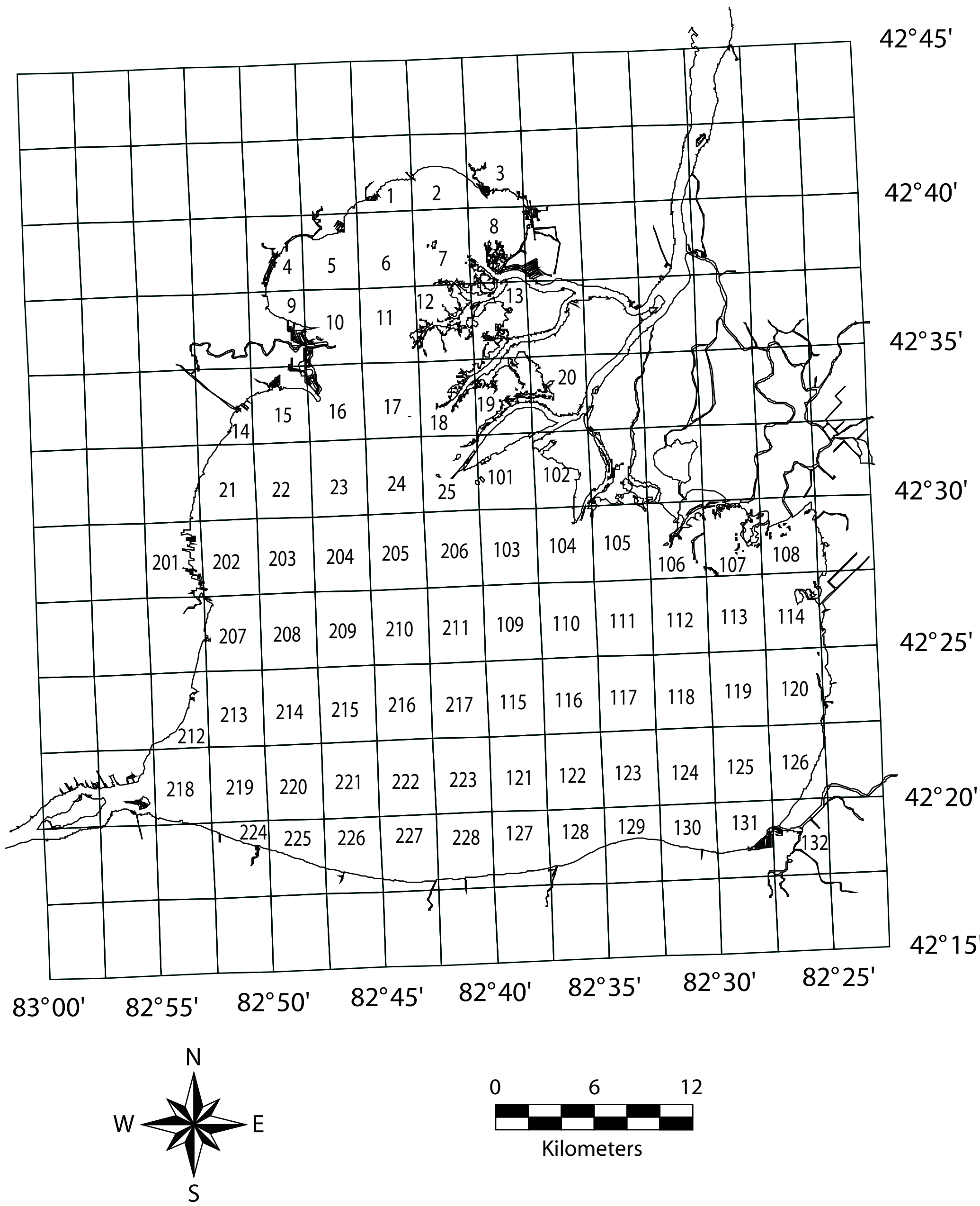

Figure 2.–Map of Lake St. Clair showing 2.5-minute by 2.5-minute grid system used for trawl site selection.

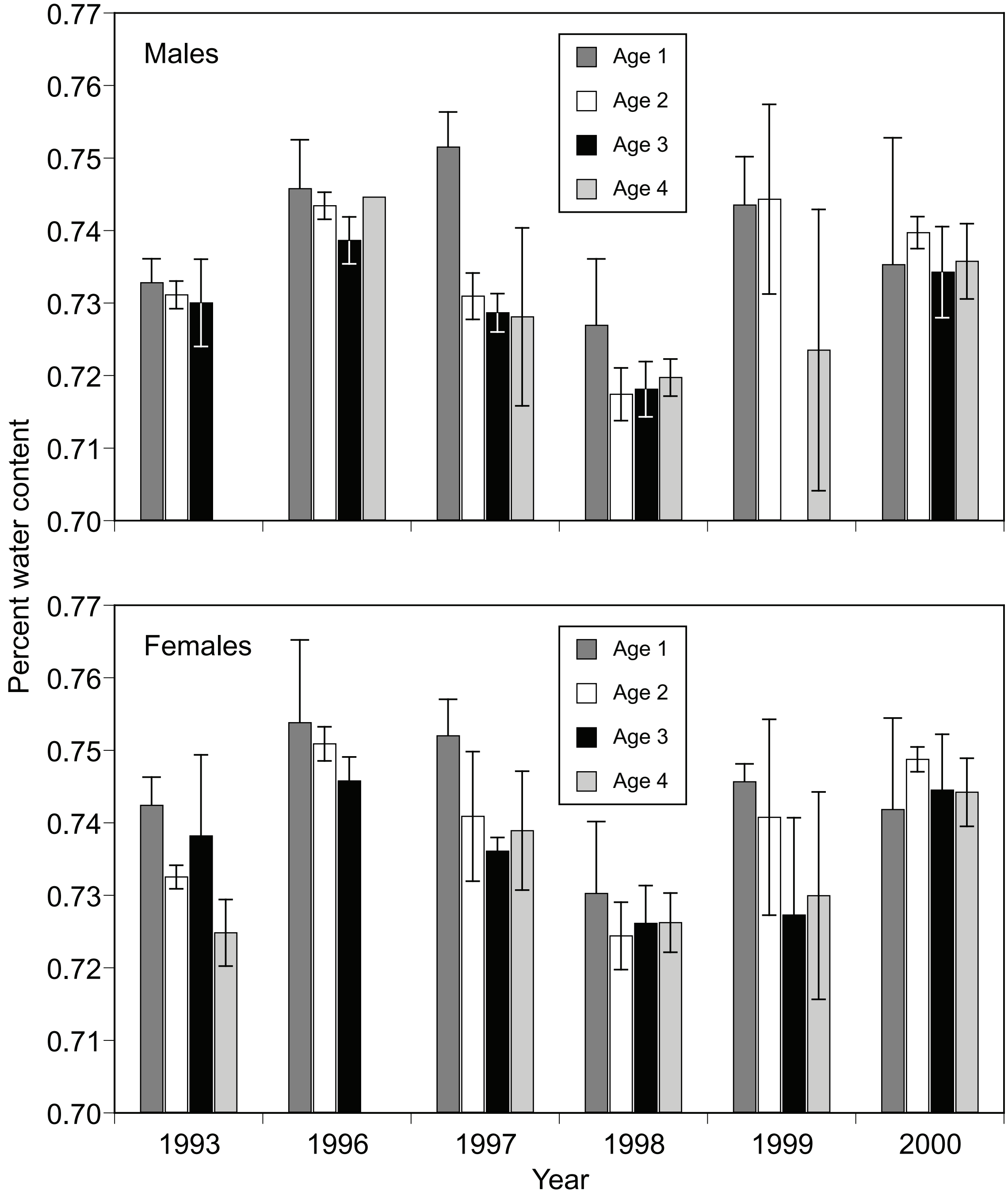

Figure 3.–Mean somatic water content for Lake St. Clair yellow perch, ages 1 to 4, for 1993 and 1996-2000. Higher values indicate poorer condition. Error bars represent ± 2 standard errors. Data for 1993 from Synnesvedt (1997).

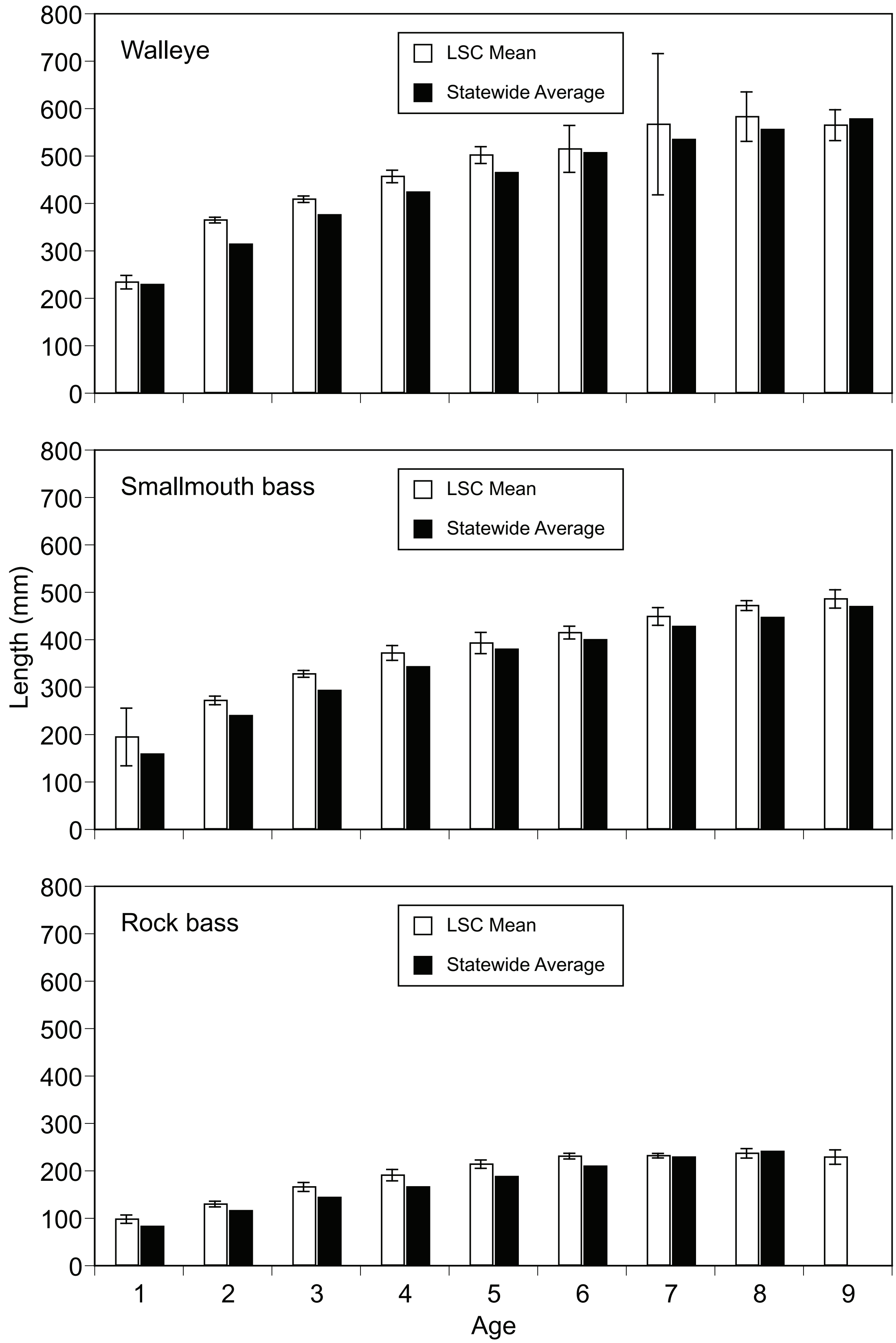

Figure 4.–Mean length at age for walleye (1997-2001), smallmouth bass (2000–2001), and rock bass (2000) in Lake St. Clair (LSC) compared with Michigan statewide average lengths for the June to October period. Error bars represent ± 2 standard errors.

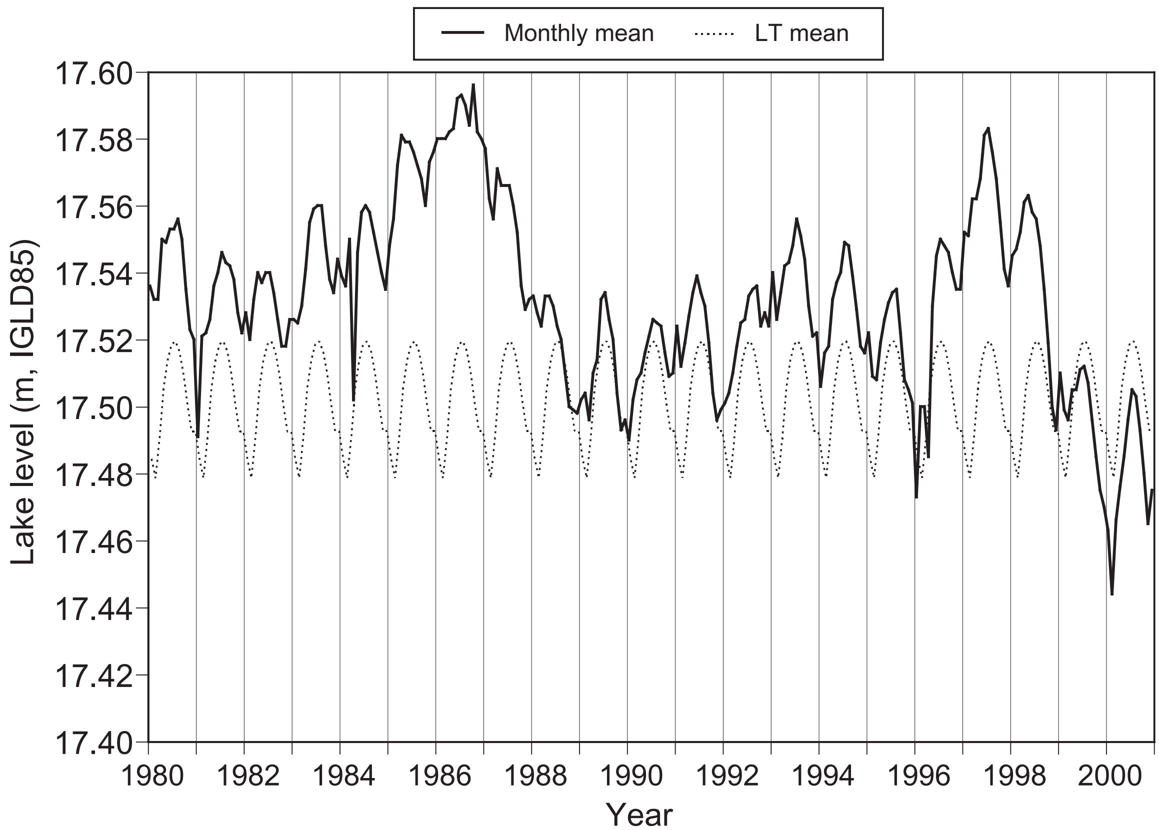

Figure 5.–Long-term monthly means and observed mean monthly water levels for Lake St. Clair from 1980 to 2000. Data from US Army Corps of Engineers.

Table 1.–Fishes collected from 1996 to 2001 with two sizes of bottom trawls on Lake St. Clair, listed in decreasing order of total abundance for the two gears combined. (*) denotes alien species; (T) denotes state-listed threatened species; (E) denotes state-listed endangered species.

	Offshore		Nearshore		Lakewide	
Species	Number	%	Number	%	Number	%
Trout-perch	77832	28.1	639	1.3	78471	24.1
Spottail shiner	59246	21.4	11600	23.4	70846	21.7
Yellow perch	62178	22.5	2323	4.7	64501	19.8
Mimic shiner	24645	8.9	15740	31.8	40385	12.4
Rainbow smelt*	12760	4.6	79	0.2	12839	3.9
Alewife*	6495	2.3	2570	5.2	9065	2.8
Round goby*	6177	2.2	2701	5.5	8878	2.7
Rock bass	5952	2.2	2085	4.2	8037	2.5
White perch*	5199	1.9	1870	3.8	7069	2.2
Smallmouth bass	3619	1.3	1695	3.4	5314	1.6
Northern logperch	3512	1.3	260	0.5	3772	1.2
Gizzard shad	972	0.4	1967	4.0	2939	0.9
Emerald shiner	2801	1.0	62	0.1	2863	0.9
Bluntnose minnow	972	0.4	1704	3.4	2676	0.8
Bluegill	144	0.1	1733	3.5	1877	0.6
Johnny darter	562	0.2	693	1.4	1255	0.4
Largemouth bass	348	0.1	465	0.9	813	0.2
Pumpkinseed	218	0.1	439	0.9	657	0.2
Freshwater drum	515	0.2	43	0.1	558	0.2
Walleye	517	0.2	9	0.0	526	0.2
Tubenose goby*	178	0.1	165	0.3	343	0.1
White sucker	310	0.1	10	0.0	320	0.1
Shorthead redhorse	297	0.1	22	0.0	319	0.1
Silver redhorse	260	0.1	7	0.0	267	0.1
White bass	132	0.0	64	0.1	196	0.1
Banded killifish	38	0.0	129	0.3	167	0.1
Brook silverside	61	0.0	105	0.2	166	0.1
Lake sturgeon (T)	131	0.0	0	0.0	131	<0.1
Quillback	127	0.0	0	0.0	127	<0.1
Common carp*	99	0.0	15	0.0	114	<0.1
Black crappie	2	0.0	83	0.2	85	<0.1
Silver lamprey	66	0.0	1	0.0	67	<0.1
Creek chub	1	0.0	61	0.1	62	<0.1
Brook stickleback	34	0.0	5	0.0	39	<0.1
Northern pike	24	0.0	8	0.0	32	<0.1

Table 1.–Continued.

Species	Offshore		Nearshore		Lakewide	
	Number	%	Number	%	Number	%
Channel catfish	22	0.0	9	0.0	31	<0.1
Muskellunge	22	0.0	3	0.0	25	<0.1
Eastern sand darter (T)	0	0.0	24	0.0	24	<0.1
Tadpole madtom	8	0.0	16	0.0	24	<0.1
Longnose gar	23	0.0	0	0.0	23	<0.1
Brindled madtom	3	0.0	19	0.0	22	<0.1
Golden redhorse	19	0.0	2	0.0	21	<0.1
Lake whitefish	2	0.0	15	0.0	17	<0.1
Brown bullhead	1	0.0	9	0.0	10	<0.1
Stonecat	7	0.0	0	0.0	7	<0.1
Channel darter (E)	5	0.0	1	0.0	6	<0.1
Slimy sculpin	5	0.0	0	0.0	5	<0.1
Sand shiner	0	0.0	3	0.0	3	<0.1
Goldfish*	0	0.0	3	0.0	3	<0.1
Rainbow darter	0	0.0	2	0.0	2	<0.1
Grass pickerel	0	0.0	2	0.0	2	<0.1
Mooneye (T)	2	0.0	0	0.0	2	<0.1
River darter (E)	0	0.0	1	0.0	1	<0.1
Blackside darter	1	0.0	0	0.0	1	<0.1
Iowa darter	0	0.0	1	0.0	1	<0.1
Greenside darter	0	0.0	1	0.0	1	<0.1
Green sunfish	1	0.0	0	0.0	1	<0.1
Hornyhead chub	1	0.0	0	0.0	1	<0.1
Spotfin shiner	0	0.0	1	0.0	1	<0.1
Carp x goldfish hybrid*	1	0.0	0	0.0	1	<0.1
Northern hog sucker	1	0.0	0	0.0	1	<0.1
Black bullhead	0	0.0	1	0.0	1	<0.1

Table 2.–Mean density (number per hectare) for fish species commonly caught during spring (June) and fall (September or October) with 10.7-m headrope trawls at the Anchor Bay index area.

	Spring						Fall					
Species	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Alewife	29.2	10.6	2.5	1.9	3.9	2.9	28.3	30.7	11.5	1.6	2.8	32.3
Bluntnose minnow	0.7	0.0	0.2	0.0	11.1	10.0	0.0	33.5	0.2	9.4	14.8	53.8
Common carp	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.9	0.0	0.1	0.0	1.1
Emerald shiner	0.7	0.2	0.0	0.0	5.1	0.0	3.8	1.1	7.5	0.0	0.0	0.0
Freshwater drum	6.6	12.5	5.0	2.3	0.7	4.5	1.1	0.6	0.2	1.4	1.0	2.3
Johnny darter	21.7	2.8	7.0	0.0	0.2	0.3	17.7	4.0	0.0	0.0	0.10	0.0
Lake sturgeon	2.3	0.4	0.0	0.1	0.2	0.0	1.8	0.0	1.4	0.0	0.1	0.0
Largemouth bass	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0	3.0	1.8	16.4
Northern logperch	8.8	75.6	83.3	7.6	0.2	1.6	32.4	40.0	20.6	1.3	5.2	17.5
Mimic shiner	17.2	26.3	1.6	0.0	13.5	20.4	267.6	1094.9	0.2	29.8	14.8	9.6
Muskellunge	0.0	0.2	0.0	0.1	0.0	0.6	0.2	0.2	0.0	0.0	0.1	1.1
Northern pike	0.0	0.4	0.2	0.0	0.1	1.3	0.0	0.4	0.0	0.1	0.3	0.6
Shorthead redhorse	7.7	6.7	0.7	6.9	2.5	3.6	0.2	0.4	0.2	0.4	0.7	2.3
Pumpkinseed	0.0	0.6	0.0	0.0	0.0	1.9	0.2	4.0	0.0	1.6	0.4	5.1
Quillback	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.1	1.1	0.0	0.7	0.0
Rainbow smelt	593.0	656.1	4.3	4.0	3.8	61.1	0.9	16.5	0.2	0.0	1.0	0.0
Rock bass	43.0	17.5	5.4	1.0	12.8	29.8	18.3	81.5	0.9	89.0	92.8	39.6
Round goby	4.8	14.3	28.1	6.0	10.8	1.3	65.7	9.7	22.2	9.6	10.0	10.2
Silver lamprey	0.0	0.2	0.0	0.9	0.3	0.0	0.5	0.0	0.0	0.2	0.0	0.3
Silver redhorse	0.7	2.3	0.2	0.4	0.9	0.0	4.5	0.9	0.7	0.0	0.4	1.1
Smallmouth bass	0.2	3.2	0.5	0.0	0.8	2.9	13.6	10.6	24.5	10.7	6.1	0.0
Spottail shiner	178.2	122.6	8.2	68.9	935.4	7.4	17.0	487.2	45.3	200.0	50.5	878.5
Trout-perch	231.2	345.9	98.5	154.0	34.3	11.0	775.7	92.3	25.8	2.9	0.2	0.0
Walleye	4.5	10.4	0.9	1.7	1.2	0.6	7.2	1.3	2.7	0.9	0.8	0.0
White perch	1.4	0.7	0.0	0.4	13.3	0.6	16.1	11.7	7.5	0.1	0.1	0.0
White sucker	5.4	3.7	3.6	0.0	2.5	1.3	0.5	2.3	0.0	0.3	1.0	0.6
Yellow perch	1184.1	560.3	249.7	866.9	157.8	1131.7	34.2	26.8	68.8	21.7	40.9	113.8

Table 3.–Catch rate by year class for yellow perch in June index trawl tows at the Anchor Bay index area on Lake St. Clair.

Year class	Total CPUE	Survey year 1993[1]	1994[1]	1995[1]	1996	1997	1998	1999	2000	2001
1984	0.4	0.1	0.1	0.3	–	–	–	–	–	–
1985	0.2	0.0	0.2	0.0	–	–	–	–	–	–
1986	0.3	0.2	0.1	0.0	–	–	–	–	–	–
1987	1.0	0.0	0.6	0.3	0.1	–	–	–	–	–
1988	4.1	0.9	1.6	0.9	0.3	0.3	–	–	–	–
1989	10.2	2.8	3.7	2.2	1.2	0.3	–	–	–	–
1990	30.4	6.1	4.1	13.4	5.2	1.3	0.3	–	–	–
1991	164.4	51.3	47.0	32.1	18.7	12.9	1.8	0.6	–	–
1992	43.3	1.0	3.4	5.8	11.5	9.6	10.4	1.1	0.1	0.5
1993	569.2	–	56.3	125.8	171.4	113.7	43.0	54.3	1.5	3.3
1994	935.1	–	–	166.2	293.2	348.2	88.1	20.6	8.3	10.6
1995	154.1	–	–	–	21.4	40.7	26.4	32.2	12.3	21.1
1996	226.0	–	–	–	–	33.3	77.1	70.3	11.3	34.1
1997	95.8	–	–	–	–	–	2.7	37.6	5.5	50.0
1998	1,114.8	–	–	–	–	–	–	650.2	114.1	350.5
1999	31.8	–	–	–	–	–	–	–	4.8	27.0
2000	2.7	–	–	–	–	–	–	–	–	2.7

[1]Data collected during previous studies.

Table 4.–Mean length at age (mm) for yellow perch from Lake St. Clair trawls in June at the Anchor Bay index area. Sample size in parentheses. SWavg = statewide average length at age.

Age	1996		1997		1998		1999		2000		2001		SWavg
							Males						
1	94	(33)	87	(33)	102	(4)	102	(59)	109	(6)	109	(3)	–
2	126	(106)	126	(32)	132	(104)	140	(48)	129	(110)	127	(11)	–
3	167	(122)	147	(172)	162	(39)	158	(64)	158	(17)	144	(56)	–
4	198	(9)	181	(74)	171	(111)	179	(45)	171	(60)	179	(13)	–
5	212	(56)	206	(11)	187	(43)	186	(70)	189	(57)	196	(19)	–
6	226	(15)	213	(24)	209	(12)	193	(43)	200	(47)	206	(18)	–
7	237	(5)	225	(3)	238	(4)	218	(4)	209	(4)	207	(6)	–
							Females						
1	97	(20)	90	(23)	101	(5)	106	(94)	108	(2)	114	(2)	–
2	130	(119)	136	(20)	141	(70)	139	(38)	138	(147)	132	(2)	–
3	177	(119)	160	(136)	167	(11)	170	(43)	171	(18)	164	(69)	–
4	190	(20)	195	(56)	186	(54)	181	(29)	194	(35)	180	(14)	–
5	236	(26)	211	(8)	196	(47)	209	(42)	206	(46)	230	(25)	–
6	246	(16)	245	(4)	226	(17)	223	(45)	229	(24)	241	(15)	–
7	237	(2)	–	–	253	(2)	247	(4)	234	(14)	263	(12)	–
							Sexes combined						
1	94	(62)	88	(61)	102	(9)	103	(163)	109	(8)	111	(5)	102
2	128	(227)	130	(52)	135	(174)	139	(86)	134	(257)	127	(13)	145
3	171	(241)	152	(308)	163	(50)	163	(107)	164	(35)	155	(125)	173
4	192	(29)	187	(130)	176	(165)	180	(74)	180	(95)	180	(27)	198
5	219	(82)	208	(19)	192	(90)	195	(112)	197	(103)	215	(44)	221
6	236	(31)	218	(28)	219	(29)	208	(88)	210	(71)	221	(33)	246
7	239	(7)	229	(4)	243	(6)	233	(8)	228	(18)	245	(18)	267

Table 5.–Frequency of occurrence of food items (expressed as percent of non-empty stomachs containing each taxon) in fall yellow perch diets in Lake St. Clair (LSC) and Saginaw Bay (SB).

Taxa	1996	1997	1998	1999	2000	LSC All years	SB 1996–1998[a]
Amphipoda	4.8	4.6	0.8	33.0	14.0	11.2	15.5
Chironomid larvae	33.3	11.1	9.5	31.9	16.7	19.4	57.0
Chironomid pupae	2.7	1.3	1.2	3.8	25.6	7.4	16.5
Dressiena polymorpha	0.7	0.0	2.0	3.2	0.5	1.4	9.9
Decapoda	7.5	7.8	9.9	1.6	1.4	5.7	0.0
Ephemeroptera	49.7	58.8	93.7	34.0	34.4	56.3	0.7
Gastropoda	8.8	30.7	1.6	28.6	23.7	17.6	1.3
Hydracarina	0.7	0.6	0.4	0.5	1.9	0.8	0.5
Isopoda	1.4	0.0	0.0	0.0	0.0	0.2	0.5
Pelecepoda	0.0	0.6	1.2	0.0	0.5	0.5	17.5
Tricoptera	23.8	23.5	4.0	21.1	12.1	15.3	15.8
All fish species	21.1	17.0	17.4	31.9	44.6	26.9	23.3
All zooplankton	17.1	16.3	3.2	22.2	42.8	20.0	48.7
Non-empty stomachs	147	153	253	185	215	953	448

[a] Saginaw Bay results from unpublished data, Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station.

Table 6.–Frequency of occurrence of food items (expressed as percent of non-empty stomachs containing each taxon) in walleye from Lake St. Clair.

Taxa	1997	1998	1999	LSC All years
Alewife	26.6	26.8	12.7	21.9
Rainbow smelt	21.9	0.0	1.6	8.2
Trout-perch	1.6	0.0	0.0	0.5
White perch	0.0	1.8	0.0	0.5
Unidentifiable shiner	1.6	0.0	3.2	1.6
Emerald shiner	1.6	0.0	1.6	1.1
Spottail shiner	3.1	1.8	3.2	2.7
Northern logperch	1.6	8.9	0.0	3.3
Yellow perch	1.6	5.4	7.9	4.9
Round goby	3.1	1.8	30.2	12.0
Unidentifiable fish	48.4	67.9	60.3	58.5
Hexagenia spp.	4.7	5.4	11.1	7.1
Other invertebrates	0.0	3.6	1.6	1.6
Non-empty stomachs	64	56	63	183

Table 7.–Angler diary participation, reported effort, reported catch, and catch rates for major species in the Lake St. Clair sport fishery.

Year	Trips seeking	Effort (rod-hours)	Number caught	Number kept	Catch per rod-hour
		Walleye			
1996	484	6,102	1,906	1,685	0.31
1997	408	4,681	1,479	1,311	0.32
1998	510	5,599	2,481	1,947	0.44
1999	625	5,850	2,610	2,239	0.44
2000	444	4,672	1,753	1,646	0.37
2001	342	4051	1,893	1,681	0.47
		Yellow perch			
1996	265	3,462	10,654	5,846	3.08
1997	252	2,701	9,661	5,773	3.58
1998	305	3,520	7,134	5,048	2.03
1999	226	2,087	6,142	3,654	2.94
2000	235	2,892	10,436	5,660	3.61
2001	164	2,047	5,862	4,350	2.86
		Smallmouth bass			
1996	153	1,537	545	190	0.35
1997	143	1,375	687	148	0.50
1998	127	1,248	495	94	0.40
1999	222	1,841	1,112	204	0.60
2000	190	1,126	1,484	126	1.22
2001	74	512	280	48	0.55
		Muskellunge			
1996	494	15,629	1,458	12	0.093
1997	425	15,199	1,573	11	0.103
1998	383	11,336	1,075	8	0.094
1999	318	9,370	645	5	0.069
2000	269	8,874	749	16	0.084
2001	241	7,248	851	2	0.117

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