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*Abstract.–*Yellow perch *Perca flavescens* and walleye *Stizostedion vitreum* population characteristics were summarized using annual creel surveys conducted during 1985-96, and field sampling and tagging studies conducted in Michigan waters of Green Bay during 1988-96. Recreational catches of yellow perch were highest in the late 1980s, declined in the early 1990s, and rebounded somewhat by about 1995. Angler catch rates were as high as 6.3 perch per hour in 1985 but fell to 0.03 fish per hour in 1994. The best walleye fishery in Michigan waters of Green Bay was in Little Bay de Noc, both in terms of annual harvests and catch rates. Walleye populations are building at other locations and the Menominee River fishery, in particular, has been strong since 1992. Field assessments caught over 27,000 fish representing 17 families and 53 species. Yellow perch was the most abundant fish in field catches, followed by trout-perch *Percopsis omiscomaycus*, spottail shiner *Notropis hudsonius*, johnny darter *Etheostoma nigrum*, and alewife *Alosa pseudoharengus*. Walleye ranked 8th in overall catches. Mean size-at-age was generally comparable for both yellow perch and walleye across different areas, years, and collection methods. Trawling data were used to produce indices of young-of-the-year yellow perch abundance, and gill-net data provided an abundance index of perch 178 mm and longer in the bays de Noc. Indices showed that strength of yellow perch year classes varied from year to year and variations were not synchronous between bays. Good to very good recruitment occurred during some years between 1990 and 1996, a period during which yellow perch recruitment in Lake Michigan proper was not detectable. Diet information obtained from 4,879 yellow perch and 416 walleye indicated that food habits have not changed substantially from those reported in previous studies except that an exotic cladoceran, *Bythotrephes cederstroemi*, figured prominently in yellow perch diets in Little Bay de Noc. Exotic fish species that were caught in field samples and reported for the first time in Michigan waters of Green Bay included the threespine stickleback *Gasterosteus aculeatus* and white perch *Morone americana*. Walleye eggs and larvae were collected in Little Bay de Noc, and contributions to fisheries by year classes from non-stocked years provided evidence of successful recruitment from natural reproduction. Totals of 31,272 walleye and 19,572 yellow perch were affixed with individually-numbered jaw tags between 1988 and 1996. Recoveries of tagged fish indicated that yellow perch movement was limited. Walleye ranged farther but no fish were reported outside the waters of Green Bay. On average, walleye tagged in Cedar River were captured farthest from their tagging site. Anglers from 18 different states provided tag-return information. Tagged walleye were caught throughout the day and night. Spawning site fidelity was documented for both yellow perch and walleye based on recaptures of previously-tagged fish during subsequent tagging operations. Preliminary catch-at-age models developed for Little Bay de Noc yellow perch and walleye populations yielded projections of observed vs. predicted harvest, instantaneous mortality rates, and abundance. These models need further development but outputs appeared reasonable.

Introduction

Throughout the 1900s, walleye *Stizostedion vitreum* and yellow perch *Perca flavescens* have been two of the most ecologically and economically important fish species in Michigan waters of Green Bay. Abundance of both species fluctuated greatly during the last century (e.g., Figure 1) due to many factors including successive invasion of exotic species, fishing intensity, deterioration of water quality, and loss of habitat. Trends in abundance and their putative causes have been documented by Schneider and Leach (1979) and Schneider et al. (1991). Walleye populations crashed during the 1960s, but rebounded during the 1970s due to management actions and improved habitat. Yellow perch were also at low abundance during the 1960s but cycled higher during the 1970s due to natural population swings and conservative management.

Rehabilitation of self-sustaining walleye populations in Green Bay is a long-standing management goal of the Michigan Department of Natural Resources (MDNR), Fisheries Division. Attaining self-sustaining walleye stocks is also listed as a goal in the fish-community objectives of the Great Lakes Fishery Commission, Lake Committee for Lake Michigan (Eshenroder et al. 1995) and in their walleye rehabilitation guidelines for the Great Lakes (Colby et al. 1994). The MDNR, with cooperation from local sport and community groups, has worked to re-establish walleye in Michigan waters of Green Bay. Extensive stocking and managerial controls on walleye harvest have been the most effective tools used in this effort. Between 1969 and 1996, totals of 32,714,640 walleye fry and 9,391,947 walleye fingerlings have been stocked in Michigan waters of Green Bay. Of these totals, Little Bay de Noc received 51% of the fry and 54% of the fingerlings, Big Bay de Noc received 39% of the fry and 23% of the fingerlings, Cedar River received 10% of the fry and 12% of the fingerlings, and Menominee River received 11% of the fingerlings (Table 1). Managerial controls on harvest have included: a) banning state-licensed commercial fishing with gill nets in 1968; b) banning commercial harvest of walleyes in 1969; c) truncating the sport fishing season for walleye in the late 1960s (open season changed from last Saturday in April through March 15 to a shorter season of May 15 through February 28); d) raising the minimum size limit for sport-caught walleye from 330 to 381 mm (13 to 15 inches) in 1976; and e) issuing executive orders since 1994 limiting Little Bay de Noc sport anglers to a daily bag of one walleye 584 mm (23 inches) and longer. These efforts have resulted in emerging walleye populations in Big Bay de Noc, Cedar River, and Menominee River, and creation of a "world class" fishery in Little Bay de Noc where fishing has improved to the point that it has attracted national-level tournaments for most of the past decade.

Yellow perch have been important to local and visiting anglers for many years. Perch fishing occurs year-round in the bays de Noc, and activities associated with the fishery (bait, tackle, service, etc.) are important to local economies. The daily bag limit was 50 yellow perch in Great Lakes waters within 5 miles of the Upper Peninsula during the time period of this study.

Increased demand on rehabilitated yellow perch and walleye stocks, and lack of detailed population parameter data led to the initiation of the present study. Objectives of the study included: (1) to assemble yellow perch and walleye catch and effort data from the sport fisheries; and, where data allowed, determine age and size composition, growth, and mortality of fish in those catches; (2) to establish indices of abundance for pre-recruit yellow perch and walleyes, and similar indices for populations not monitored by sport or commercial fisheries; (3) to determine discreteness of yellow perch and walleye populations, and movements and range of these populations; (4) to determine interspecific relationships (food habits, predation, and competition for food and space); and (5) to determine standing crop and harvestable surplus for yellow perch and walleye populations.

Study Area

Michigan waters of Green Bay (Figure 2) cover an area of 277,537 ha (563,609 acres) in northern Lake Michigan. These waters feature diverse depths, vegetation types, substrates, temperatures, and currents. Riverine, estuarine, bay, and lake environments provide habitat for numerous fish species as documented by MDNR assessment surveys between 1988 and 1996 (see Table 2 for a listing of common and scientific names of fish). There are four geographically and physically distinct areas of Michigan waters of Green Bay that support four fairly distinct fish communities. The four areas are Little Bay de Noc, Big Bay de Noc, Cedar River, and Menominee River.

Little Bay de Noc is the embayment delineated by statistical grid 306 (Figure 2). Its surface area is 16,100 ha (39,880 acres). Shallow waters characterize the northern end and nearshore areas, but there is a 12- to 30-m (40- to 100-ft) channel that runs the length of the bay. Rivers that flow into Little Bay de Noc include the Whitefish, Rapid, Tacoosh, Days, Escanaba, and Ford. Of these, the Whitefish River receives the largest spawning run of walleye. Reef-spawning walleye concentrate at the northern end of the bay to use extensive rock and cobble substrate. Yellow perch spawn throughout the waters of Little Bay de Noc and are especially prolific near the northern end of the bay.

Big Bay de Noc is a larger embayment of 37,771 ha (93,560 acres) delineated by statistical grids 308 and 309 (Figure 2). Big Bay de Noc is relatively shallow with over half its area less than 9-m (30-ft) deep and a maximum depth of 21 m (70 ft). Rivers that empty into Big Bay de Noc include the Big, Little, Ogontz, Sturgeon, Fishdam, and Little Fishdam. These rivers do not at present support walleye spawning runs of much consequence. Rocky reefs suitable for walleye spawning are located throughout the bay and around St. Vital, Round, and Snake islands. Yellow perch are present and spawn throughout the bay.

The Cedar River area includes statistical grid 504 (mouth), and parts of grids 505, 604, and 605 (Figure 2). The river has stretches of rocky rapids about 3-8 km (2-5 miles) upstream from the mouth that provide good walleye spawning habitat. Walleye also spawn on rocky reef areas in the lake near the mouth.

The Menominee River area includes Michigan's portion of statistical grid 703 (mouth), and parts of grids 604, and 704 (Figure 2). A hydro-electric dam blocks the river about 3 km (2 miles) upstream from the mouth, but rocky substrates and rapids provide good walleye spawning habitat between the mouth and the dam.

Methods

Creel survey data were collected for Michigan waters of Green Bay by MDNR personnel from offices in Escanaba and Crystal Falls. Different waters and seasons were surveyed during various years. Creel survey methods and results were summarized by Rakoczy and Rogers (1987, 1988, 1990), Rakoczy and Lockwood (1988), Rakoczy (1992a, 1992b), and Rakoczy and Svoboda (1994). Targeted effort was not recorded in creel surveys.

Marquette Fisheries Research Station personnel collected monthly bottom trawl and gill-net samples from June through September in both Big and Little bays de Noc each year during 1988-96. In addition, October samples were obtained during 1988-90 and a May sample was collected in 1991. Supplemental samples were taken sporadically using seines and boomshocking equipment. During 1990-92, fish eggs were collected using a dip net and larval fish were sampled using a plankton net.

The bottom trawl was a shrimp try net with a 3.05-m (10-ft) headrope, 19-mm (0.75-in) square mesh body, and 6.4-mm (0.25-in) square mesh cod-end liner. Trawl hauls were of 10-min duration in waters 3-12 m (10-40 ft) deep. Although stations were not established, trawling was conducted in the same general areas from month to month and from year to year. In Little Bay de Noc, trawling was concentrated in waters north of the city of Gladstone near the launch site at Kipling and east along the shore near Hunters Point. In Big Bay de Noc, trawling was conducted mostly in Ogontz Bay and in waters north of St. Vital Island.

Gill nets were 1.83-m (6-ft) deep and 18.3-m (60-ft) long, with 3.05-m (10-ft) panels of experimental monofilament stretch mesh measuring 25.4-, 38.1-, 50.8-, 63.5-, 76.2-, and 101.6-mm (1.0-, 1.5-, 2.0-, 2.5-, 3.0-, and 4.0-in). Two 18.3-m (60-ft) gangs were tied together to provide replication of each mesh size for any given overnight (~24-hr) set. A 3-m

(10-ft) and a 6-m (20-ft) station were established in each of the bays de Noc. In Little Bay de Noc, the 3-m station was located near the east shore along a bank just north of Hunters point and the 6-m station was located along the west shore just south of Saunders Point. In Big Bay de Noc, both the 3-m and 6-m stations were located south of Ogontz Bay between the public access site and St. Vital Island. Gill nets were set on the bottom parallel to shore at the appropriate depth contour.

Dimensions of seines used for supplementary sampling varied – length: 6.4, 30.5, and 61 m (25, 100, and 200 ft.); height: 1.2 to 1.8 m (4 to 6 ft); mesh: 6.4 and 12.8 mm (0.25 and 0.5 inch). Seine hauls were conducted in shallow water parallel to shore for distances of approximately 47-94 m (100-200 ft). Seining was conducted throughout the nearshore waters of Little Bay de Noc north of Gladstone, including areas in the Whitefish River and its estuary. Seining in Big Bay de Noc was confined mostly to waters in Ogontz Bay and the shallows surrounding St. Vital Island. Big Bay de Noc seining data were very limited and were not included in table summaries.

Electrofishing was conducted using a 5.5-m (18-ft) aluminum boomshocking boat manufactured by Smith-Root. Electrofishing was performed during daylight and nighttime hours to search for walleye fingerlings and to obtain supplemental samples of other fish species. Sampling was conducted during fall in shallow waters throughout Little Bay de Noc and connecting rivers. Although electrofishing was also conducted in Big Bay de Noc, no fish of interest were observed.

The long-handled dip net used for egg collections was lined with 3.05-mm (0.12-in) mesh. The net was held tight to the bottom in stretches of rapids located 2-11 km (1-7 miles) upstream from the mouth of the Whitefish River. A 1.8-m (6-ft) square area immediately upstream of the net was kicked vigorously to dislodge any eggs from rocky substrates. Kick samples were made during the first two weeks of May during 1990-92. Some eggs were kept in the laboratory in aerated water through hatch.

Larval fish samples were collected using a 0.75-m (2.46-ft) diameter, number 2 (363-µm [0.014-inch]), nylon plankton net. The plankton net was suspended in river currents with a rope for 5 minutes, towed by hand for 91 m (300 ft), or towed at the surface or on the bottom behind a boat for 5-35 minutes. A 3.2-kg (7-lb) weight was tied ahead of the net to lower it in the water column during bottom boat tows. Larval fish samples were taken during the last two weeks of May in 1990, 1991, 1992, 1994, and 1995. Samples were collected near the mouth of the Whitefish River during 1990-92, and protracted open-water boat tows were made in the northern ends of Big and Little bays de Noc during 1994-95.

Fish captured in trawls, gill nets, and seines were examined in the field; total length, sex, maturity, and diet data were recorded for representative numbers of each species. Weights were obtained for 131 walleye, 1,380 yellow perch, and various numbers of other fish species using spring scales and battery-operated balances in the field or electronic balances in the laboratory. Many fish were measured but not examined internally, and others were only counted. Each year, scales and/or spines were collected from up to 75 walleyes (average = 37/yr) and as many as 406 yellow perch (average = 188/yr). In the laboratory, spine sections and acetate impressions of scales were examined using dissecting scopes and/or microfiche readers to determine fish ages. Yellow perch and walleye lengths-at-age were compared with state averages compiled by Merna et al. (1981). Fish stomach contents were examined in the field and food items were identified and counted. Fish prey were measured and identified to species when possible, insects were identified to order or family, and zooplankton was considered a broad, inclusive category except that *Bythotrephes cederstroemi* was differentiated from other zooplankton. Food items were grouped by Class (Table 3) for purposes of summarization. Larval fish and eggs were preserved in 10% buffered formalin in the field. Samples were brought back to Marquette Fisheries Research Station for identification, enumeration, and measurement. Fish eggs and larval fish were identified using keys developed by Auer (1982).

Catch-per-unit effort (CPUE) was calculated for yellow perch caught in standard monthly trawl hauls and gill net sets. Trawl CPUEs of young-of-the-year (YOY) yellow perch were used as an index of year-class strength, and gill-net CPUEs of perch 178-mm (7-inches) and larger (generally ≥ 3-years old) were used as an index of abundance for perch big enough to interest recreational anglers.

Keys constructed from age-at-length data were applied to walleye that had not been aged directly in Little Bay de Noc creel samples and tagging operations. These walleye were partitioned annually according to their assigned ages; year-class strength was evaluated based on cumulative representation by individual year classes in creel catches and spawning stocks monitored between 1988 and 1996.

Individually-numbered monel bird leg bands were used to jaw tag 31,272 walleye between 1988 and 1996, and 19,572 yellow perch between 1989 and 1993 (Table 4). Walleye and yellow perch were captured for tagging during April and May, when fish were concentrated for spawning. Total length, sex, location, and date were recorded for each tagged fish. Tag number, length, sex, and location were noted for tagged fish that were recaptured during tagging operations. In addition, occurrence of lymphocystis disease was noted for walleye. Virtually all tagged walleye were of legal size (≥ 381 mm [15 inches], total length), and 99.8% of the tagged yellow perch were 178 mm (7 inches) or larger. Spines and scales were collected to age tagged walleye in 1988 (N=330) and 1996 (N=706). Walleye were tagged at the head of Little Bay de Noc (N=14,522; 1988-96), at various locations in Big Bay de Noc (N=6,613; 1990-91, 1993-96), and in Cedar River (N=4,934; 1993-96) and Menominee River (N=5,203; 1993-96). Yellow perch were tagged at the head of Little Bay de Noc (N=16,029; 1989-93) and in Big Bay de Noc (N=3,543; 1990-91). Trap nets (0.91-m [3-ft] high with 38.1-mm [1.5-inch] mesh) and boomshocking boats were used to catch fish for tagging, and a few Cedar River walleye were provided by state-licensed fishers using commercial pound nets in 1996. Tagging operations were conducted by personnel from the Marquette Fisheries Research Station and fisheries personnel from MDNR offices in Escanaba, Crystal Falls, Baraga, and Newberry. Additional help for the Menominee River walleye population was provided by personnel from the Wisconsin Department of Natural Resources. Target numbers of fish to tag, as well as estimates of exploitation and survival rates, were calculated for walleye and yellow perch using tag return data and formulae provided by Brownie et al. (1985).

Advertisements for the return of tags appeared in local newspapers, sport-club information bulletins, and on notices at launch sites. Anglers catching tagged fish were asked to contact a creel clerk or an MDNR office to report the species, tag number, fish length, date, location of capture, and whether they kept or released the fish. Anglers' names, addresses, and phone numbers were also solicited. Beginning in 1995, anglers were further asked to provide the time of day when they caught their fish. All data were entered into computer files, and a computer-generated letter was sent to anglers, thanking them for their cooperation and providing them with information about their catch (number of days between the tag and capture dates, the distance between the tag and capture sites, and the estimated age and growth of their fish).

Age-structured deterministic models were developed for walleye and yellow perch in Little Bay de Noc. Model parameters were fit from sport fishery data collected during 1985-1996 using AD Model Builder software (Otter Research, Ltd. 1996). Use of this software has a proven track record assessing marine stocks (Quinn and Deriso 1999) and was recently used for the first time to assess Great Lakes fish stocks (Sitar et al. 1999). A flexible model-building approach was followed that used a likelihood-fitting criterion (Fournier and Archibald 1982; Methot 1990). A Bayesian approach was adopted to incorporate prior information on natural mortality and to determine uncertainty in parameter estimates. For each year in the data set, model inputs included weight-at-age, maturity schedule, von Bertalanffy growth parameters, age composition, number of fish harvested, sport-fishing effort, percent females in the population, and average number of eggs per kg of female biomass. Model outputs included predictions of fishery harvest and effort, and estimates of total population size and mortality rates.

Results

Creel Assessment

Open-water sport catches of yellow perch were highest in the bays de Noc between 1985 and 1992, decreased in 1993 and 1994, then rebounded somewhat during 1995-96 (Figure 3; Appendix 1). Sport harvest of yellow perch in Big Bay de Noc ranged from 2,139 in 1994 to 153,036 in 1985, and averaged 72,466 during 1985-96. Catches in Little Bay de Noc ranged from 17,872 fish in 1993 to 191,480 fish in 1991, and averaged 78,099. Yellow perch catch rates fell dramatically in Big Bay de Noc from a high of 6.296 fish/hr in 1985 to a low of 0.034 fish/hr in 1994 (Figure 4; Appendix 1). Catch rates in Little Bay de Noc were somewhat less variable, ranging between 0.070 fish/hr in 1993 to 0.699 fish/hr in 1992. Other sites in Michigan waters of Green Bay (Menominee River, Cedar River, Stoney Point, Ford River) were surveyed with less regularity, contributed fewer yellow perch to fisheries overall, but were important locations for perch anglers during the mid 1990s (Figure 3; Appendix 1). Relatively good yellow perch catch rates (approximately 1 fish/hr or better) were estimated at Stoney Point in 1995 and 1996 and at Cedar River in 1996 (Figure 4; Appendix 1).

Open-water sport catches of walleye were highest in waters of Little Bay de Noc and lowest in waters near Cedar River (Figure 5, Appendix 2). In Little Bay de Noc, catches ranged from 11,149 fish in 1987 to 67,297 in 1995, and averaged 28,267 between 1985 and 1996. In Big Bay de Noc, annual open-water catches ranged from 518 fish in 1986 to 8,228 in 1994, and averaged 3,076 fish for the survey years between 1986 and 1996. Catches at Menominee River were low during the 1980s (average = 307 fish for 1985-89) but increased considerably during the 1990s (average = 12,485 fish for 1993-96). Open-water creel surveys were performed at Cedar River only during 1993-96 and walleye catches averaged just 253 fish over this period. Year-to-year fluctuations in catches did not correspond among the four areas surveyed (Figure 5; Appendix 2) but did reflect catch rates (number of walleye per angler hour) at each of the four sites (Figure 6; Appendix 2).

Creel surveys during the ice-fishing season were very minimal and sporadic except in Little Bay de Noc. Ice fishing produced between 25,290 and 517,372 yellow perch (average = 147,925), and between 2,703 and 11,798 walleye (average = 5,846) in Little Bay de Noc from 1985 to 1996 (Figures 7 and 8; Appendices 1 and 2). Trends in catch rates mirrored trends in numbers caught for both species.

Nearly a third of the yellow perch aged from creel samples were 4-years old (Figure 9). Only 12% were older than 6, but perch up to age 13 were represented in catches. Modal length was 203 mm (8 inches) for yellow perch in creel samples (Figure 10). Approximately 88% of the catch was between 152 and 254 mm (6 and 10 inches) in length; the two largest fish measured were in the 432- to 457-mm (17-inch) category.

Walleye aged from scales collected by creel clerks ranged in age from 2 to 14 (Figure 11). Modal age was 4 and 63% of the fish were 3-5 years old. Length range was 330 to 762 mm (13 to 30 inches) for walleye in the creel (Figure 12). Minimum length limit for walleye is 381 mm (15 inches), and nearly 18% of the legal sport catch was in the 381- to 404-mm (15- to 15.9-inch) length category. Walleye less than 508 mm (20 inches) composed 64% of the fishery.

Field Assessment

Field sampling conducted between 1988 and 1996 produced a total of 27,476 fish representing 17 families and 53 species (Tables 2 and 5). Measurements and examination of stomach contents were performed on 28% of the total; the remainder were measured or counted only. Standard sampling effort (gill-net and trawl sampling) and catch numbers were approximately equal in the two bays de Noc, and species composition of catches was similar as well (Table 5). Yellow perch dominated catches in both bays.

Yellow Perch and Walleye Populations.– Yellow perch was the most abundant species in annual gill-net catches (Table 6), except in 1994 when alewife slightly surpassed yellow perch. Yellow perch numbers represented 37.9–65.2% of gill-net catches in any given year. Average length of yellow perch in gill nets was 152 mm (6.0 inches).

Species composition in trawl catches (Table 7) ranged between 19.1 and 86.6% yellow perch between 1988 and 1996. Trout-perch and johnny darter were more abundant than yellow perch in trawl catches during 1992, and trout-perch were more numerous in 1993, but numbers of yellow perch were highest during other years. Yellow perch in trawl samples were mostly YOY (average length = 91 mm [3.6 inches]).

Seine catches mostly contained YOY fish of 26 different species; the most abundant of which was yellow perch (averaging 38.6% of the total; Table 8). Average length of yellow perch in seines was 86.4 mm (3.4 inches).

Yellow perch composed 69% of the fish examined in supplemental boomshocking samples (Table 9). Most perch collected by boomshocking were examined and returned to the water alive without being measured.

The trawl index for YOY perch indicated variable year-class strength between 1988 and 1996 (Table 10), but variations were not synchronous between bays. The strongest year class in Little Bay de Noc was produced in 1993, but year classes in 1988, 1991, and 1995 were moderately strong. The weakest year classes were produced in Little Bay de Noc during 1992 and 1996. Trawling in Big Bay de Noc indicated very strong yellow perch year classes in 1991 and 1994, a strong year class in 1990, and moderate year classes in 1988 and 1995. Weak year classes occurred in 1989 and 1992.

Indices for yellow perch 178 mm (7 inches) and larger in gill nets had a fairly narrow range of 0.7 to 7.1 fish per lift (Table 10). The highest index values in Little Bay de Noc occurred in 1988, 1991, and 1992, and the lowest value occurred in 1996. In Big Bay de Noc, index values were relatively high from 1988 through 1992 and lower thereafter.

Yellow perch diet in Little Bay de Noc consisted mostly of crustaceans, insects, and fish (Table 11). Of the yellow perch eating crustaceans, 56% contained *Bythotrephes*, 23% contained unidentified zooplankton, 14% contained amphipods, 13% contained isopods, and 0.08-4% contained other crustacean food items. For yellow perch containing a given crustacean food item, mean number of those items per fish was highest for *Bythotrephes* (37.9) and unidentified zooplankton (34.6). Mean number for other crustacean food items ranged from 1 to 6. Of the fish that ate insects, 45% contained dipterans, 45% contained ephemeropterans, 15% contained tricopterans, and 0.1-4% contained other insects. Perch that ate tricopterans had the largest mean number of insects per fish (12.2), followed by dipterans (6.5), and odonates (4.2). Perch that ate ephemeropterans had a relatively low mean number per fish (2.0) because in most instances, this food category consisted of burrowing mayflies (*Hexagenia* spp.) that were much larger than other insects consumed. Twelve different fish species were found in yellow perch stomachs (Table 11). Trout-perch was the most common prey fish, followed by alewife, johnny darter, yellow perch, and rainbow smelt. Top food categories (classes) were consistent through the sampling season but relative prominence of individual food items varied by month. During June, insects, especially dipterans dominated. Mayfly nymphs was the food category consumed most during July, and *Bythotrephes* was the most common food item found during August and September. The proportion of yellow perch found with empty stomachs also showed seasonal variation, with highest proportions in June (21.8%) and July (27.7%) and lowest proportions in August (14.0%) and September (10.5%). The overall proportion of yellow perch with empty stomachs was 22.1%. Data indicated that YOY perch attained lengths of 66-94 mm (2.6-3.7 inches) before they consumed fish, but basically, all food categories were eaten by the entire size range of yellow perch in samples.

Yellow perch in Big Bay de Noc also ate mostly crustaceans, insects, and fish; other food categories were eaten less frequently (Table 12). However, diet composition within categories differed from that of yellow perch in Little Bay de Noc. Of fish that ate crustaceans, amphipods were found in stomachs most frequently (52%), followed by unidentified zooplankton (40%), and *Bythotrephes* (12%). Mean numbers of these items per stomach was 22.8 for zooplankton, 9.9 for *Bythotrephes*, and 8.6 for amphipods. Dipterans were found in 56% of the yellow perch that ate insects, ephemeropterans were in 36%, and tricopterans were in 11%. Fish species most common in yellow perch stomachs included alewife, trout-perch, johnny darter, and stickleback. Dominant food items by month were as follows: June–amphipods; July–amphipods, alewife, and dipterans; August–unidentified zooplankton, dipterans, alewife, and amphipods; September–unidentified zooplankton, amphipods, and dipterans. Proportion of yellow perch found with empty stomachs was 26.1% in June, 28.4% in July, 27.5% in August, 10.9% in September, and 22.0% overall. Even the smallest yellow perch examined (38-43 mm; 1.5-1.7 inches) ate crustaceans and insects, but in general, perch were 50 mm (2 inches) or larger before they ate other food categories in Big Bay de Noc.

Length-at-age for yellow perch in field samples was generally similar whether comparing males and females, Little Bay de Noc with Big Bay de Noc, or all fish with the state average (Figure 13; Appendix 3). Weight-at-age was comparable for all fish regardless of sex or bay through age 4; thereafter, means for female weight-at-age exceeded those for males and means from Little Bay de Noc were higher than those for yellow perch from Big Bay de Noc (Figure 14). Confidence intervals showed that these differences were not significant, however.

Walleye ranked 8th in overall abundance for all assessment methods combined (Table 5). They were 4th in abundance in gill nets, 10th in abundance in trawls, 5th in abundance in seines, and 3rd in abundance in boomshocking samples (Tables 6-9). Gill nets caught walleye that measured between 140 and 660 mm (5.5-26.0 inches) in Little Bay de Noc, and between 130 and 599 mm (5.1-23.6 inches) in Big Bay de Noc. Length range of walleye in Little Bay de Noc trawls was 56 to 472 mm (2.2-18.6 inches); only one walleye (66 mm [2.6 inches]) was trawled in Big Bay de Noc. Seine samples contained walleye measuring 51-371 mm (2.0-14.6 inches) in Little Bay de Noc.

Only sucker eggs were collected in 1990 kick samples, but seven eggs in 1991 and four in 1992 were identified as walleye eggs. Walleye larvae (6.0-9.0 mm [0.24-0.35 inches]) were collected in 1990, 1991, and 1994 plankton tows at various locations throughout upper Little Bay de Noc and the Whitefish River. Assessment netting produced one or more YOY walleye (51-190 mm [2.0-7.5 inches]) in Little Bay de Noc every sampling year except 1989 and 1995. The greatest number of YOY was caught in 1991 (185 collected in seines). Only two YOY walleye were caught in Big Bay de Noc, both during 1993.

Fish were found in 51% of 369 walleye stomachs examined from Little Bay de Noc; insects were found in 10% (Table 13). Rainbow smelt and alewife combined composed 70%, and yellow perch composed 11%, of the eight fish species that could be identified in walleye stomachs. Rainbow smelt and alewife were generally the dominant species eaten from June through September, but walleyes were opportunistic, consuming various other species each month. *Hexagenia* spp. was the favored insect food item in terms of both frequency and mean number per stomach. *Hexagenia* were found in walleye stomachs during all sampling months. Other insects consumed by walleye included dipterans, coleopterans, and odonates. Proportion of walleye stomachs found empty was 30.2% in June, 33.8% in July, 44.7% in August, 32.6% in September, and 35.5% overall. Only two walleye ate crustaceans: unidentified zooplankton and *Bythotrephes*. The smallest walleye sampled were piscivorous (29 seined walleye YOY measuring 50-80 mm [avg.=67 mm] had an average of 3.2 fish larvae [90% alewife] in their stomachs in June 1991) and walleye 508 mm (20 inches) and longer ate *Hexagenia*, illustrating that all sizes of walleye ate both insects and fish.

Of 47 walleye stomachs examined from Big Bay de Noc, 54% contained fish and the rest were empty (Table 14). Alewife was the most common fish species found in stomachs, followed by rainbow smelt and johnny darter. Empty stomachs were especially prominent during July (56%) and August (45%), and less so in June (25%) and September (10%). No walleye smaller than 196 mm (7.7 inches) had food in their stomachs. Walleye 196-599 mm (7.7-23.6 inches) long contained fish.

Length-at-age was generally greater for female walleyes than for males in both bays de Noc (Figure 15; Appendix 4). Walleye in Big Bay de Noc were longer than Little Bay de Noc fish at ages 2 and 3, but lengths were similar for walleye in both bays at ages 4-6. Mean length-at-age was generally greater than statewide averages for walleyes in both bays. Weight-at-age was generally higher for walleye in Big Bay de Noc than in Little Bay de Noc, but few differences were significant (Figure 16).

Other Species.–Fish community structure was fairly similar in both Little Bay de Noc and Big Bay de Noc. Overall in field samples, trout-perch were second in abundance, followed by spottail shiner, johnny darter, alewife, white sucker, rainbow smelt, and rock bass (Table 5). Other species composed less than 1% of field samples. Food habits were not fully analyzed for species other than yellow perch and walleye, but dietary overlap appeared greatest between yellow perch and trout-perch and between walleye and northern pike.

Two fish species were reported for the first time in Michigan waters of Green Bay during this study. Threespine stickleback, a non-indigenous species, was first collected in Big Bay de Noc assessment nets in 1989. Between 1989 and 1996 an average of 14 threespine sticklebacks per year were collected in Big Bay de Noc. White perch is another non-indigenous species whose presence in Little Bay de Noc was first noted with the capture of one individual in 1990. Through 1996, a total of 23 white perch have been captured in Little Bay de Noc. In addition, 10 white perch were collected in Big Bay de Noc during the 1996 field season.

Aside from exotic fish species, other invaders were documented for the first time in Michigan waters of Green Bay during the study period. The cladoceran *Bythotrephes cederstroemi* has been observed in fish stomachs collected from both bays de Noc since 1988 (Schneeberger 1989, 1991). Although present in diets of fish in both bays, *Bythotrephes* was consistently more important for fish in Little Bay de Noc than in Big Bay de Noc over the study period. Zebra mussel *Dreissena polymorpha* was first detected during 1993 field sampling in Little Bay de Noc, and judging from non-quantified observations, their abundance increased in subsequent years. Zebra mussels of various sizes became very numerous on overnight gill-net anchors and ropes, in trawl hauls and on submersed plants (e.g., *Chara*) in Little Bay de Noc. Only a few zebra mussels were caught or observed during 1995 (when they were first detected in Big Bay de Noc) but by 1996, they were extremely abundant on vegetation collected via routine trawl sampling. Zebra mussels have been observed in fish stomachs (mostly yellow perch and white suckers) collected from both bays.

Tagging Results.–Based on cumulative tag returns through 1996 (Table 4), walleye exploitation rates (unadjusted for non-reporting) were 4.6% in Little Bay de Noc, 1.6% in Big Bay de Noc, 3.0% in Cedar River, and 5.8% in Menominee River. Estimated exploitation rate of yellow perch in Little Bay de Noc was 3.6%. Walleye survival was over 95% in Big Bay de Noc, 87% in Cedar River, 60% in Little Bay de Noc, and 41% in Menominee River. Survival of yellow perch in Little Bay de Noc was estimated to be 42%. Rough population estimates based on 1988-96 tag-return data for fish in Little Bay de Noc were 484,525 walleye of legal size and 657,304 yellow perch greater than 177 mm.

Between 1988 and 1996, catch location was reported by anglers for a total of 2,226 tagged walleye (Figures 17 - 20). On average, walleye tagged in the Cedar River were caught much farther from the tagging site (ave. = 31 km [19.4 miles]) than walleye tagged in Little Bay de Noc (ave. = 6 km [3.8 miles]), Big Bay de Noc (ave. = 2 km [1.0 miles]), or Menominee River (ave. = 2 km [1.0 miles]). No tagged walleye were caught outside the waters of Green Bay.

Of 1,297 returns from walleye tagged in Little Bay de Noc (Figure 17), 97% came from within Little Bay de Noc (0-11 km [0-7 miles] from the tagging site). Relatively small numbers of walleye were caught in Big Bay de Noc (N=4), open waters of northern Green Bay (N=34), Wisconsin waters of Green Bay (N=1), Cedar River (N=1), or Menominee River (N=4).

One walleye tagged in Big Bay de Noc traveled 106 km (66 miles) south where it was caught in Menominee River and 12 walleye rounded the Stonington Peninsula to be caught in Little Bay de Noc. However, 95% of the returns for fish tagged in Big Bay de Noc were reported within the bay (Figure 18). No walleye tagged in Big Bay de Noc were reported from Wisconsin waters of Green Bay during the study period.

Although 24% of the walleye tagged in Cedar River were caught by anglers 0-5 km (0-3 miles) from the tagging site, the majority (66%) were caught in or near the Menominee River

(Figure 19). Some Cedar River walleye moved north into both bays de Noc, while others moved into the Wisconsin waters as far south as the mouth of the Fox River.

Only a few walleye tagged in the Menominee River strayed from the immediate area (Figure 20); 98% were caught in the river or in the lake near the mouth. The furthest distance traveled was a single fish that was caught in northern Little Bay de Noc, 95 km (59 miles) from its tagging site.

Yellow perch tagged at the northern end of Little Bay de Noc were subsequently caught by anglers throughout the bay (Figure 21). Most (66%) tag returns came from the northern third of the bay. One tagged yellow perch was caught near the Cedar River mouth.

Although the number of returns from yellow perch tagged in Big Bay de Noc was limited, movements throughout the bay and into Little Bay de Noc were documented (Figure 22). Two thirds of all reported tag returns were reported from Ogontz Bay (south of the Ogontz River mouth).

Length-at-age did not change significantly for walleye aged from scales/spines collected during 1988 and 1996 tagging operations in Little Bay de Noc (Figure 23; Appendices 5 and 6). Mean length of females tended to be slightly higher than for males during both years. Length-at-age for Little Bay de Noc walleye was generally lower than for fish from other tagging areas in 1996, and differences were significant compared to Cedar River and Menominee River fish for ages 5-8 (Figure 24; Appendix 6). In general, length-at-age was not significantly different for walleye from Big and Little bays de Noc.

Most walleye were caught between 6:00 am and 6:00 pm but fish were caught throughout the day and night (Table 15). Early morning and late night fisheries were documented in all fishing areas and were most prominent in Menominee River. Mean lengths and size ranges were fairly uniform during different time periods for any given area.

Anglers from 18 different states reported catching tagged fish in Michigan waters of Green Bay (Table 16). Michigan residents composed the greatest percentage of anglers reporting either walleye or yellow perch. Wisconsin anglers were also prominent among cooperating anglers.

Many previously tagged fish (totals of 3,740 walleye and 812 yellow perch) were recaptured and recorded during subsequent tagging operations, providing evidence for fidelity to spawning sites. Relatively few fish of either species were caught at sites different from where they were originally tagged. Of the recaptured walleye originally tagged in Little Bay de Noc, only 4.1% had strayed to other sites. Straying was documented for only 0.2%, 3.8%, and 3.0% of walleye originally tagged in Big Bay de Noc, Cedar River, and Menominee River. No yellow perch tagged in Little Bay de Noc were recaptured at other sites, but 2.0% strayed from Big Bay de Noc.

Of the walleye straying from Little Bay de Noc, 53% were recaptured 1-5 years later in Cedar River, 40% were recaptured 2-7 years later in Big Bay de Noc, and 7% were recaptured 4 years later in Menominee River. Walleye originally tagged in Big Bay de Noc strayed in equal proportions to Little Bay de Noc and Menominee River after 1-7 years. Ninety-seven percent of the walleye straying from Cedar River were found 1-3 years later in Menominee River and 3% went to Big Bay de Noc after 2 years. All walleye that strayed from Menominee River ended up in Cedar River – 38% within just 3-14 days, the rest after 1-4 years. One yellow perch tagged in Big Bay de Noc was recaptured in Little Bay de Noc 3 years later.

Walleye year-class strength was only somewhat variable in Little Bay de Noc during the study period (Table 17). Year classes produced during 1991 and 1993 were quantified indications of natural reproduction because no walleye were stocked in Little Bay de Noc during those years. Based on cumulative contributions to sport fisheries and fish sampled during spawning runs (fish 3-5 years old) the 1991 year class was determined to be strong even relative to other years (1985-90, 1992) when 84,777-505,941 fingerlings were stocked in the bay. Natural reproduction also produced fish in 1993 but evaluation of this year class was not complete because only contributions by 3-year old fish could be accounted for as of 1996.

Lymphocystis was evident on 3-25% of the walleye tagged between 1988 and 1996.

Incidence of this disease varied by site and year (Figure 25). Fish observed with lymphocystis appeared vigorous and were generally comparable to healthy fish, in terms of length and weight.

Catch-at-age model

The catch-at-age model showed good agreement between observed and predicted recreational harvest for both walleye and yellow perch (Figures 26 and 27). Model predictions indicated increasing abundance of walleye (Figure 28) and decreasing abundance of yellow perch (Figure 29) in Little Bay de Noc over the study period. Total instantaneous mortality rates were fairly stable for walleye (Figure 30) as might be expected for a relatively long-lived fish at the top of the food chain. Estimates of instantaneous mortality rates for yellow perch varied without trend between 1985 and 1996 (Figure 31).

Discussion

During the early 1990s, yellow perch populations declined dramatically in Lake Michigan proper, south of the 45th parallel (Francis et al. 1996; Shroyer and McComish 1998). Decreased abundance, skewed population age-structures, and apparent lack of recruitment over several consecutive years prompted agencies to take corrective management actions. States with existing commercial fisheries for yellow perch (Indiana, Illinois, and Wisconsin) first limited, and subsequently eliminated, those fisheries. In addition, fishing regulations (bag limits, seasons) were changed by all bordering states to reduce recreational harvest of yellow perch from Lake Michigan. Abundance in Michigan waters of Green Bay fluctuated during this same time period, but these fluctuations were within the expected bounds for a historically cyclical species like yellow perch. Population age structure and recruitment were relatively stable in Michigan waters of Green Bay as well as in Wisconsin waters of Green Bay (B. Belonger, Wisconsin DNR, Marinette, personal communication). Relative to Lake Michigan, spring weather conditions favorable for yellow perch spawning are fairly consistent in Green Bay.

Index trawling indicated that several strong year classes were produced between 1988 and 1996, when yellow perch recruitment could not be detected in Lake Michigan south of the 45th parallel. The general validity of these indices was evident from a comparison of YOY indices with the index for perch ≥178 mm and with recreational catches 4 years later (age 4 was the modal age of yellow perch in recreational fisheries and is the age when perch are usually ≥178 mm). For example, the 1988 year class was relatively strong in Little Bay de Noc trawls (Table 10). These fish reached the age (4) and length (≥178 mm) favorable to recreational anglers in 1992. The gill-net index for perch 178 mm and larger, and the recreational harvest of yellow perch in Little Bay de Noc were both relatively high in 1992. Similarly, weak year classes according to index trawling (e.g., the 1989 year class in Big Bay de Noc), also appeared weak four years later in gill net indices and estimates of recreational catches.

Yellow perch diet in bays de Noc has changed somewhat through the years, though some aspects have remained constant. Toth (1959) found *Hexagenia*, isopods, amphipods, and midge larvae most frequently in perch stomachs collected from five areas of Big Bay de Noc. He did not note much piscivory by yellow perch, though a few larger specimens did contain fish. Dodge (1968) likewise documented the importance of isopods, amphipods, and *Hexagenia* in diets of Little Bay de Noc yellow perch, but his study documented greater consumption of fish; especially alewife, rainbow smelt, spottail shiner, and trout-perch. During 1988-96, crustacea, insecta, and fish were similarly the most important food categories found in yellow perch stomachs. *Bythotrephes* was a food item new to perch diets beginning in 1988 (Schneeberger 1989). During the late 1980s, scientists speculated about ramifications *Bythotrephes* might have on food-web dynamics in the Great Lakes. Their long, rigid caudal spine deters predation and reduces handling efficiency by small fish (Cullis and Johnson 1988; Barnhisel 1990). Furthermore, because *Bythotrephes* consume *Daphnia* spp. (Lehman 1988) and other species of zooplankton, they were recognized as potential competitors with fish such as YOY yellow perch (Schneeberger 1991). During 1988-96, *Bythotrephes* was consistently important in the diets of yellow perch in Little Bay de Noc and generally unimportant for perch in Big Bay de Noc. Relative differences in the consumption of *Bythotrephes* did not affect yellow perch growth rates, however, as size-at-age was comparable for perch in both bays.

Of the Green Bay waters studied, walleye rehabilitation has progressed furthest in Little Bay de Noc, mostly due to this area having consistently received greater numbers of stocked fingerlings over a longer period of years. The combination of stocking and managerial controls has established a sizable walleye population in Little Bay de Noc characterized by a broad size range, diverse age classes, and a core spawning population that contributes to stock enhancement through natural reproduction. Natural reproduction has been documented through collection of walleye eggs, larvae, and fry; recruitment has been established by ascertaining contributions from wild year classes (from years when no stocking occurred) to sport fisheries, assessment catches, and spawning stocks evaluated during tagging. Rehabilitations of walleye stocks in Big Bay de Noc, Cedar River, and to a somewhat lesser extent, Menominee River are still in earlier phases of development.

Although the population in Little Bay de Noc is more established than at other locations, it does not appear that density-dependent factors have affected walleye growth. Length-at-age was similar for age 4-6 walleye caught in Big and Little bays de Noc assessment nets. Furthermore, mean length-at-age for walleye tagged in Little Bay de Noc did not change between 1988 and 1996. Comparing Green Bay values to state-wide averages for walleye length-at-age is difficult because state averages were based on walleye in inland waters of Michigan (Merna et al. 1981). However, calculated means generally ranked above state averages, indicating that walleye grew well throughout Michigan waters of Green Bay.

Wagner (1972) provided information on Little Bay de Noc walleye diet during 1966-68. Similar to the 1988-96 diet analyses, rainbow smelt and alewife were the prey species most frequently found in walleye stomachs in the 1960s. Burrowing mayflies were more prominent in walleye diets during 1988-96 compared with 1966-68, presumably because pollution controls have provided improved water quality and increased mayfly abundance. Fish in walleye diets did not reflect relative species abundance inferred from assessment netting in the bays. Yellow perch and trout-perch were the most abundant species in assessment gear, but they composed a relatively small or negligible proportion of the fish eaten by walleye. Conversely, alewife and rainbow smelt figured prominently in walleye diets in both bays though they ranked 5th and 7th in field survey abundances. Assessment netting may not accurately depict relative abundance of these prey species but virtually all fish were caught in water considered suitable habitat for walleyes. It appeared that walleye exhibited a preference for some species over others, irrespective of their abundance.

Thomas and Haas (2000) examined reward versus non-reward walleye tag returns in Lake Erie and determined an adjustment factor of 2.7 for non-reporting. Using this factor to adjust for non-reporting in Michigan waters of Green Bay, estimated exploitation for walleye was 12.4% in Little Bay de Noc, 4.3% in Big Bay de Noc, 8.1% in Cedar River, and 15.7% in Menominee River. A similarly-adjusted estimate of yellow perch exploitation in Little Bay de Noc was 9.7%. Very high survival rates calculated for Big Bay de Noc and Cedar River walleye populations were probably artifacts of relatively low sample sizes from these areas. Rates that are more realistic should result when additional years of data are added to the time series. Survival of Little Bay de Noc walleye was in the range described as desirable for walleye rehabilitation (>50%; Colby et al. 1994), but walleye survival for the Menominee River population was below the target range.

Previous tagging studies indicated that after spawning, walleye dispersed and intermingled with various sub-populations, but few left the bays de Noc area (Crowe 1962; Crowe et al. 1963). No walleye from any tagging site was caught outside Michigan waters of Green Bay during 1988-96. Walleye movements have been much more extensive in other Great Lakes waters such as Saginaw Bay (Fielder et al. 2000) and Lake Erie (Thomas and Haas 2000).

Fidelity to spawning sites was documented for walleye and yellow perch at each tagging site. Most straying involved walleye moving either to or from Cedar River and Menominee River. Walleye tagged in Cedar River ranged farthest on average, according to reported returns from anglers, and they also had one of the higher rates of straying from their spawning site. Several recaptures of walleye documented movements between Menominee and Cedar rivers within only a few days during tagging operations, blurring the interpretation of which location should be considered their homing site. Crowe (1962) documented spawning site fidelity for bays de Noc walleye populations tagged between 1957 and 1961, and studies elsewhere also describe high rates of fidelity for walleye (e.g., Eddy and Surber 1947; Eschmeyer 1950). Spawning site fidelity of yellow perch in bays de Noc was consistent with the limited movement they exhibited based on angler reports of tagged perch.

Although walleye are adapted to foraging in low light conditions (Scott and Crossman 1973), most tagged walleye were reported caught during hours of daylight and the largest fish reported in two locations were caught during mid-day. Substantial proportions of tagged fish were reported during late night and early morning hours, however, and these fish would not be included in creel survey estimates because clerks were not on duty during these times. As additional data are obtained pertaining to time of day fish are caught, it may be possible to calculate an adjustment factor so that creel estimates more accurately reflect the whole fishery.

Lymphocystis is an endemic viral disease common to walleye throughout their range (Scott and Crossman 1973). Incidence is highest during spring when fish are stressed from activities related to spawning. Roughly 10% of the walleye in any given population show evidence of lymphocystis during spring, but incidence decreases into the summer as waters become warmer. In this context, observed proportions of infected walleye during springtime tagging operations can be considered "normal."

The modeling exercise helped validate yellow perch and walleye population parameters derived from assessment data. Modeling was useful in clarifying current status of populations and identifying data gaps that may merit future investigations. With further refinements and enhancements, these models will allow managers to track populations and aid in their ability to make informed management decisions.

Highest model estimate of total instantaneous mortality for yellow perch occurred in 1992, when the estimate of perch abundance was low. These projections were consistent with the very weak 1992 year class determined from index trawl assessment. Mortality decreased in 1993-96, but abundance did not show a corresponding increase, likely because of the 3-5 year delay for perch from 1993-96 year classes to recruit into the fishery. Yellow perch abundance estimated by the model (327,408) was well below the estimate made from tag-return data for 1996 (657,304), but was of the same magnitude.

The strong 1991 walleye year class produced in Little Bay de Noc by natural reproduction was clearly evident in model projections of harvest and abundance. Both graphs indicated sharp increases in 1994 or 1995 when walleyes from the 1991 year class would be 3-4 years old. High population abundance was sustained through 1996 while the 1991 year class was still in the fishery. Model estimates of walleye abundance agreed well with population estimates derived from tag returns, reinforcing confidence in both estimates.

Population catch-at-age models for walleye and yellow perch are still in their initial stages of development. Long-term data sets are invaluable for these efforts, and additional years of data inputs will be incorporated to help make models more meaningful and reliable. There is potential to build more model modules using stocking rates and data from tagging and field assessment studies to more accurately describe populations. Furthermore, modelers using the AD Model builder software for Great Lakes lake trout and lake whitefish populations are pursuing developments that will allow harvest and abundance to be predicted in the future. These developments will be incorporated into future perch and walleye models.

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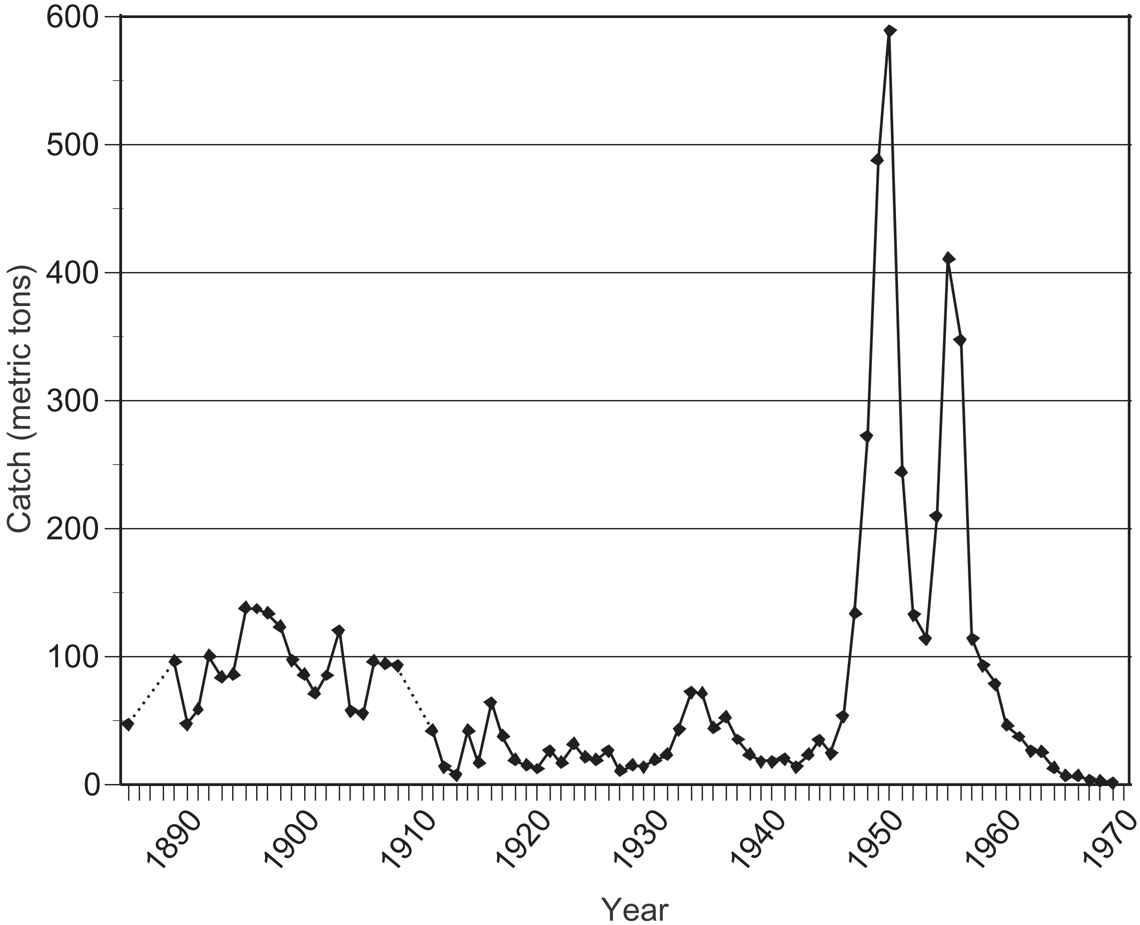

Figure 1.–Commercial catch of walleye in Michigan waters of Green Bay, 1885-1969. Data from Baldwin et al. 2000.

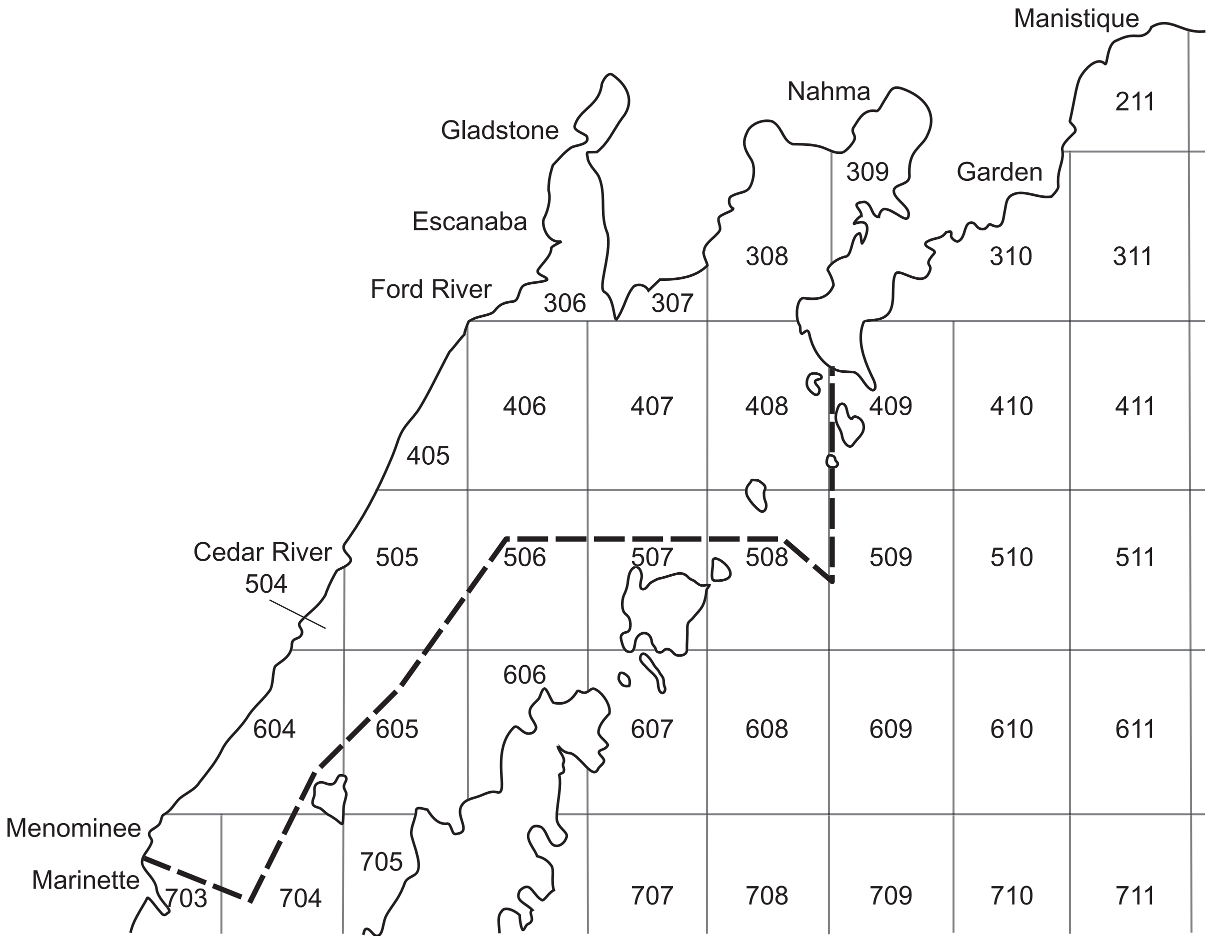

Figure 2.–Statistical grid map of Michigan waters of Green Bay, Lake Michigan (inside heavy black dashed line).

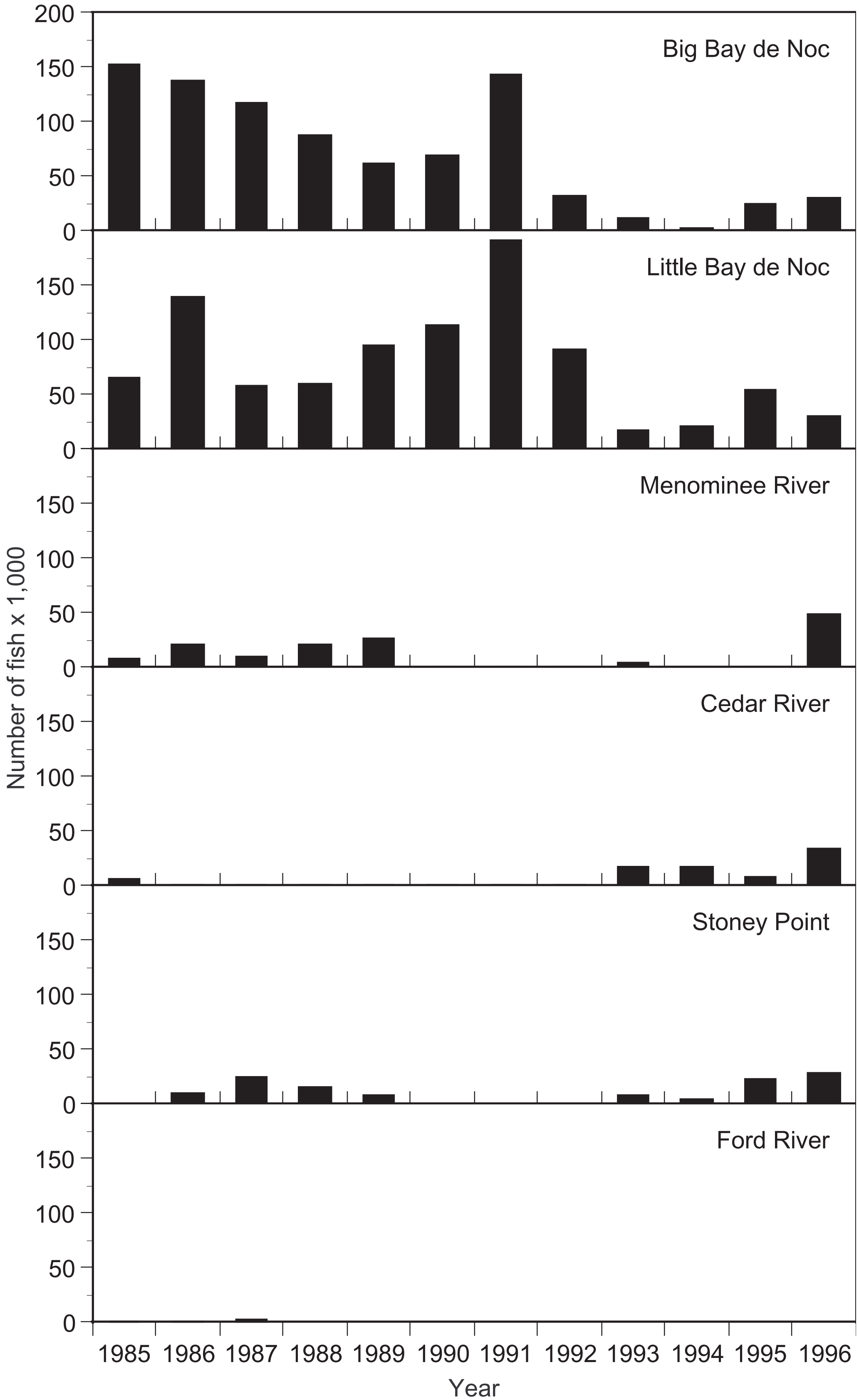

Figure 3.–Estimated open-water sport catch of yellow perch in Michigan waters of Green Bay, 1985-96.

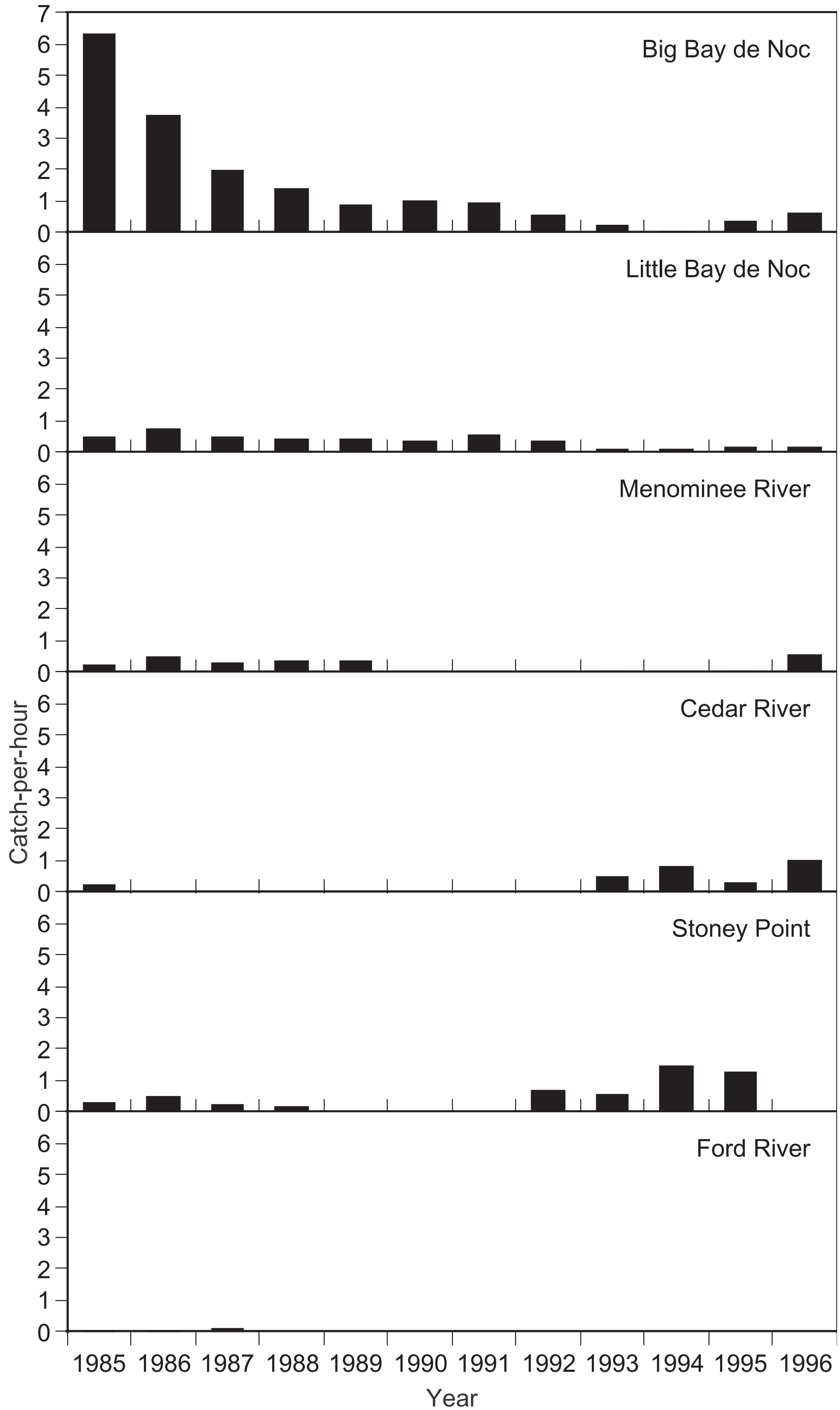

Figure 4.–Estimated catch-per-hour for yellow perch in open-water sport fisheries, Michigan waters of Green Bay, 1985-96.

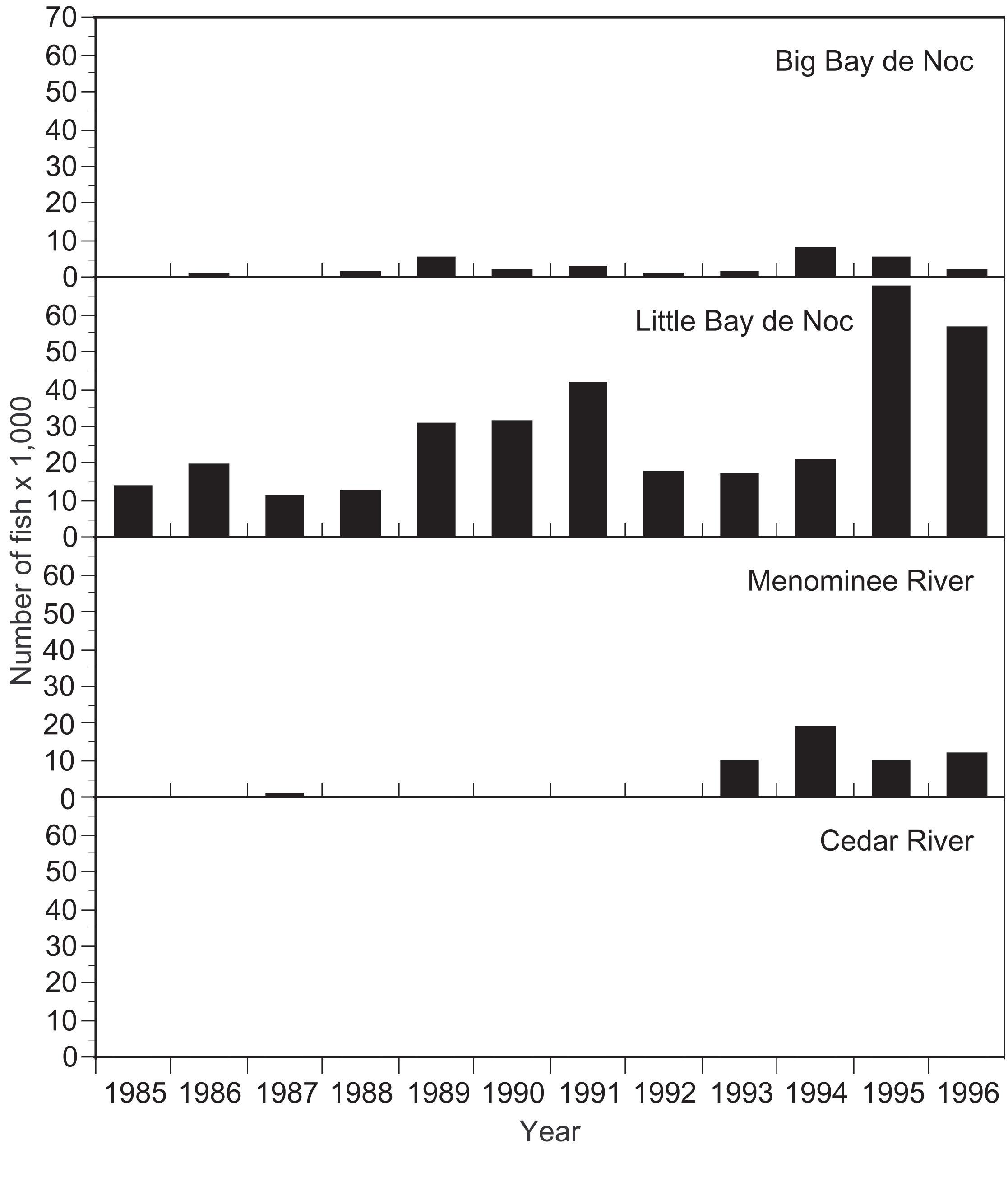

Figure 5.–Estimated sport catch of walleye during the open-water season in Michigan waters of Green Bay, 1985-96.

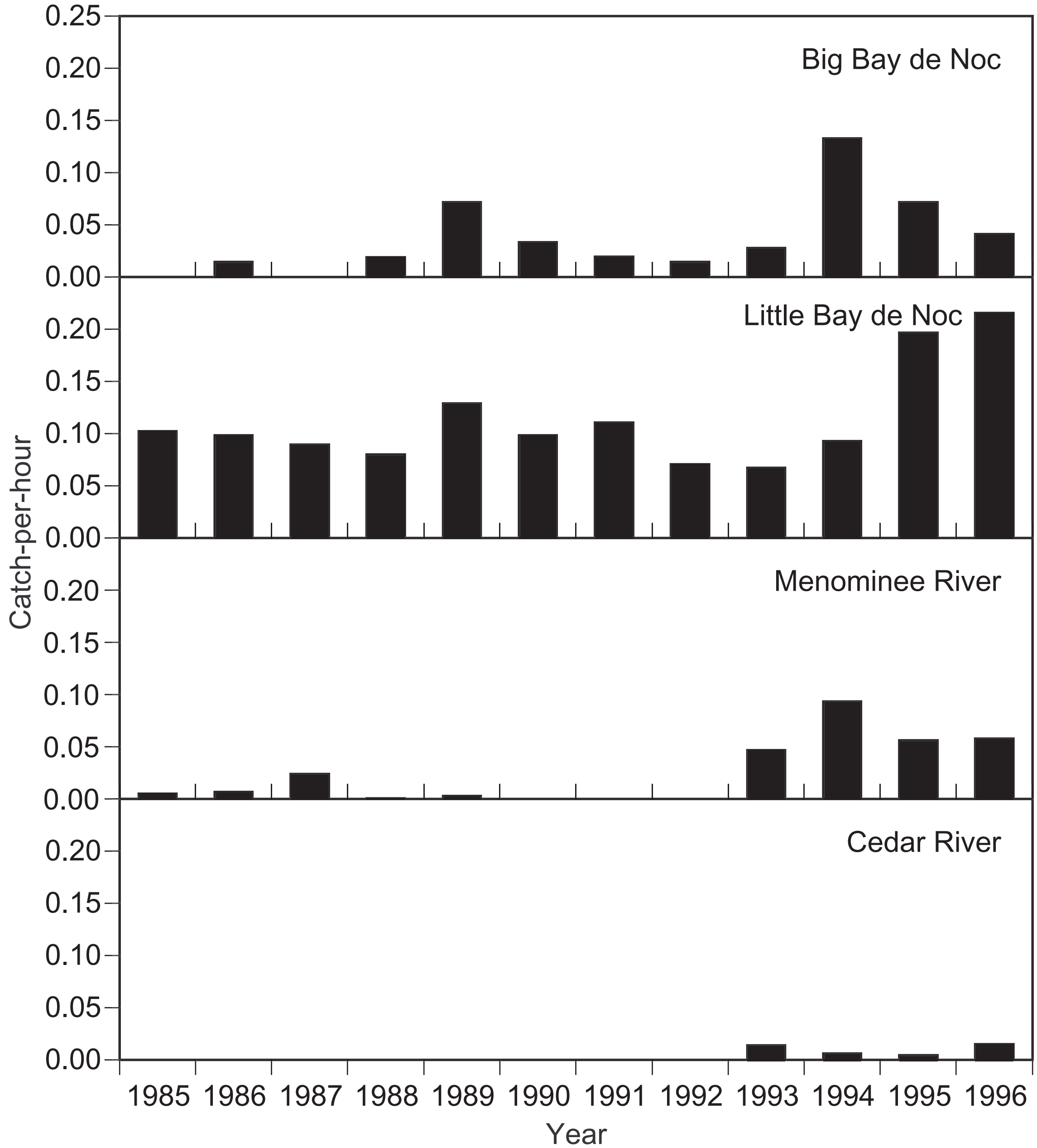

Figure 6.–Estimated catch-per-hour for walleye in open-water sport fisheries, Michigan waters of Green Bay, 1985-96.

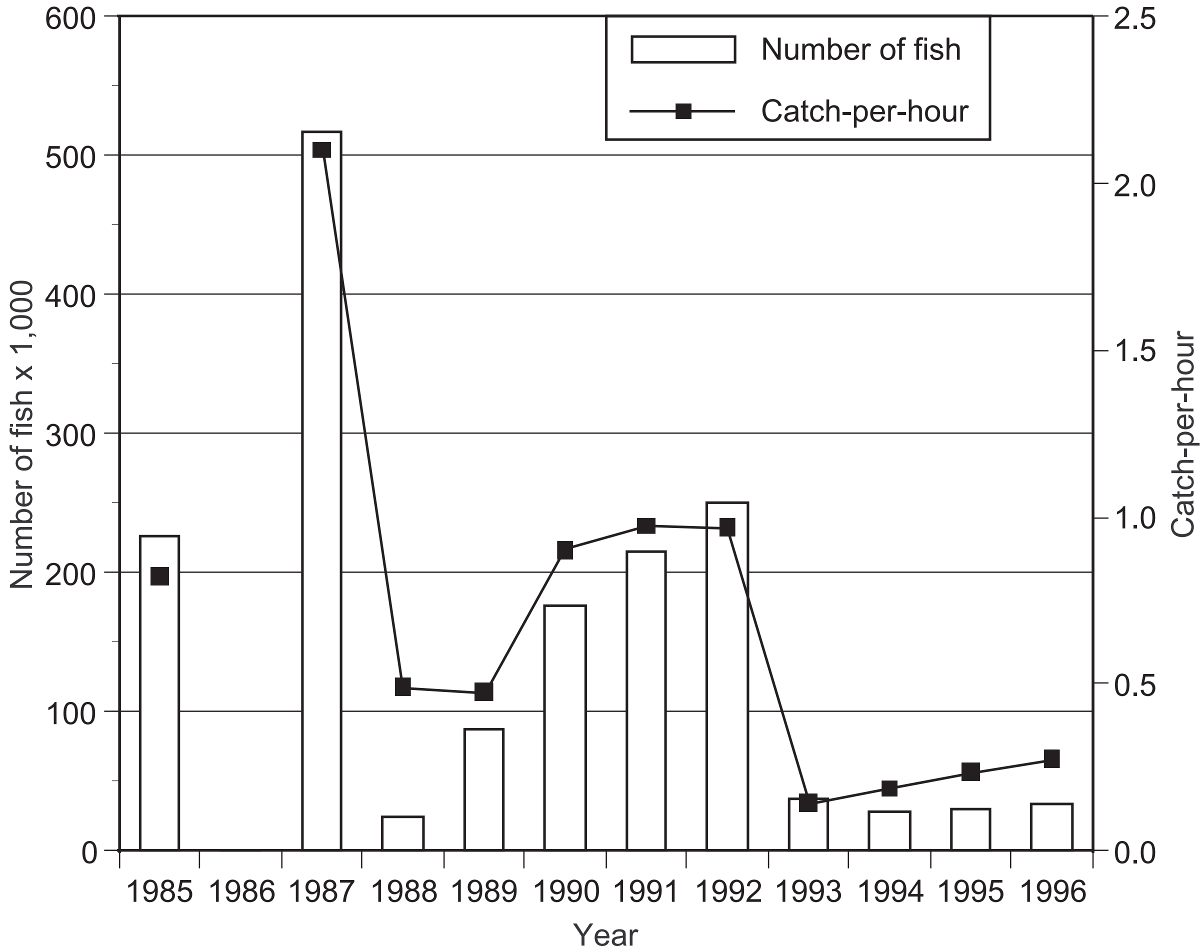

Figure 7.–Estimated catch and catch-per-hour for yellow perch in the Little Bay de Noc ice fishery, 1985-96.

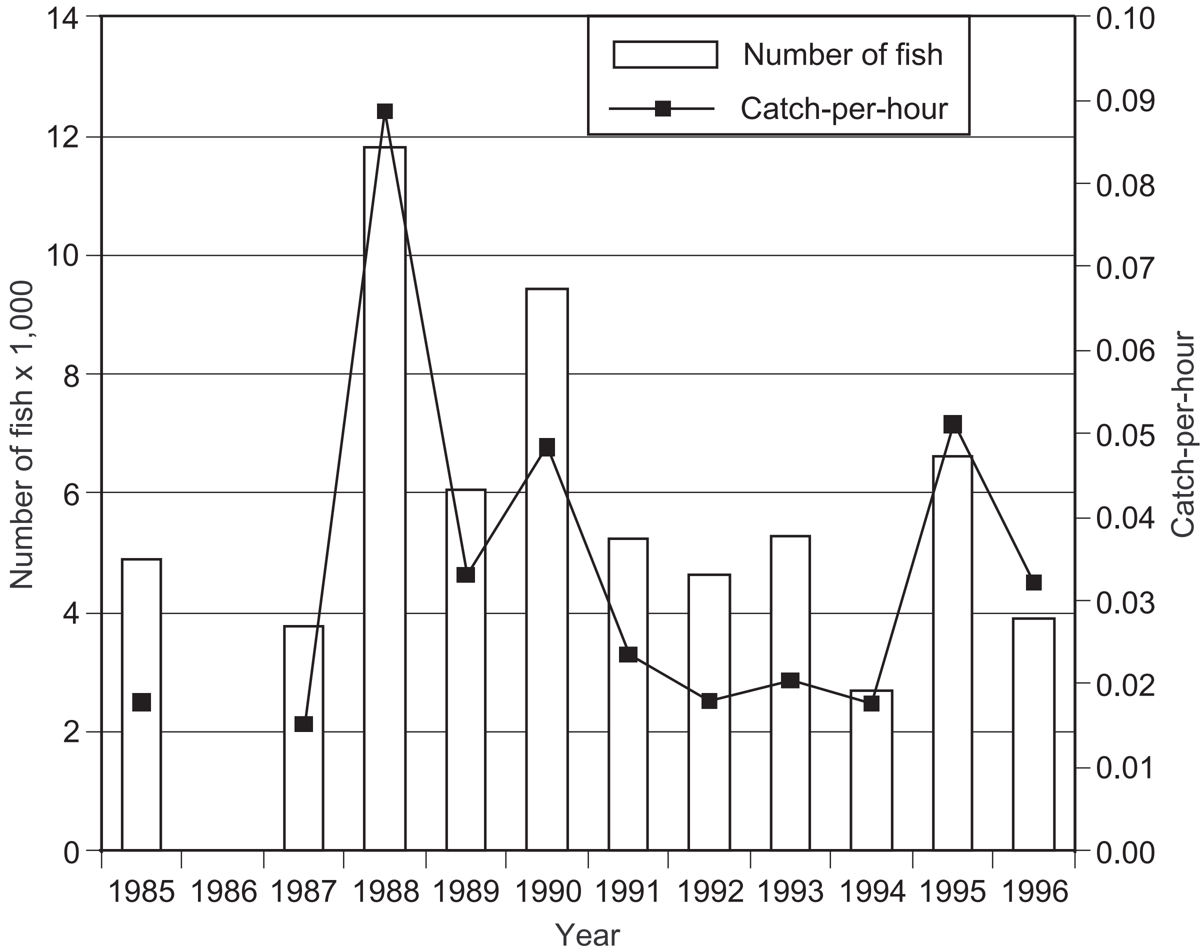

Figure 8.–Estimated catch and catch-per-hour for walleye in the Little Bay de Noc ice fishery, 1985-96.

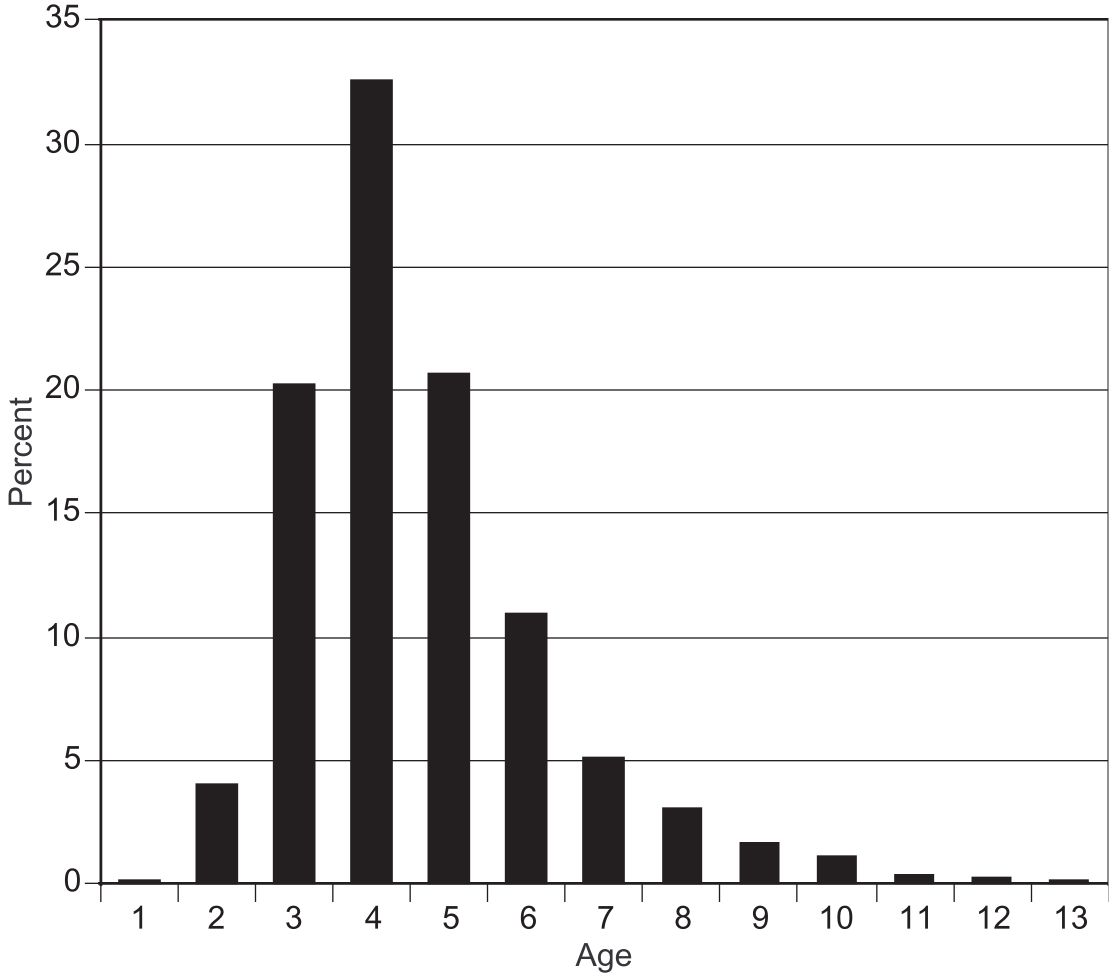

Figure 9.–Proportion-at-age for yellow perch in MM-1 sport fishery in Michigan waters of Green Bay, 1985-96.

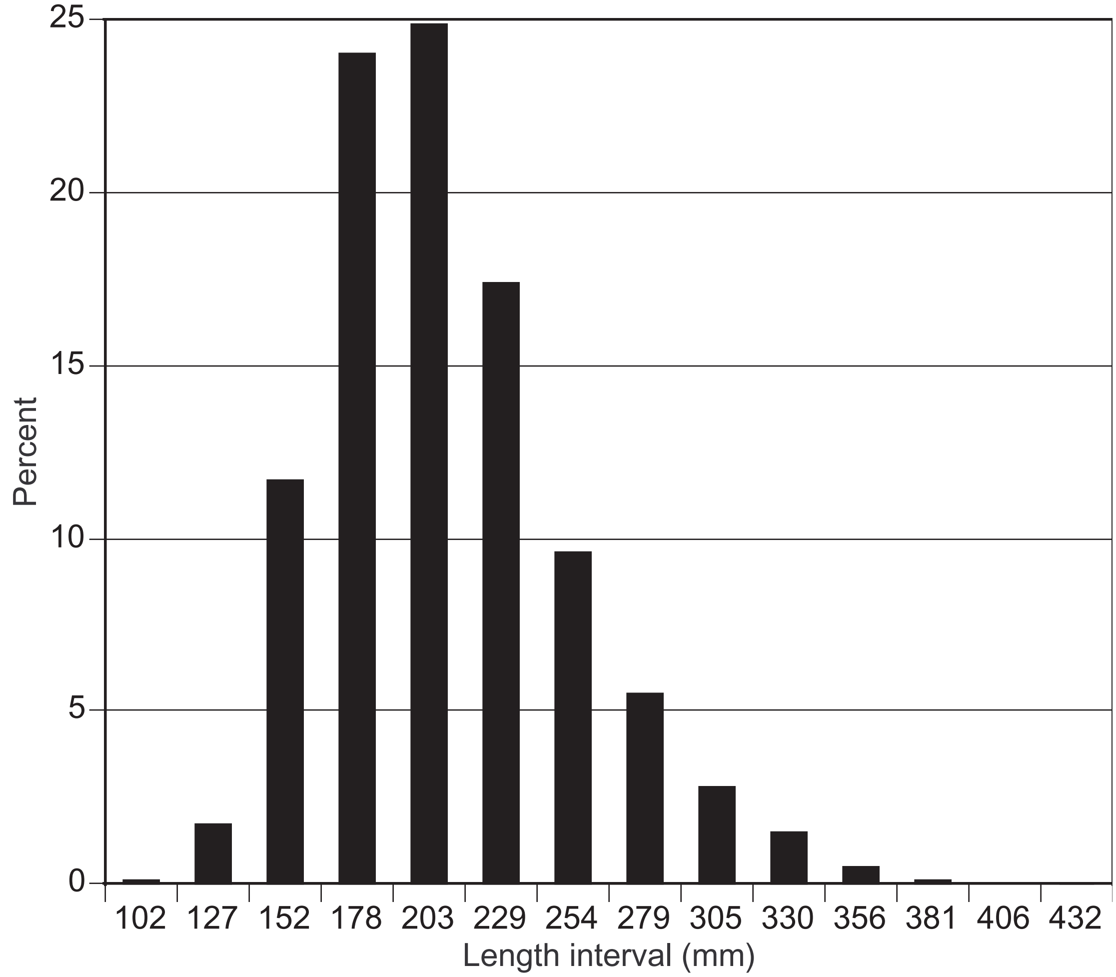

Figure 10.–Proportion-at-length of yellow perch caught in MM-1 sport fishery in Michigan waters of Green Bay, 1985-96.

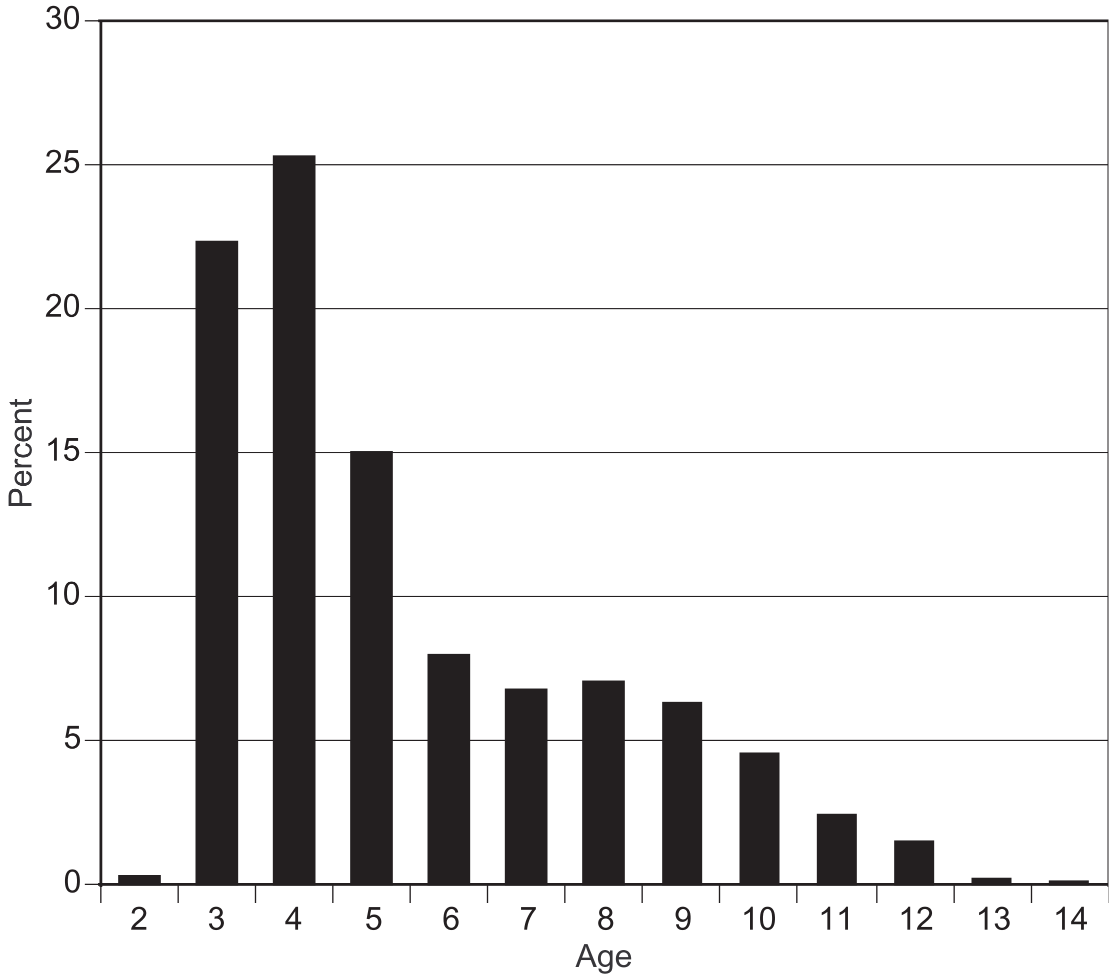

Figure 11.–Proportion-at-age walleye in MM-1 sport fishery in Michigan waters of Green Bay, 1985-96.

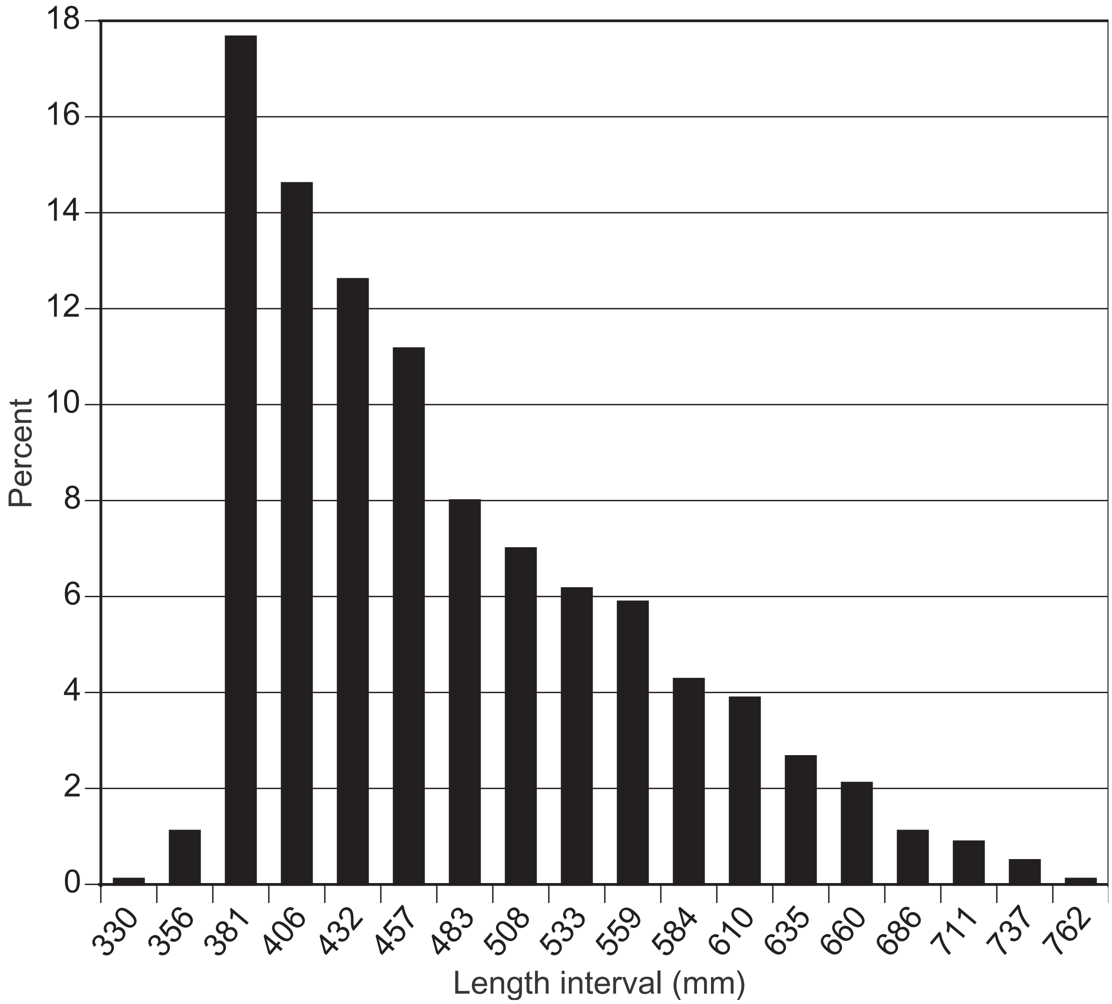

Figure 12.–Proportion-at-length of walleye caught in MM-1 sport fishery in Michigan waters of Green Bay, 1985-96.

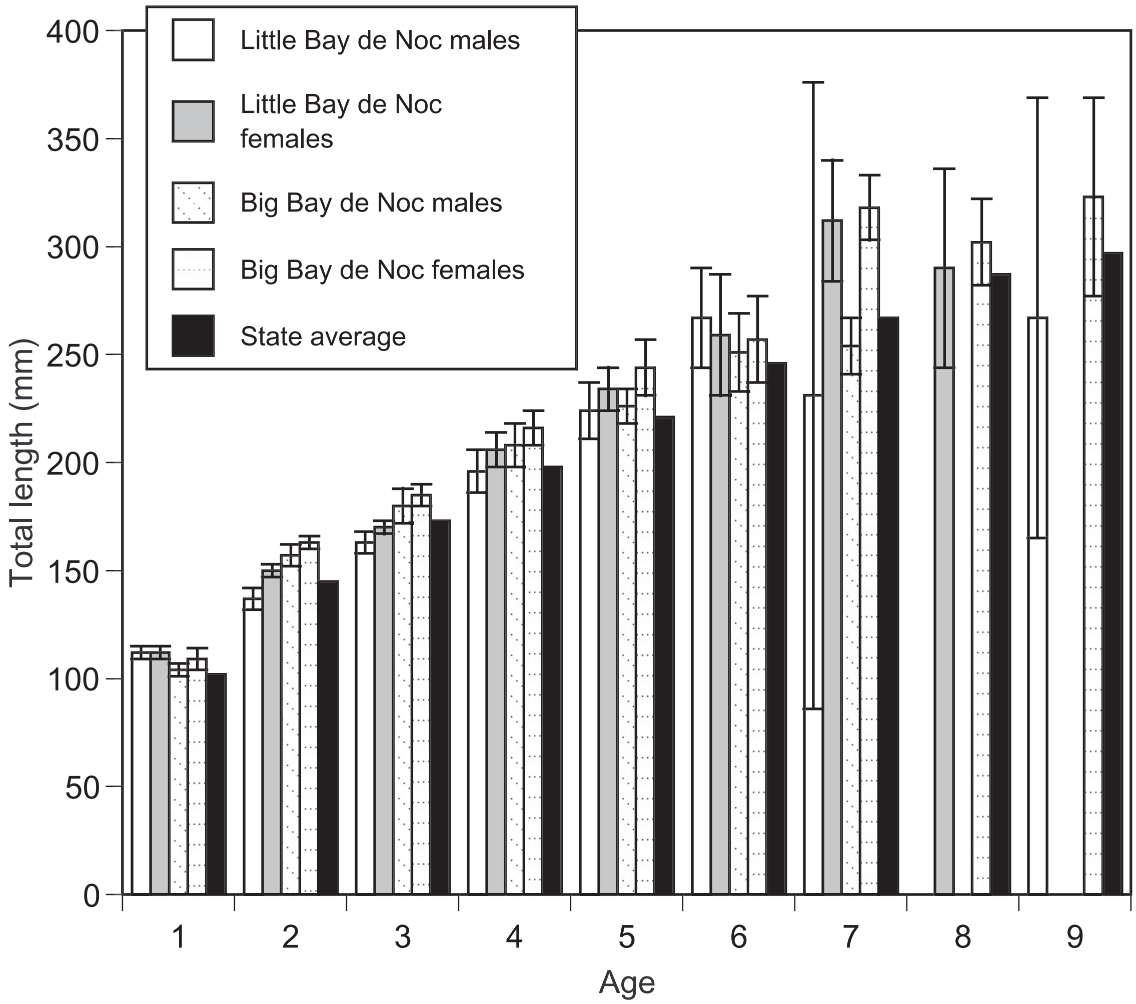

Figure 13.–Length-at-age and 2SE for yellow perch in field samples in Michigan waters of Green Bay, 1988-96.

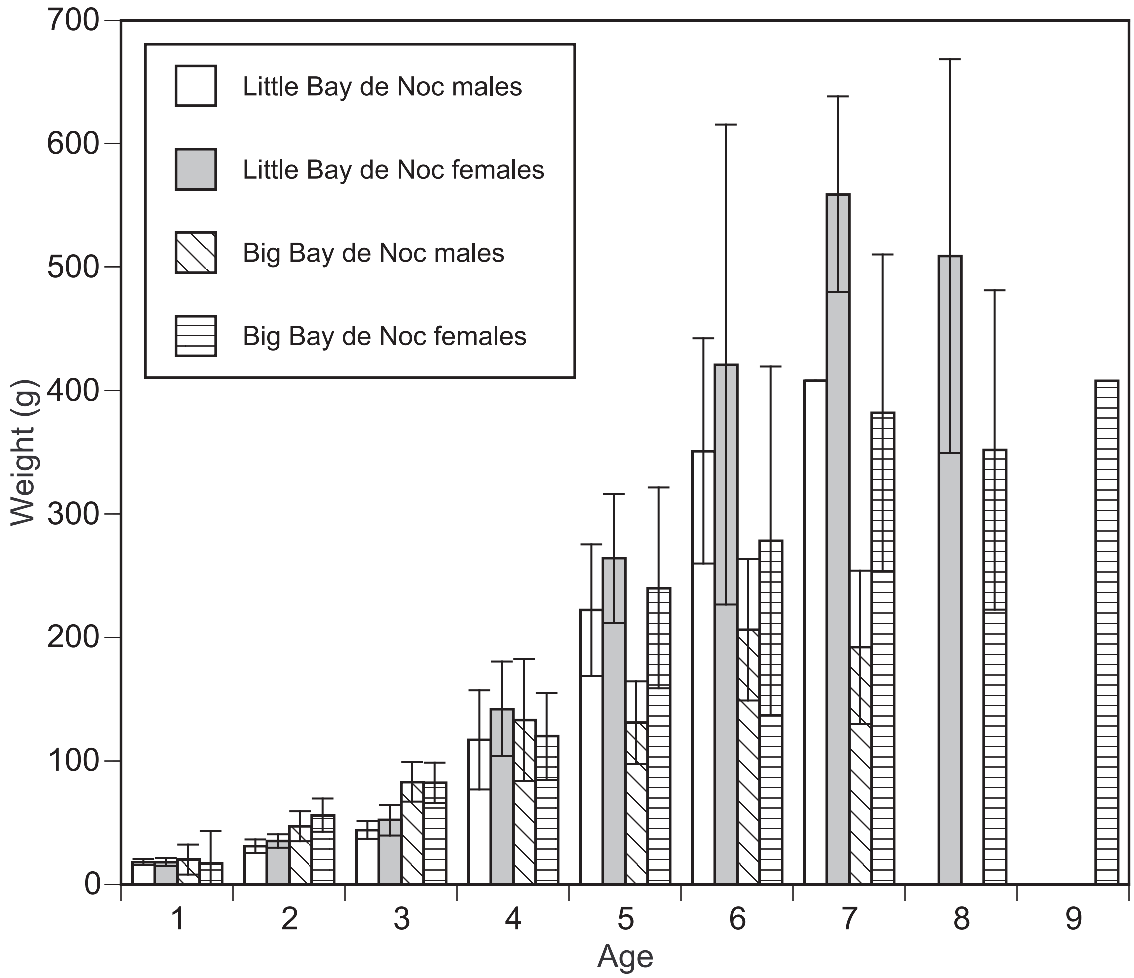

Figure 14.–Weight-at-age and 2SE for yellow perch in field samples in Michigan waters of Green Bay, 1988-96.

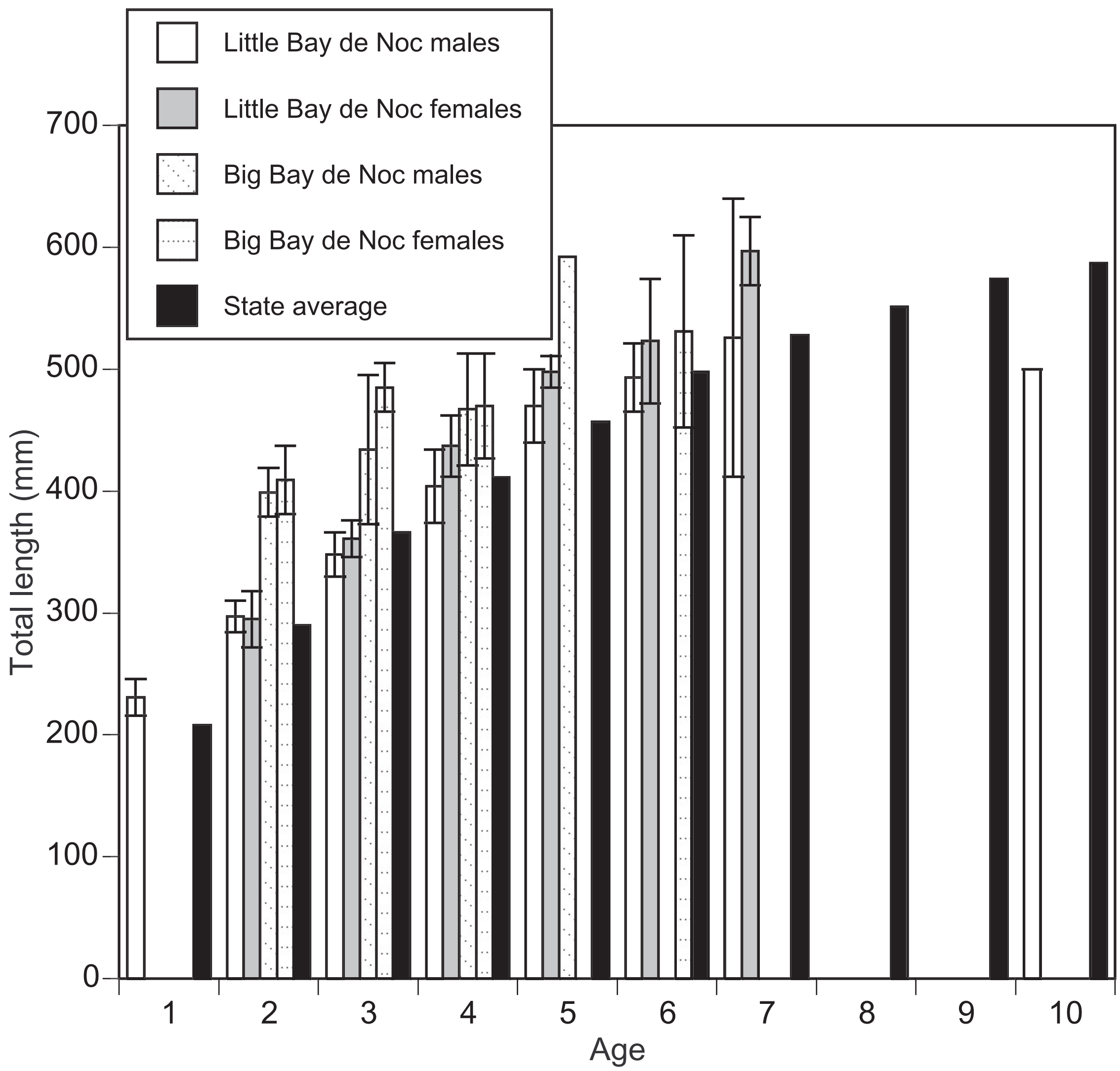

Figure 15.–Length-at-age and 2SE for walleye in field samples in Michigan waters of Green Bay, 1988-96.

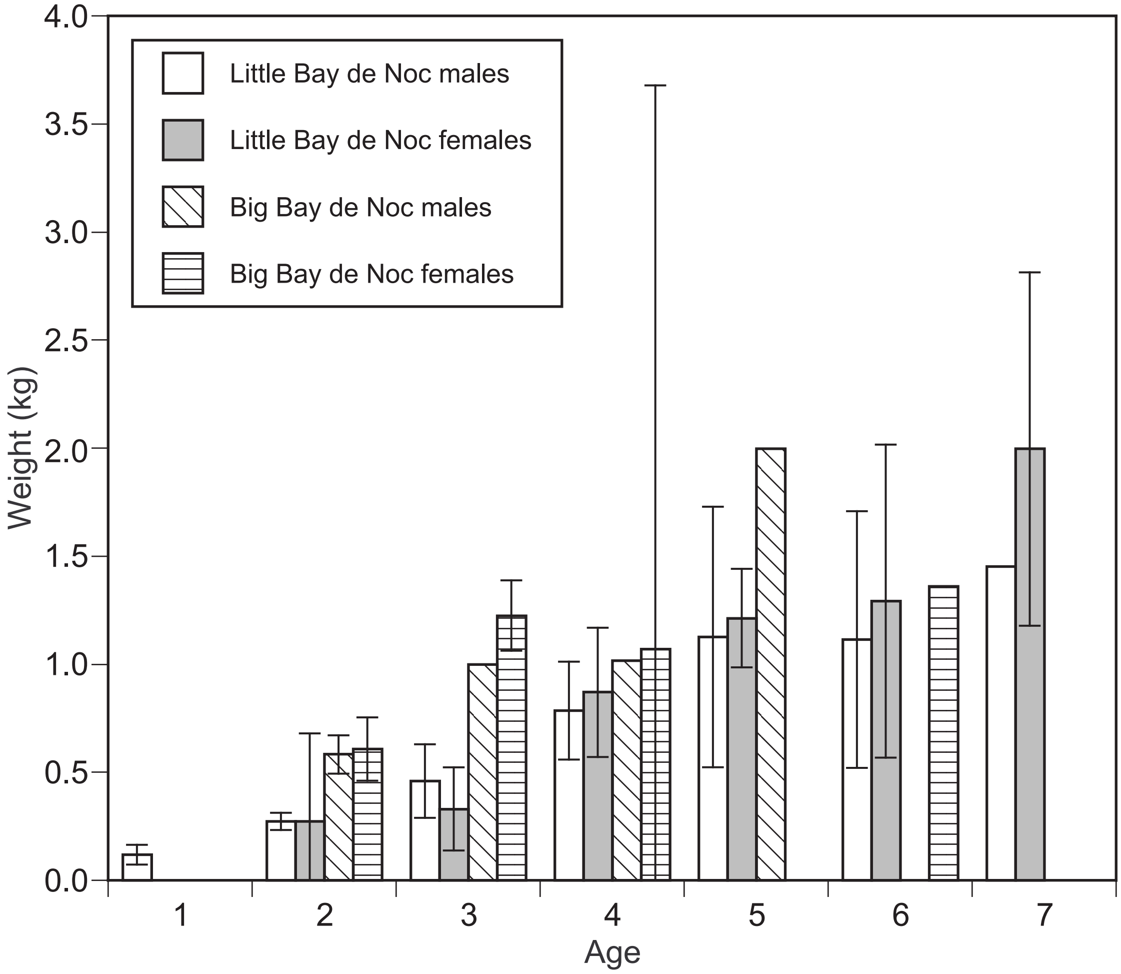

Figure 16.–Weight-at-age and 2SE for walleye in field samples in Michigan waters of Green Bay, 1988-96.

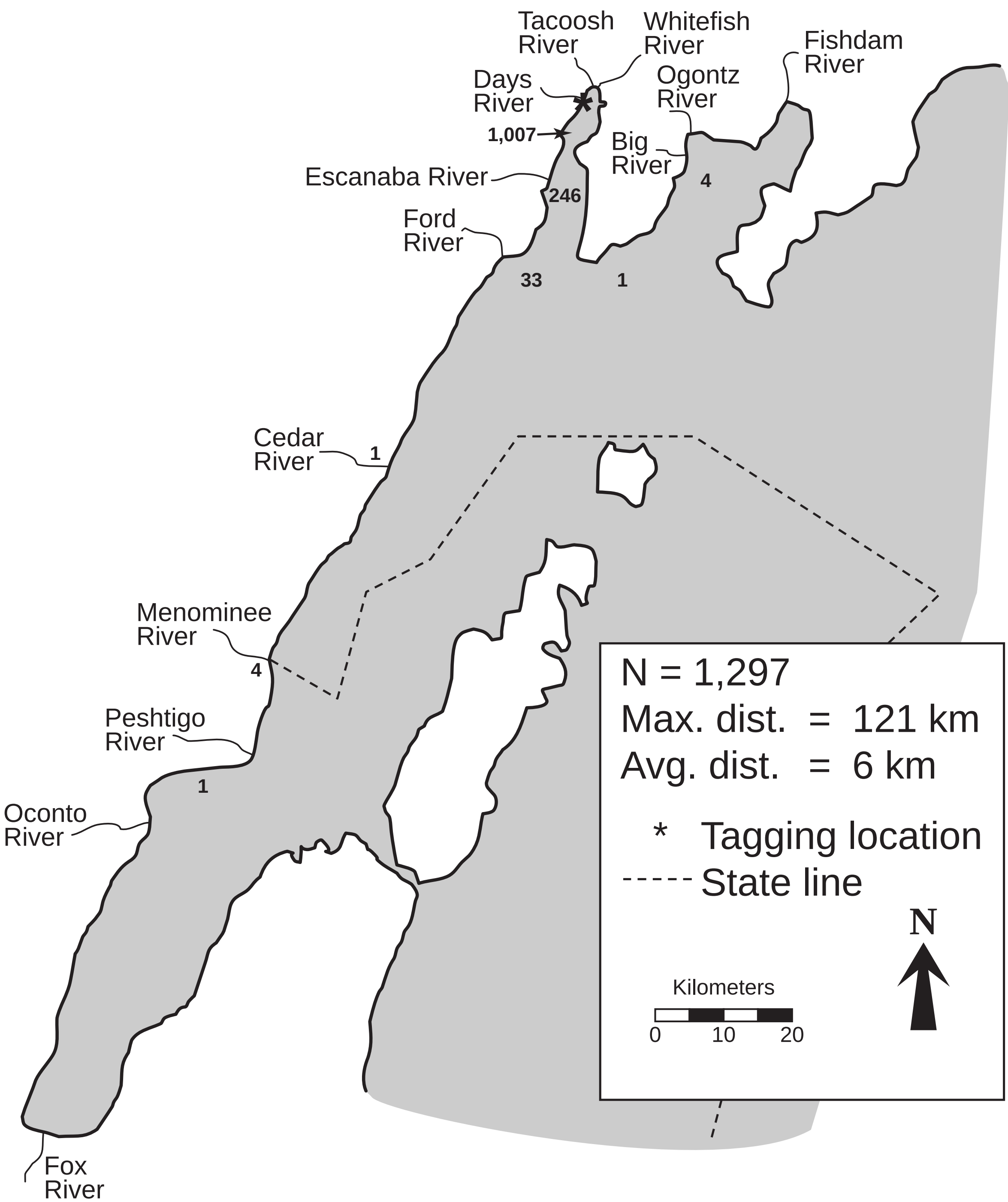

Figure 17.–Returns from 1988 through 1996 of walleye tagged in Little Bay de Noc.

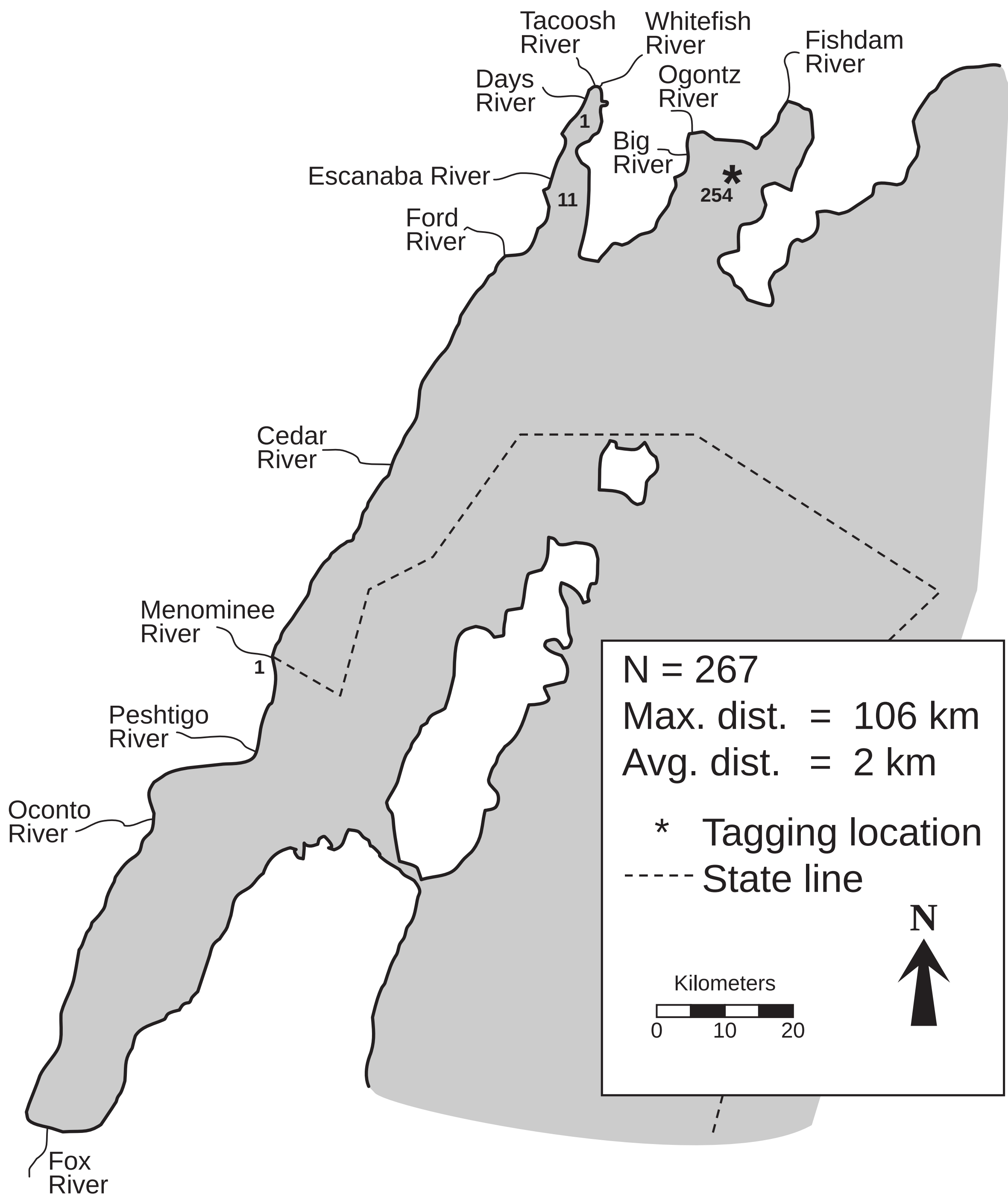

Figure 18.–Returns from 1988 through 1996 of walleye tagged in Big Bay de Noc.

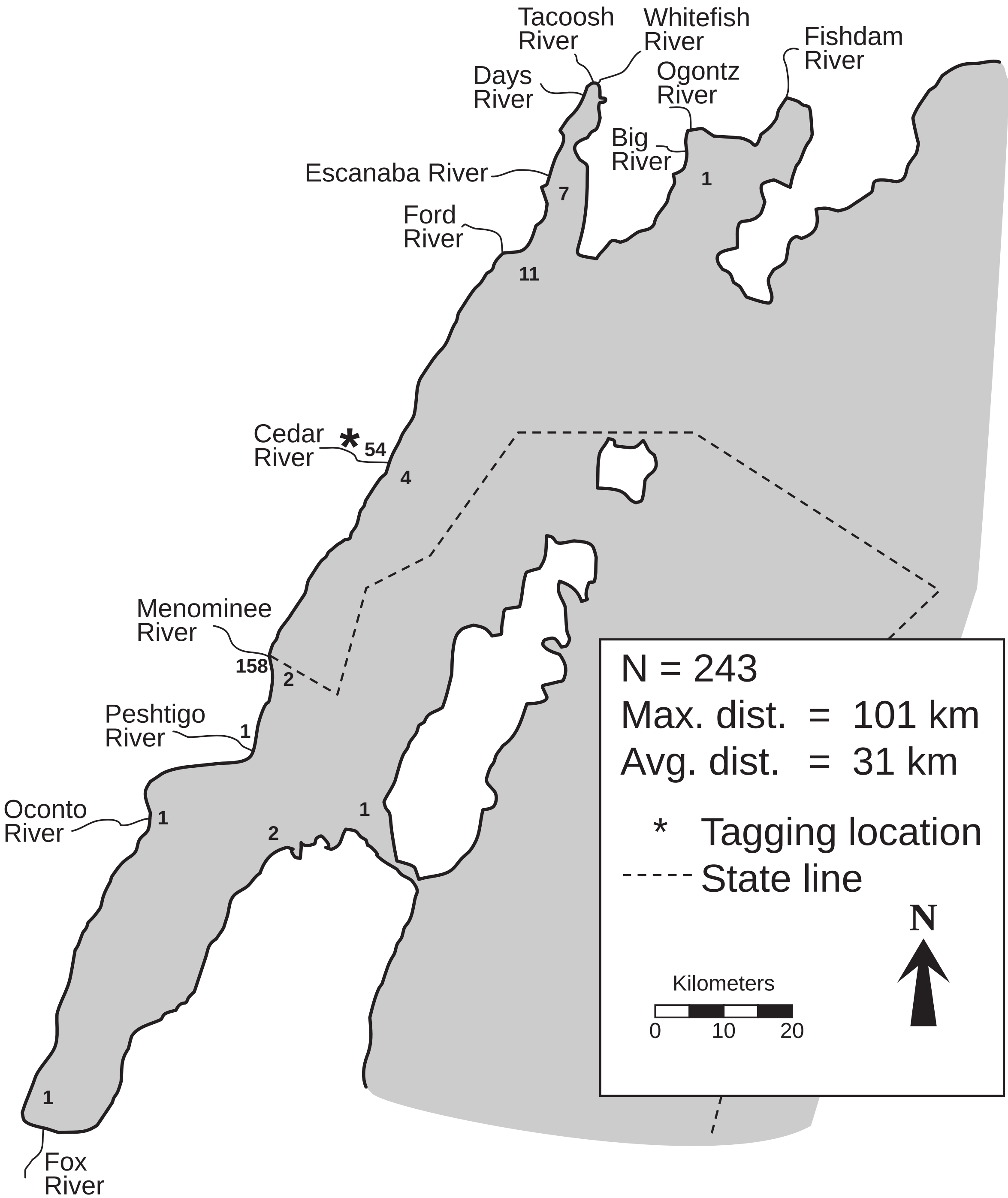

Figure 19.–Returns from 1988 through 1996 of walleye tagged in Cedar River.

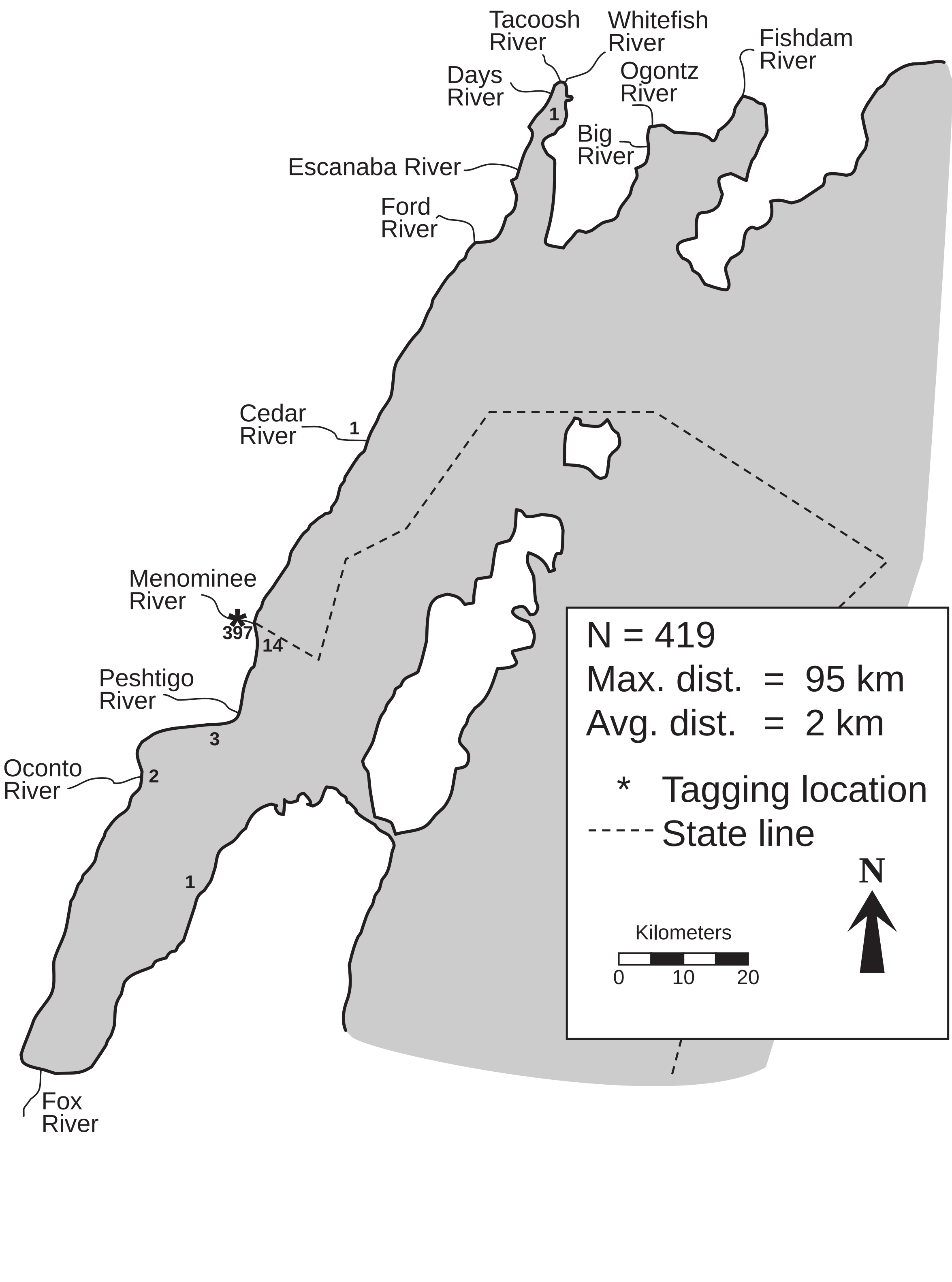

Figure 20.–Returns from 1988 through 1996 of walleye tagged in Menominee River.

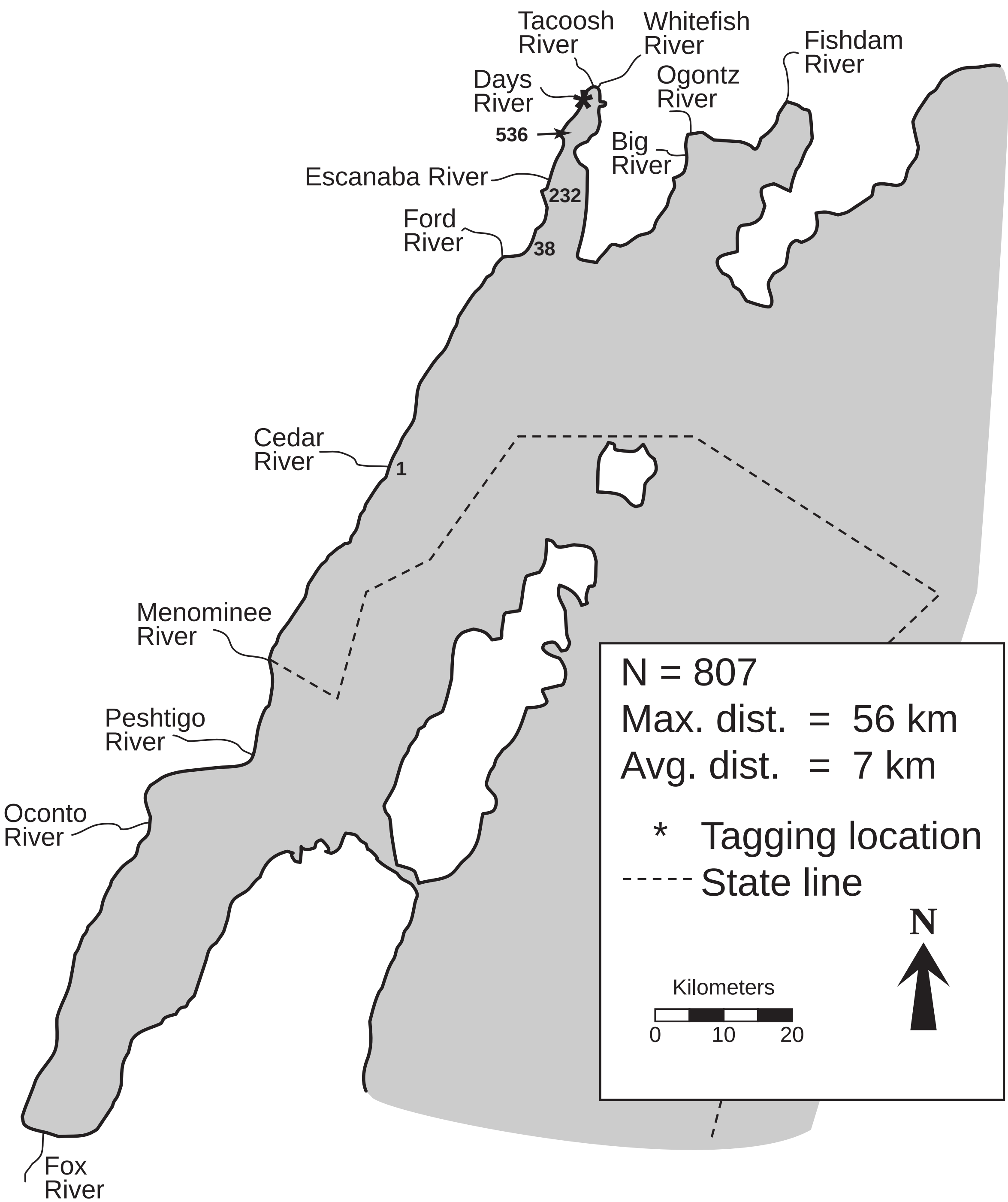

Figure 21.–Returns from 1989 through 1996 of yellow perch tagged in Little Bay de Noc.

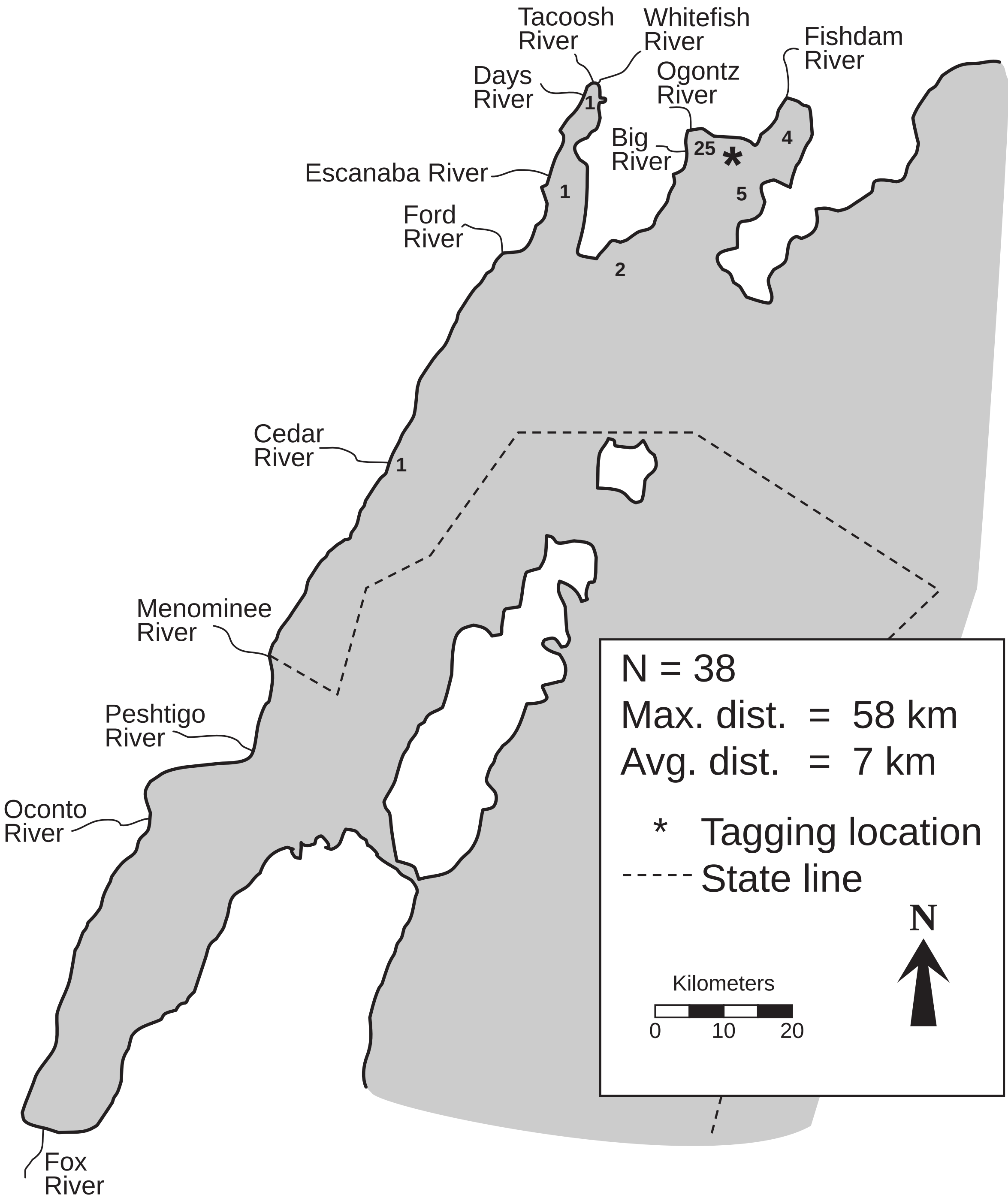

Figure 22.–Returns from 1990 through 1996 of yellow perch tagged in Big Bay de Noc.

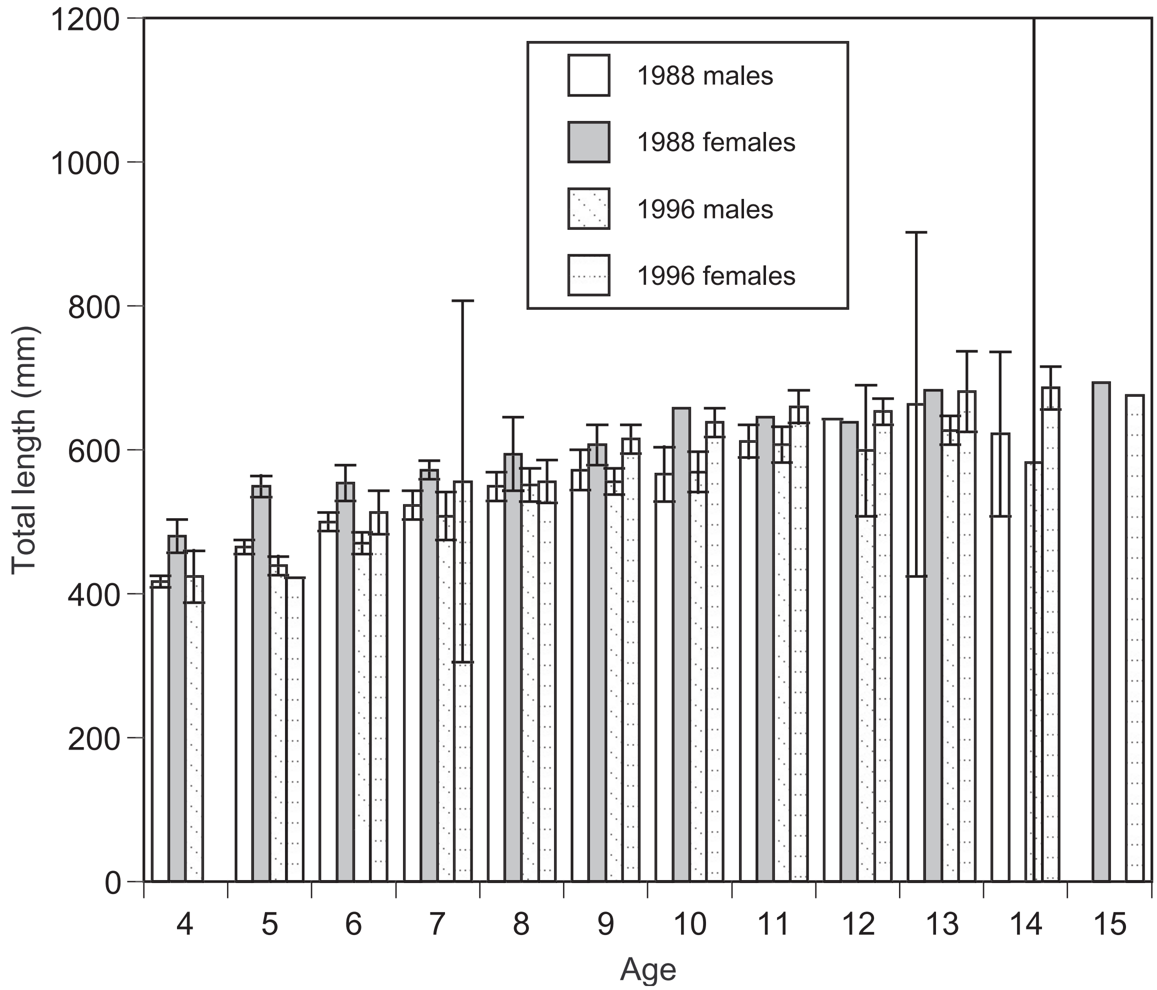

Figure 23.–Length-at-age and 2SE for walleye tagged in Little Bay de Noc, 1988 and 1996.

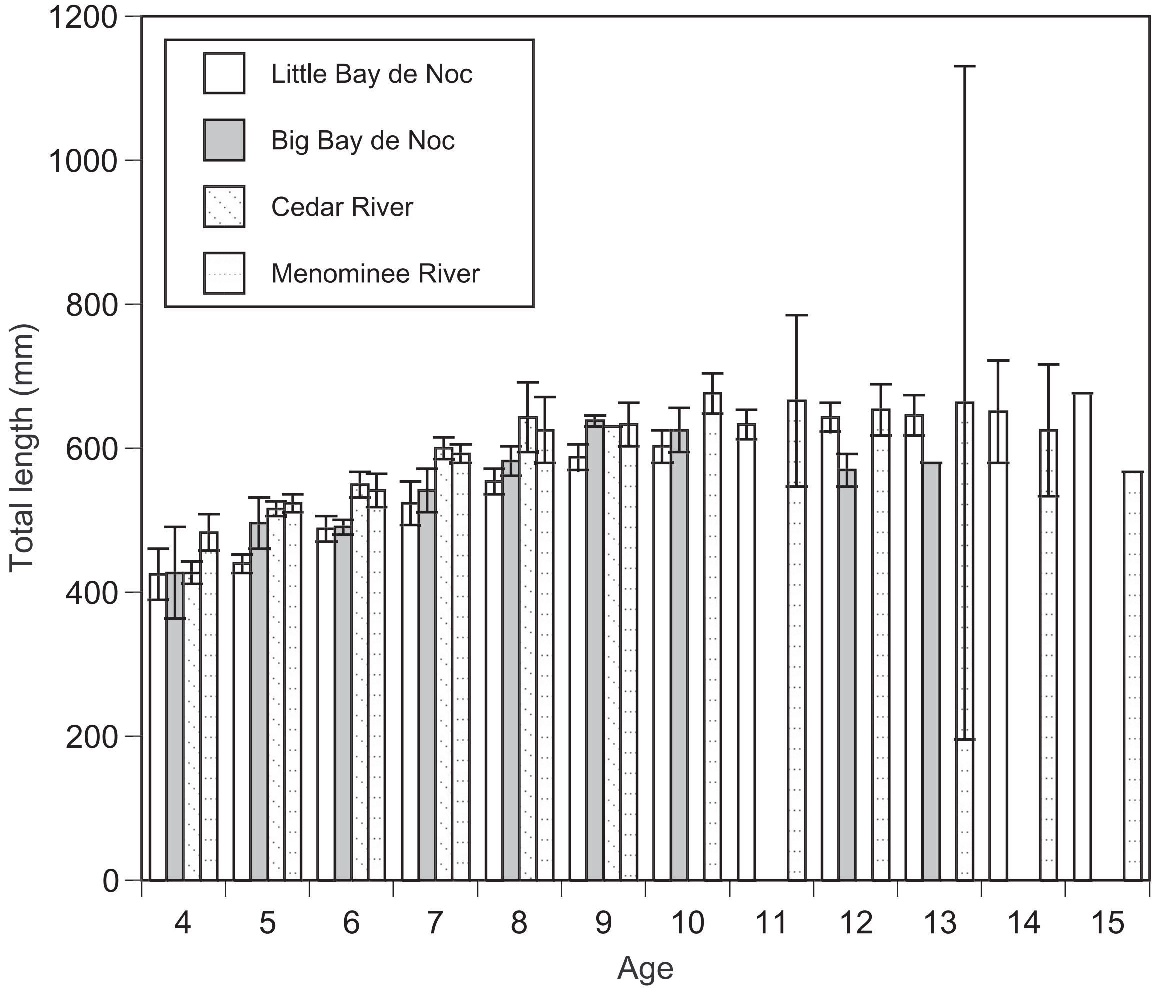

Figure 24.–Length-at-age and 2SE for walleye tagged in Michigan waters of Green Bay during 1996.

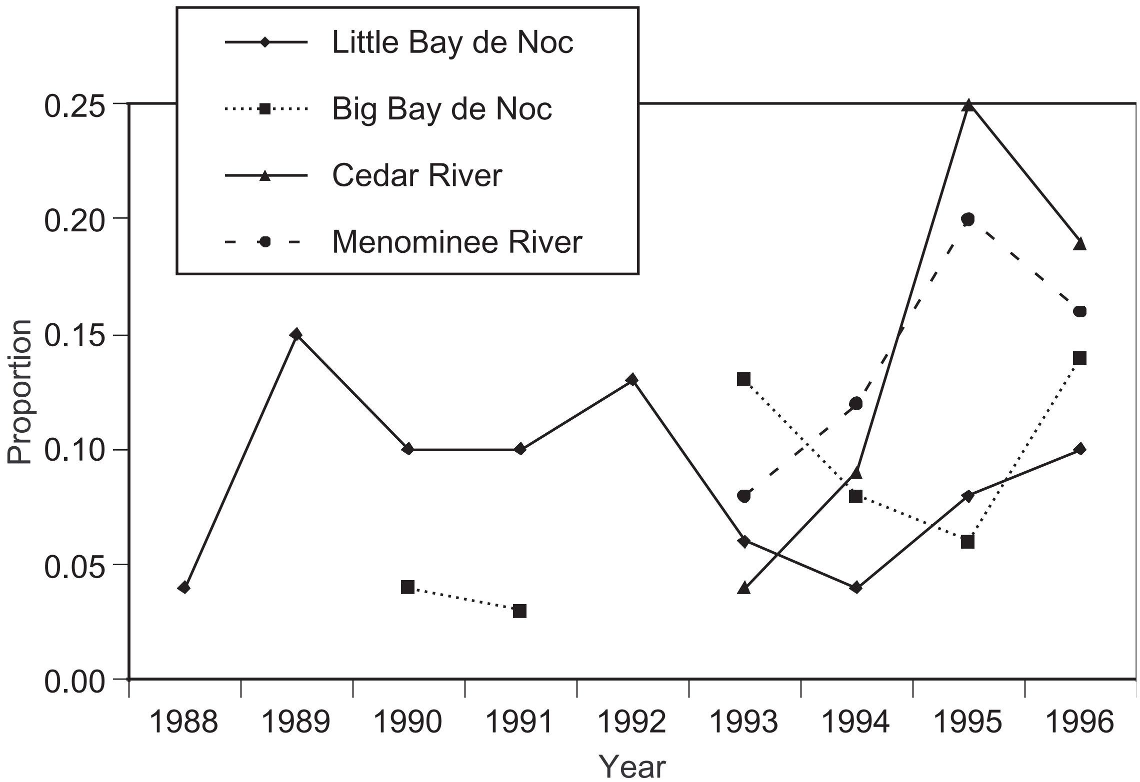

Figure 25.–Incidence of lymphocystis in walleye at tagging sites in Michigan waters of Green Bay, 1988-96.

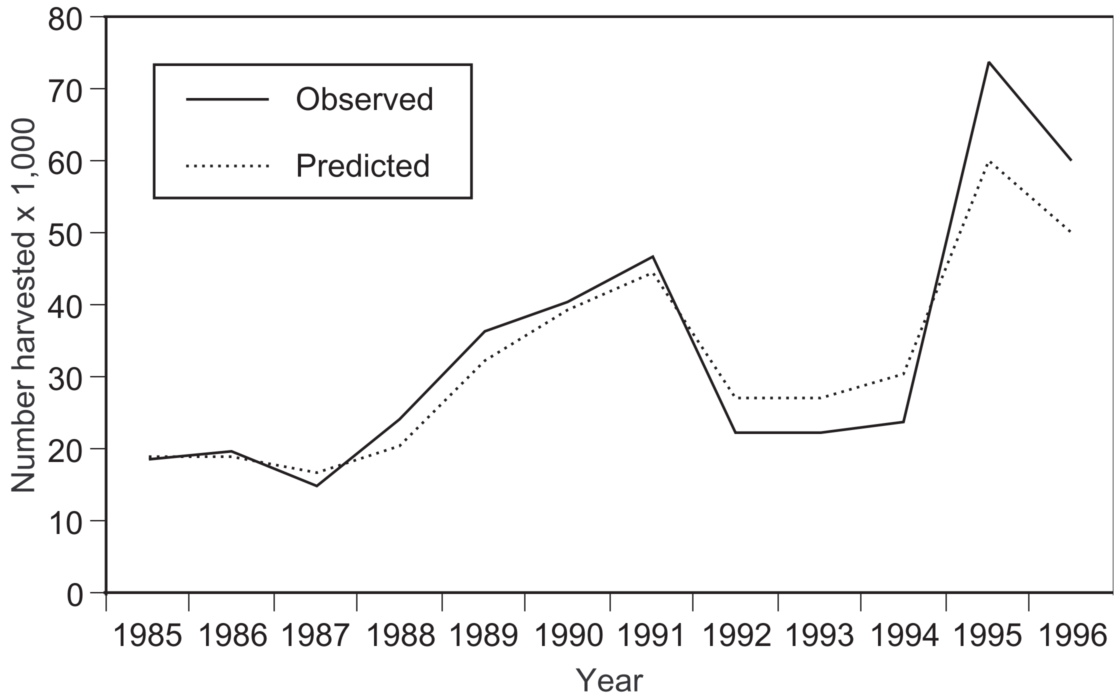

Figure 26.–Comparison of Little Bay de Noc walleye catch-at-age model predictions to observed values for recreational harvest.

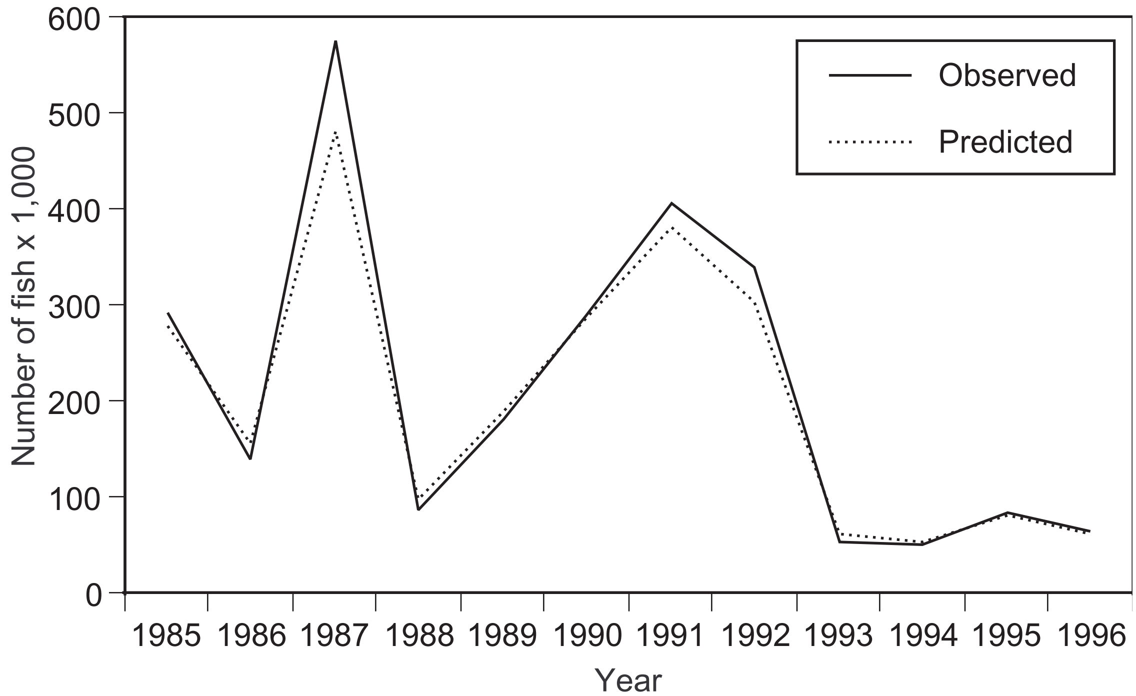

Figure 27.–Comparison of Little Bay de Noc yellow perch catch-at-age model predictions to observed values for fishery harvest, 1985-96.

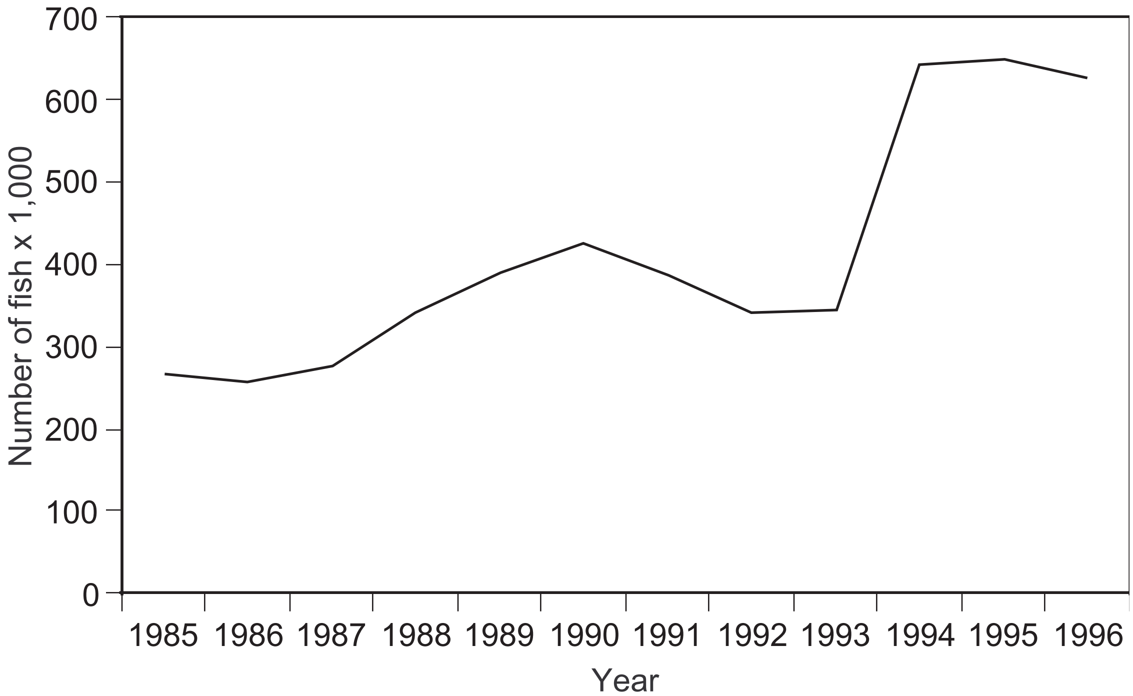

Figure 28.–Model predictions of Little Bay de Noc walleye (age 3 and older) abundance, 1985-96.

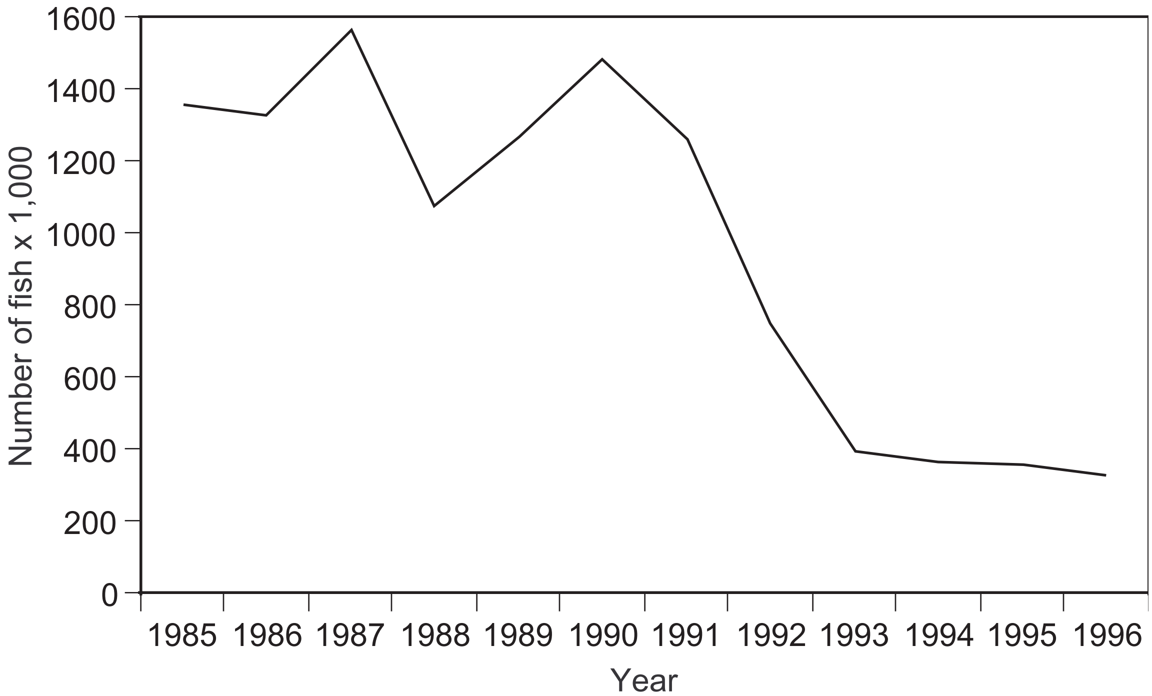

Figure 29.–Model predictions of Little Bay de Noc yellow perch (age 3 and older) abundance, 1985-96.

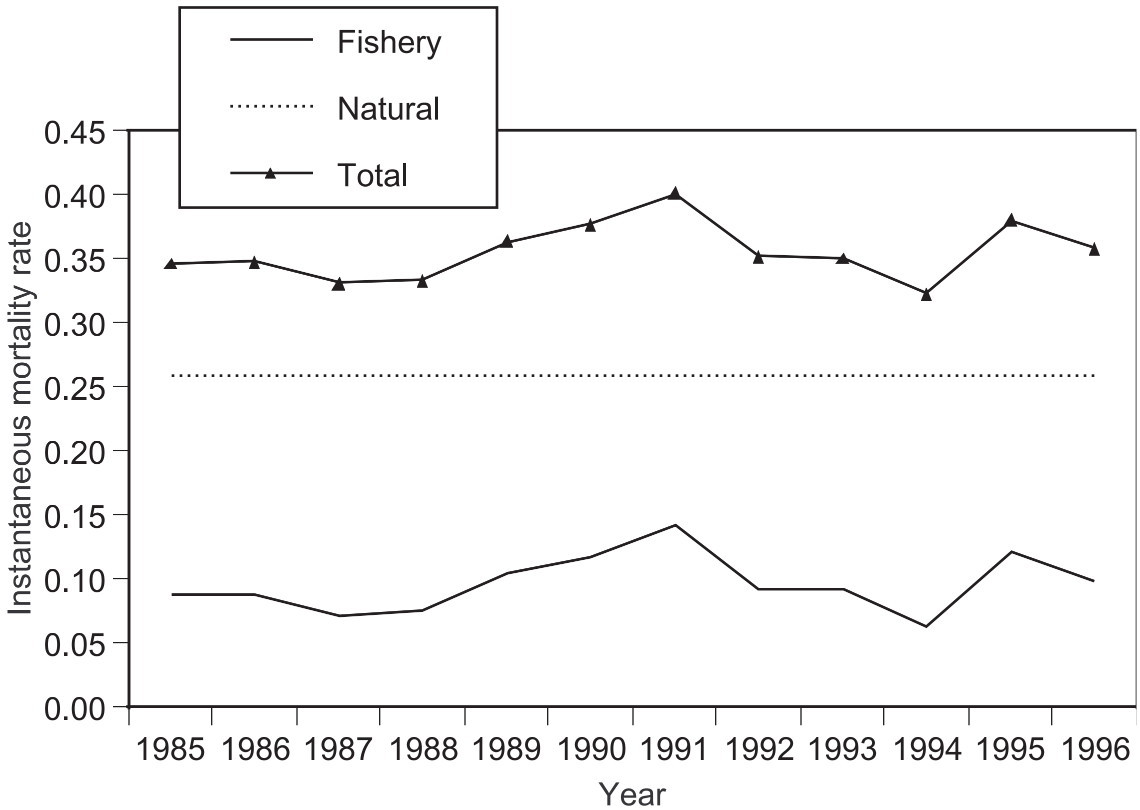

Figure 30.–Model estimates of fishing, natural, and total instantaneous mortality rates for walleye in Little Bay de Noc, averaged over ages 3-7, 1985-96.

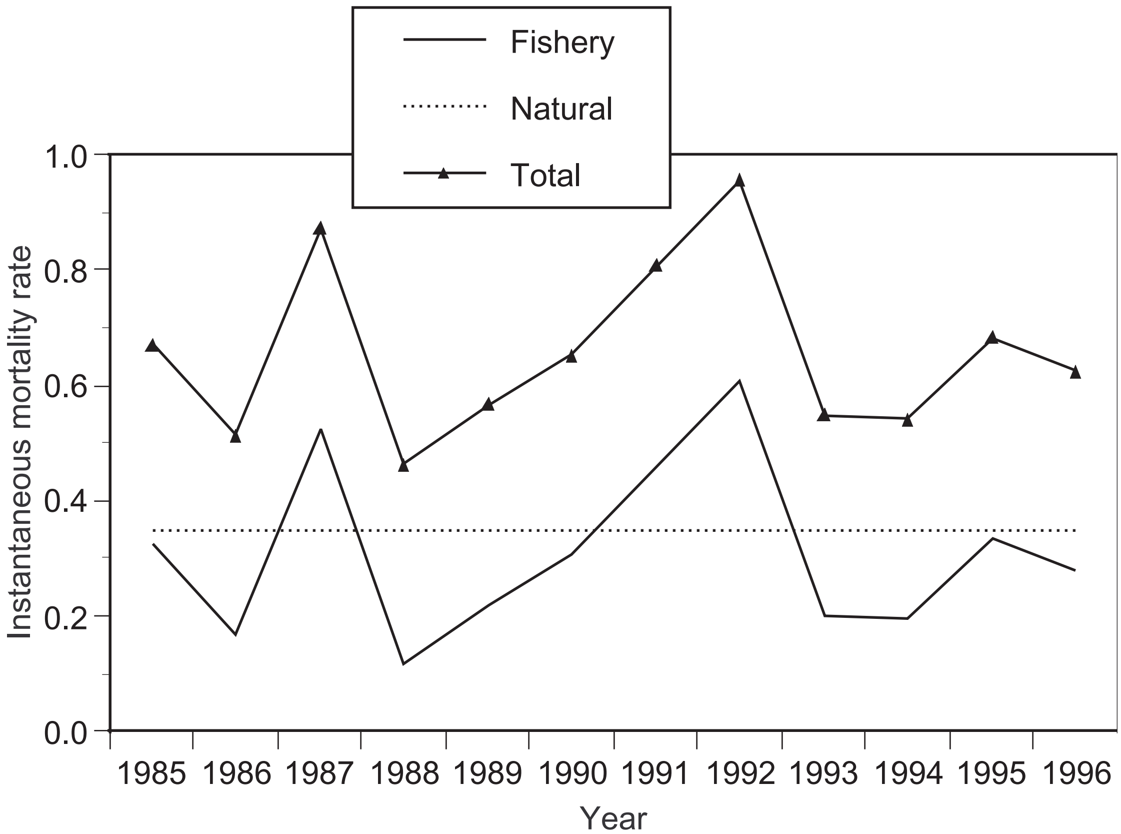

Figure 31.–Model estimates of fishing, natural, and total instantaneous mortality rates for yellow perch in Little Bay de Noc, averaged over ages 3-5, 1985-96.

Table 1.–Numbers of walleye stocked in Michigan waters of Green Bay, 1969-96.

	Little Bay de Noc		Big Bay de Noc		Cedar River		Menominee River
Year	Fingerlings	Fry	Fingerlings	Fry	Fingerlings	Fry	Fingerlings
1969		400,000					
1970							
1971	20,217		16,446	4,760,000			
1972	51,325	1,400,000					
1973	108,311			230,000			
1974	83,655		8,644				
1975	80,971			300,000			
1976	121,685			1,775,000			
1977	101,753		47,936				
1978	131,878						
1979	110,019						
1980	117,640	455,245					
1981	119,344	1,691,625				1,125,000	
1982	13,725	2,000,000				1,000,000	
1983	793,540	1,350,000				1,000,000	
1984	230,090	2,000,000					
1985	319,660	1,900,000					
1986	255,291	2,000,000	205,722	2,954,500			
1987	318,200	3,598,270	175,600				
1988	84,777		73,322		72,068		7,400
1989	278,076		217,507	2,775,000	96,727		
1990	505,941				157,757		92,797
1991	164		694,059		206,207		99,986
1992	426,471				32,770		166,563
1993			325,201		44,070		46,982
1994	263,508				217,162		307,145
1995			383,519		190,354		189,474
1996	560,558				96,161		123,569
All	5,096,799	16,795,140	2,147,956	12,794,500	1,113,276	3,125,000	1,033,916

Table 2.–List of common and scientific names of fish caught in field assessments nets in Michigan waters of Green Bay, 1988-96.

Common Name (family)	Scientific name	Numbers caught by gear type				
		Gill net	Trawl	Seine	Boom-shocker	Total
Gars (Lepisosteidae)						
Longnose gar	*Lepisosteus osseus*	2				2
Bowfins (Amiidae)						
Bowfin	*Amia calva*				1	1
Herrings (Clupeidae)						
Alewife	*Alosa pseudoharengus*	1,316	27	10		1,353
Gizzard shad	*Dorosoma cepedianum*	12		2	2	16
Carps and Minnows (Cyprinidae)						
Bluntnose minnow	*Pimephales promelas*		4	73	13	90
Common carp	*Cyprinus carpio*	9	1	4	1	15
Common shiner	*Luxilus cornutus*	3		1		4
Emerald shiner	*Notropis atherinoides*			75		75
Golden shiner	*Notemigonus crysoleucas*			8		8
Spottail shiner	*Notropis hudsonius*	345	1,532	184		2,061
Suckers (Catostomidae)						
Golden redhorse	*Moxostoma erythrurum*	4	1	1		6
Longnose sucker	*Catostomus catostomus*	4				4
Shorthead redhorse	*Moxostoma macrolepidotum*	2			1	3
Silver redhorse	*Moxostoma anisurum*	1				1
White sucker	*Catostomus commersoni*	220	118	954	8	1,300
Catfishes (Ictaluridae)						
Black bullhead	*Ameiurus melas*	1				1
Brown bullhead	*Ameiurus nebulosus*	14	1	1		16
Channel catfish	*Ictalurus punctatus*	1				1
Yellow bullhead	*Ameiurus natalis*					
Pikes (Esocidae)						
Northern pike	*Esox lucius*	217	1	8	19	245
Smelts (Osmeridae)						
Rainbow smelt	*Osmerus mordax*	9	802			811
Trouts (Salmonidae)						
Atlantic salmon	*Salmo salar*				1	1
Brook trout	*Salvelinus fontinalis*	1				1
Brown trout	*Salmo trutta*	4			1	5
Chinook salmon	*Oncorhynchus tshawytscha*	5			2	7
Coho salmon	*Oncorhynchus kisutch*				1	1
Lake herring	*Coregonus artedi*		2			2
Lake trout	*Salvelinus namaycush*	1				1
Lake whitefish	*Coregonus clupeaformis*	1	139			140
Rainbow trout	*Oncorhynchus mykiss*	1				1
Round whitefish	*Prosopium cylindraceum*	1				1
Splake	*Salvelinus namaycush x S. fontinalis*	12				12
Trout-perches (Percopsidae)						
Trout-perch	*Percopsis omiscomaycus*	188	3,895	2		4,085

Table 2.–Continued.

Common Name (family)	Scientific name	Numbers caught by gear type				
		Gill net	Trawl	Seine	Boom-shocker	Total
Cods (Gadidae)						
Burbot	Lota lota		4			4
Killifishes (Cyprinodontidae)						
Banded killifish	Fundulus diaphanus			2		2
Sticklebacks (Gasterosteidae)						
Brook stickleback	Culaea inconstans		125	1		126
Ninespine stickleback	Pungitius pungitius		12			12
Threespine stickleback	Gasterosteus aculeatus		111			111
Sculpins (Cottidae)						
Mottled sculpin	Cottus bairdi		5			5
Temperate basses (Percichthyidae)						
White bass	Morone chrysops	14				14
White perch	Morone americana	30	5			35
Sunfishes (Centrarchidae)						
Black crappie	Pomoxis nigromaculatus		2	10	2	14
Bluegill	Lepomis macrochirus		7		5	12
Green sunfish	Lepomis cyanellus			3		3
Largemouth bass	Micropterus salmoides		5	20	32	57
Pumpkinseed	Lepomis gibbosus	4	4	6	5	19
Rock bass	Ambloplites rupestris	61	72	203	9	345
Smallmouth bass	Micropterus dolomieu	49	31	91	8	179
Perches (Percidae)						
Johnny darter	Etheostoma nigrum		1,292	159	3	1,454
Logperch	Percina caprodes	3	43	153	3	202
Sauger	Stizostedion canadense	3				3
Walleye	Stizostedion vitreum	284	84	41	24	433
Yellow perch	Perca flavescens	3,169	9,192	1,286	309	13,956

Table 3.–Food items identified in fish stomachs collected in field samples from Big and Little bays de Noc, 1988-96.

Class/category	Items
Arachnoida	Hydrachnids
Crustacea	Amphipods, *Bythotrephes cedrestroemi*, crayfish, daphnids, isopods, ostracods, zooplankton
Gastropoda	Snails
Hirudinea	Leeches
Insecta	Coleopterans, corixids, dipterans, ephemeropterans, neuropterans, odonates, trichopterans
Oligochaeta	Oligochaet worms
Pelecypoda	Clams, zebra mussels
Pisces	Fish, fish eggs, fish larvae
Plant	Pollen, seeds, vascular plants

Table 4.–Number of fish tagged and tag returns by year from Michigan waters of Green Bay, 1988-96. Recovery year considered May of the year in the heading through April of the following year for walleye, and April through March for yellow perch.

Tag	Number	Recovery year									
year	tagged	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Walleye in Little Bay de Noc											
1988	2,496	167	141	72	42	12	21	14	5	2	476
1989	2,486	–	150	58	25	20	7	7	8	1	276
1990	1,744	–	–	94	33	13	15	3	0	0	158
1991	1,886	–	–	–	79	30	10	5	2	1	127
1992	1,690	–	–	–	–	50	18	14	5	4	91
1993	1,563	–	–	–	–	–	69	22	10	5	106
1994	1,246	–	–	–	–	–	–	69	23	7	99
1995	711	–	–	–	–	–	–	–	33	18	51
1996	700	–	–	–	–	–	–	–	–	25	25
Walleye in Big Bay de Noc											
1990	867	–	–	22	19	1	2	1	0	1	46
1991	354	–	–	–	6	3	3	1	2	1	16
1993	617	–	–	–	–	–	20	13	11	1	45
1994	1,458	–	–	–	–	–	–	37	15	5	57
1995	1,993	–	–	–	–	–	–	–	67	28	95
1996	1,324	–	–	–	–	–	–	–	–	32	32
Walleye in Cedar River											
1993	1,312	–	–	–	–	–	50	27	9	1	87
1994	1,500	–	–	–	–	–	–	73	17	6	96
1995	1,677	–	–	–	–	–	–	–	36	23	59
1996	445	–	–	–	–	–	–	–	–	7	7
Walleye in Menominee River											
1993	1,280	–	–	–	–	–	100	24	6	4	134
1994	1,500	–	–	–	–	–	–	127	16	4	147
1995	1,879	–	–	–	–	–	–	–	103	25	128
1996	544	–	–	–	–	–	–	–	–	20	20
Yellow perch in Little Bay de Noc											
1989	2,523	–	102	51	17	2	5	0	0	0	177
1990	2,127	–	–	73	30	12	1	1	0	0	117
1991	2,418	–	–	–	71	32	13	0	1	0	117
1992	3,683	–	–	–	–	137	49	3	2		192
1993	5,278	–	–	–	–	–	153	28	13	2	196
Yellow perch in Big Bay de Noc											
1990	1,059	–	–	19	3	0	0	0	0	0	22
1991	2,484	–	–	–	14	2	2	0	0	0	18

Table 5.–Species of fish captured with assessment gear (gill nets, trawls, seines, boomshocker) in Little Bay de Noc (LBDN) and Big Bay de Noc (BBDN), 1988-96.

Common name	Measured and examined[a]		Measured or counted only		Totals			
	LBDN	BBDN	LBDN	BBDN	LBDN	BBDN	All	%
Yellow perch	2,847	1,864	3,396	5,857	6,243	7,721	13,964	50.80
Trout-perch	496	124	2,390	1,075	2,886	1,199	4,085	14.86
Spottail shiner	132	120	813	1,006	945	1,126	2,071	7.53
Johnny darter	77	46	733	598	810	644	1,454	5.29
Alewife	358	335	295	365	653	700	1,353	4.92
White sucker	107	86	1,076	31	1,183	117	1,300	4.73
Rainbow smelt	34	33	332	412	366	445	811	2.95
Walleye	349	44	189	4	538	48	586	2.13
Rock bass	97	7	240	1	337	8	345	1.26
Northern pike	158	32	48	7	206	39	245	0.89
Logperch	44	0	168	0	212	0	212	0.77
Smallmouth bass	49	20	103	7	152	27	179	0.65
Lake whitefish	0	3	1	136	1	139	140	0.51
Brook stickleback	1	5	2	118	3	123	126	0.46
Threespine stickleback	0	44	0	67	0	111	111	0.40
Bluntnose minnow	0	2	86	2	86	4	90	0.33
Emerald shiner	1	0	74	0	75	0	75	0.27
Largemouth bass	6	0	51	0	57	0	57	0.21
White perch	22	12	1	0	23	12	35	0.13
Bullhead	0	0	30	0	30	0	30	0.11
Pumpkinseed	9	1	9	0	18	1	19	0.07
Golden shiner	0	0	18	0	18	0	18	0.07
Brown bullhead	6	7	2	1	8	8	16	0.06
Gizzard shad	9	2	4	1	13	3	16	0.06
Common carp	0	2	6	7	6	9	15	0.05
Black crappie	2	0	12	0	14	0	14	0.05
White bass	14	0	0	0	14	0	14	0.05
Bluegill	4	2	2	4	6	6	12	0.04
Ninespine stickleback	0	3	1	8	1	11	12	0.04
Splake	10	1	1	0	11	1	12	0.04
Chinook salmon	5	0	2	0	7	0	7	0.03
Redhorse	7	0	0	0	7	0	7	0.03
Golden redhorse	5	0	1	0	6	0	6	0.02
Brown trout	3	0	2	0	5	0	5	0.02
Mottled sculpin	3	0	2	0	5	0	5	0.02
Burbot	1	1	1	1	2	2	4	0.01
Common shiner	1	3	0	0	1	3	4	0.01
Longnose sucker	0	4	0	0	0	4	4	0.01
Green sunfish	0	0	3	0	3	0	3	0.01
Sauger	1	0	2	0	3	0	3	0.01
Shorthead redhorse	2	0	1	0	3	0	3	0.01
Banded killifish	0	0	2	0	2	0	2	0.01
Lake herring	2	0	0	0	2	0	2	0.01

Table 5.–Continued.

Common name	Measured and examined[a]		Measured or counted only		Totals			
	LBDN	BBDN	LBDN	BBDN	LBDN	BBDN	All	%
Longnose gar	0	0	0	2	0	2	2	0.01
Yellow bullhead	1	0	0	1	1	1	2	0.01
Atlantic salmon	0	0	1	0	1	0	1	>0.01
Black bullhead	0	0	1	0	1	0	1	>0.01
Bowfin	1	0	0	0	1	0	1	>0.01
Brook trout	1	0	0	0	1	0	1	>0.01
Channel catfish	1	0	0	0	1	0	1	>0.01
Coho salmon	0	0	1	0	1	0	1	>0.01
Lake trout	1	0	0	0	1	0	1	>0.01
Rainbow trout	0	0	1	0	1	0	1	>0.01
Round whitefish	0	1	0	0	0	1	1	>0.01
Silver redhorse	1	0	0	0	1	0	1	>0.01
Total	4,868	2,804	10,103	9,711	14,971	12,515	27,486	100.00

[a]Stomach contents, sex, and maturity.

Table 6.–Species of fish captured with assessment gill nets in Little Bay de Noc (LBDN) and Big Bay de Noc (BBDN), 1988-96.

	Measured and examined[a]		Measured or counted only		Totals			
Common name	LBDN	BBDN	LBDN	BBDN	LBDN	BBDN	All	%
Yellow perch	1,416	1,229	324	200	1,740	1,429	3,169	52.82
Alewife	343	323	285	365	628	688	1,316	21.93
Spottail shiner	78	106	51	110	129	216	345	5.75
Walleye	218	43	19	4	237	47	284	4.73
White sucker	89	81	34	16	123	97	220	3.67
Northern pike	157	32	22	6	179	38	217	3.62
Trout-perch	53	58	4	73	57	131	188	3.13
Rock bass	54	1	5	1	59	2	61	1.02
Smallmouth bass	34	8	5	2	39	10	49	0.82
White perch	17	12	1	0	18	12	30	0.50
Brown bullhead	5	7	1	1	6	8	14	0.23
White bass	14	0	0	0	14	0	14	0.23
Gizzard shad	8	2	1	1	9	3	12	0.20
Splake	10	1	1	0	11	1	12	0.20
Common carp	0	2	1	6	1	8	9	0.15
Rainbow smelt	2	7	0	0	2	7	9	0.15
Redhorse	7	0	0	0	7	0	7	0.12
Chinook salmon	5	0	0	0	5	0	5	0.08
Brown trout	3	0	1	0	4	0	4	0.07
Golden redhorse	4	0	0	0	4	0	4	0.07
Longnose sucker	0	4	0	0	0	4	4	0.07
Pumpkinseed	4	0	0	0	4	0	4	0.07
Common shiner	0	3	0	0	0	3	3	0.05
Logperch	3	0	0	0	3	0	3	0.05
Sauger	1	0	2	0	3	0	3	0.05
Longnose gar	0	0	0	2	0	2	2	0.03
Shorthead redhorse	2	0	0	0	2	0	2	0.03
Yellow bullhead	1	0	0	1	1	1	2	0.03
Black bullhead	0	0	1	0	1	0	1	0.02
Brook trout	1	0	0	0	1	0	1	0.02
Channel catfish	1	0	0	0	1	0	1	0.02
Lake trout	1	0	0	0	1	0	1	0.02
Lake whitefish	0	0	1	0	1	0	1	0.02
Rainbow trout	0	0	1	0	1	0	1	0.02
Round whitefish	0	1	0	0	0	1	1	0.02
Silver redhorse	1	0	0	0	1	0	1	0.02
Total	2,532	1,920	760	788	3,292	2,708	6,000	100.00

[a]Stomach contents, sex, and maturity.

Table 7.–Species of fish captured with assessment trawls in Little Bay de Noc (LBDN) and Big Bay de Noc (BBDN), 1988-96.

	Measured and examined[a]		Measured or counted only		Totals			
Common name	LBDN	BBDN	LBDN	BBDN	LBDN	BBDN	All	%
Yellow perch	1,257	635	1,643	5,657	2,900	6,292	9,192	52.47
Trout-perch	443	66	2,384	1,002	2,827	1,068	3,895	22.24
Spottail shiner	52	14	570	896	622	910	1,532	8.75
Johnny darter	76	46	572	598	648	644	1,292	7.38
Rainbow smelt	32	26	332	412	364	438	802	4.58
Lake whitefish	0	3	0	136	0	139	139	0.79
Brook stickleback	1	5	1	118	2	123	125	0.71
White sucker	18	5	80	15	98	20	118	0.67
Threespine stickleback	0	44	0	67	0	111	111	0.63
Walleye	79	1	4	0	83	1	84	0.48
Rock bass	38	6	28	0	66	6	72	0.41
Logperch	26	0	17	0	43	0	43	0.25
Smallmouth bass	13	12	1	5	14	17	31	0.18
Alewife	15	12	0	0	15	12	27	0.15
Ninespine stickleback	0	3	1	8	1	11	12	0.07
Bluegill	1	2	0	4	1	6	7	0.04
Largemouth bass	5	0	0	0	5	0	5	0.03
Mottled sculpin	3	0	2	0	5	0	5	0.03
White perch	5	0	0	0	5	0	5	0.03
Bluntnose minnow	0	2	0	2	0	4	4	0.02
Burbot	1	1	1	1	2	2	4	0.02
Pumpkinseed	1	1	2	0	3	1	4	0.02
Black crappie	2	0	0	0	2	0	2	0.01
Lake herring	2	0	0	0	2	0	2	0.01
Brown bullhead	1	0	0	0	1	0	1	0.01
Common carp	0	0	0	1	0	1	1	0.01
Golden redhorse	1	0	0	0	1	0	1	0.01
Northern pike	0	0	0	1	0	1	1	0.01
Total	2,072	884	5,638	8,923	7,710	9,807	17,517	100.00

[a]Stomach contents, sex, and maturity.

Table 8.–Species of fish captured with assessment seines in Little Bay de Noc, 1988-96.

Common name	Measured and examined[a]	Measured or counted only	Total	Percent
Yellow perch	152	1,142	1,294	36.77
White sucker	0	954	954	27.11
Rock bass	1	202	203	5.77
Spottail shiner	2	192	194	5.51
Walleye	31	163	194	5.51
Logperch	15	148	163	4.63
Johnny darter	1	158	159	4.52
Smallmouth bass	1	90	91	2.59
Emerald shiner	1	74	75	2.13
Bluntnose minnow	0	73	73	2.07
Bullhead	0	30	30	0.85
Largemouth bass	0	20	20	0.57
Golden shiner	0	18	18	0.51
Alewife	0	10	10	0.28
Black crappie	0	10	10	0.28
Northern pike	0	8	8	0.23
Pumpkinseed	2	4	6	0.17
Common carp	0	4	4	0.11
Green sunfish	0	3	3	0.09
Banded killifish	0	2	2	0.06
Gizzard shad	0	2	2	0.06
Trout-perch	0	2	2	0.06
Brook stickleback	0	1	1	0.03
Brown bullhead	0	1	1	0.03
Common shiner	1	0	1	0.03
Golden redhorse	0	1	1	0.03
Total	207	3,312	3,519	100.00

[a]Stomach contents, sex, and maturity.

Table 9.–Species of fish captured with boomshocker equipment in Little Bay de Noc, 1988-96.

Common name	Measured and examined[a]	Measured or counted only	Total	Percent
Yellow perch	22	287	309	68.67
Largemouth bass	1	31	32	7.11
Walleye	21	3	24	5.33
Northern pike	1	18	19	4.22
Bluntnose minnow	0	13	13	2.89
Rock bass	4	5	9	2.00
Smallmouth bass	1	7	8	1.78
White sucker	0	8	8	1.78
Bluegill	3	2	5	1.11
Pumpkinseed	2	3	5	1.11
Johnny darter	0	3	3	0.67
Logperch	0	3	3	0.67
Black crappie	0	2	2	0.44
Chinook salmon	0	2	2	0.44
Gizzard shad	1	1	2	0.44
Atlantic salmon	0	1	1	0.22
Bowfin	1	0	1	0.22
Brown trout	0	1	1	0.22
Coho salmon	0	1	1	0.22
Common carp	0	1	1	0.22
Shorthead redhorse	0	1	1	0.22
Total	57	393	450	100.00

[a]Stomach contents, sex, and maturity.

Table 10.–Catch-per-unit-effort for yellow perch in 10-min trawl hauls and 24-hr, 18-m experimental gill net sets in bays de Noc, 1988-96.

Bay	Year	Number of perch per trawl haul			Number of perch per gill-net lift		
		<90 mm	≥90 mm	All	<178 mm	≥178 mm	All
Little Bay de Noc	1988	35.3	43.1	71.8	15.1	4.8	16.8
	1989	17.7	10.7	21.3	11.0	2.7	12.5
	1990	10.3	18.0	24.0	9.4	1.8	9.8
	1991	33.1	11.3	36.7	6.4	4.3	9.6
	1992	4.3	11.0	13.2	12.6	5.9	16.1
	1993	64.1	17.6	67.1	9.9	1.8	10.5
	1994	9.7	3.2	12.9	14.4	3.2	17.5
	1995	34.3	3.8	28.6	10.8	4.0	12.7
	1996	3.4	0.9	4.2	7.9	0.7	8.6
Big Bay de Noc	1988	34.7	34.0	51.5	3.0	3.0	5.0
	1989	3.5	3.7	3.6	14.9	7.1	20.2
	1990	70.3	12.0	70.4	6.6	4.2	9.7
	1991	205.0	1.5	205.2	8.4	3.8	9.4
	1992	2.9	2.8	3.8	11.6	3.6	13.6
	1993	23.4	1.7	24.0	9.4	2.0	9.5
	1994	141.7	8.5	150.2	3.9	1.9	5.8
	1995	44.1	60.0	52.6	5.2	1.4	5.9
	1996	7.6	27.8	35.2	15.2	2.0	17.2

Table 11.–Diet data from 2,933 yellow perch collected in Little Bay de Noc, 1988-96.

	Observed occurrence in yellow perch stomachs			Length of yellow perch (mm)	
Food category	Frequency	Mean number per fish	Months	Min.	Max.
Crustacea	1,297	31.6	5, 6, 7, 8, 9, 10	28	350
Insecta	879	5.9	5, 6, 7, 8, 9, 10	38	361
Pisces	333	5.4	6, 7, 8, 9, 10	66	361
Hirudinea	66	9.4	6, 7, 8, 9	76	165
Oligochaeta	62	2.5	6, 7, 8, 9, 10	66	198
Pelecypoda	17	3.1	6, 7, 8, 9	76	203
Plant	16	4.9	5, 7, 8, 9, 10	94	201
Gastropoda	9	2.3	6, 7, 9	89	231
Empty	503	0.0	6, 7, 8, 9, 10	33	325
(Details of Pisces category)					
Trout-perch	63	1.3	6, 7, 8	124	277
Alewife	27	1.9	6, 7, 8, 9	142	361
Johnny darter	15	1.5	6, 7	97	211
Yellow perch	13	1.4	7, 8, 9	130	231
Rainbow smelt	12	1.0	6, 7, 8	66	297
Lake herring	7	1.7	6, 8	127	218
Logperch	4	2.5	7	107	185
Spottail shiner	4	1.0	7, 8, 9	216	290
Largemouth bass	1	1.0	6	150	150
Pumpkinseed	1	1.0	7	198	198
Splake	1	1.0	8	165	165
Walleye	1	1.0	7	216	216
Unidentified fish	102	1.4	6, 7, 8, 9, 10	79	340
Eggs	32	43.3	6, 7, 8	74	175

Table 12.–Diet data from 1,946 yellow perch collected in Big Bay de Noc, 1988-96.

Food category	Observed occurrence in yellow perch stomachs			Length of yellow perch (mm)	
	Frequency	Mean number per fish	Months	Min.	Max.
Crustacea	814	14.9	6, 7, 8, 9, 10	38	343
Insecta	539	5.3	6, 7, 8, 9, 10	43	287
Pisces	284	4.4	6, 7, 8, 9, 10	58	328
Oligochaeta	34	3.2	6, 7, 9, 10	79	254
Gastropoda	15	5.7	7, 8, 9, 10	81	300
Plant	15	1.7	6, 7, 8, 9	84	236
Pelecypoda	3	1.0	6, 8, 10	66	160
Hirudinea	1	1.0	9	155	155
Empty	411	0.0	6, 7, 8, 9, 10	56	325
(Details of Pisces category)					
Alewife	69	2.0	6, 7, 8, 9	104	328
Trout-perch	38	1.2	6, 7, 8, 9	152	272
Johnny darter	23	1.8	6, 7, 8, 9, 10	147	246
Brook stickleback	18	1.4	6, 7	145	251
Threespine stickleback	4	1.8	6, 7	117	310
Spottail shiner	3	1.0	8, 9	130	231
Rainbow smelt	2	2.0	6	295	307
Walleye	2	4.5	6	99	198
Yellow perch	2	1.0	7, 8	155	175
Lake herring	1	5.0	8	180	180
Mottled sculpin	1	1.0	8	203	203
Pumpkinseed	1	1.0	9	206	206
Stickleback	1	1.0	6	193	193
Unidentified fish	116	1.5	6, 7, 8, 9, 10	58	328
Eggs	23	31.6	6, 7, 10	89	249

Table 13.–Diet data from 369 walleye collected in Little Bay de Noc, 1988-96.

	Observed occurrence in walleye stomachs			Length of walleye (mm)	
Food category	Frequency	Mean number per fish	Months	Min.	Max.
Pisces	177	1.8	6, 7, 8, 9, 10	51	610
Insecta	36	4.5	5, 6, 7, 8, 9, 10	69	564
Oligochaeta	4	1.0	5, 9, 10	140	371
Crustacea	2	24.5	8, 9	135	183
Empty	124	0.0	5, 6, 7, 8, 9, 10	58	660
(Details of Pisces category)					
Rainbow smelt	40	1.6	6, 7, 8, 9, 10	81	516
Alewife	26	2.0	6, 7, 8, 9	66	572
Yellow perch	10	1.6	6, 7, 8, 9	74	607
Johnny darter	6	1.2	6, 7, 9, 10	150	310
White sucker	4	1.0	6, 7	74	483
Centrarchid	3	1.0	10	165	175
Pumpkinseed	3	2.3	7, 9, 10	155	323
Bluegill	1	1.0	10	173	173
Trout-perch	1	2.0	10	155	155
Unidentified fish	93	1.7	6, 7, 8, 9, 10	51	610

Table 14.–Diet data from 47 walleye collected in Big Bay de Noc, 1988-96.

	Observed occurrence in walleye stomachs			Length of walleye (mm)	
Food category	Frequency	Mean number per fish	Months	Min.	Max.
Pisces	24	2.6	6, 7, 8, 9	196	599
Empty	19	0.0	6, 7, 8, 9	66	592
(Details of Pisces category)					
Alewife	9	3.0	6, 7, 9	312	599
Rainbow smelt	3	2.7	7, 8, 9	312	531
Johnny darter	1	1.0	9	196	196
Unidentified fish	15	1.7	6, 7, 8, 9	211	531

Table 15.–Numbers and lengths of walleye caught at different times of day and night in Michigan waters of Green Bay, 1995-96 (all months combined).

Location	Hours past midnight	N	Percent	Total length (mm)		
				Mean	Minimum	Maximum
Little Bay de Noc	0-3	1	0.9	584	584	584
	3-6	0				
	6-9	14	13.1	455	394	521
	9-12	32	29.9	516	394	818
	12-15	24	22.4	546	411	737
	15-18	15	14.0	508	394	589
	18-21	12	11.2	521	429	655
	21-24	9	8.4	561	470	648
	All	107	99.9	518	394	818
Big Bay de Noc	0-3	2	2.0	597	584	610
	3-6	0				
	6-9	9	9.1	544	437	660
	9-12	28	28.3	526	432	660
	12-15	16	16.2	533	452	599
	15-18	22	22.2	541	427	706
	18-21	13	13.1	556	439	622
	21-24	9	9.1	579	480	724
	All	99	100.0	544	427	724
Cedar River	0-3	0				
	3-6	2	6.7	521	445	597
	6-9	8	26.7	556	500	635
	9-12	7	23.3	490	437	508
	12-15	0				
	15-18	6	20.0	485	452	544
	18-21	5	16.7	493	424	559
	21-24	2	6.7	488	455	521
	All	30	100.1	508	424	635
Menominee River	0-3	2	1.2	526	503	546
	3-6	5	3.1	511	406	653
	6-9	27	16.8	500	394	688
	9-12	28	17.4	513	394	787
	12-15	15	9.3	483	401	648
	15-18	18	11.2	498	414	635
	18-21	40	24.8	511	371	732
	21-24	26	16.1	505	411	599
	All	161	99.9	505	371	787

Table 16.–State of origin for anglers reporting tagged fish caught in Michigan waters of Green Bay, 1988-96.

State	Walleye		Yellow perch	
	Number	Percent	Number	Percent
AL	2	0.1		
AR	2	0.1		
AZ	1	>0.1	1	0.1
CO	1	>0.1		
FL			1	0.1
IA	8	0.4	1	0.1
IL	81	3.6	8	1.0
IN	16	0.7		
KY	4	0.2		
LA	1	>0.1		
MI	1,362	60.7	691	81.9
MN	1	>0.1		
MO	2	0.1		
OH	11	0.5	1	0.1
PA	1	>0.1		
TX	1	>0.1		
WI	584	26.0	65	7.7
WV	1	>0.1		
Unknown	164	7.3	76	9.0

Table 17.–Relative year-class strength of walleye in Little Bay de Noc based on age distributions of fish observed during creel surveys (C) or caught during tagging operations (T), 1985-93. Tag numbers-at-age were adjusted to compensate for unequal numbers of fish tagged each year. Note that walleye were not stocked in Little Bay de Noc in 1991 and 1993, and that the 1992 and 1993 year classes were not fully represented because 4- and/or 5-year old fish were not present in 1996, the last year covered in this report.

Year class	Numbers at age 3 C	Numbers at age 3 T	Numbers at age 4 C	Numbers at age 4 T	Numbers at age 5 C	Numbers at age 5 T	Cumulative numbers (year-class strength) C	Cumulative numbers (year-class strength) T
1985	10,138	941	8,660	947	4,555	774	23,353	2,662
1986	9,353	467	10,510	627	7,562	776	27,425	1,870
1987	15,065	250	15,596	737	2,805	854	33,466	1,841
1988	7,752	297	6,026	589	2,478	721	16,066	1,607
1989	4,987	189	3,556	377	1,979	560	10,522	1,126
1990	2,802	110	3,725	650	11,949	442	18,476	1,202
1991[a]	10,825	387	29,209	465	21,050	691	61,084	1,543
1992	8,630	220	13,868	568	[b]	[b]	31,968	788
1993[a]	1,238	203	[b]	[b]	[b]	[b]	1,238	203

[a]Non-stocking year.
[b]Age-class not present in 1996.

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