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Lake Trout Assessment And Management In Michigan Waters Of Lake Superior, 1988-92

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Abstract.- Five years (1988-92) of lean and siscowet lake trout *Salvelinus namaycush* population data from Michigan waters of Lake Superior are presented and analyzed in this report. Otoliths replaced scales as the principal structure for aging lean lake trout (leans) larger than 23 in and all siscowet lake trout (siscowets). Stocking of hatchery lake trout, which had been curtailed during the 1980s due to disease problems in hatcheries, resumed at pre-disease levels by 1992 (700-800 thousand yearlings per year). Commercial-sized (≥17 in, total length) leans were mostly wild fish (>80%) in all management areas. Abundance, based on number per 1,000 feet of gill net (CPE), was highest in MI-5 (33.1) and lowest in MI-3 (10.0). Abundance of wild leans decreased in MI-2 through MI-6, and remained constant in MI-7 during 1988-92. Abundance of mature-sized (≥25 in, total length) wild leans was highest in MI-2 (5.2) and lowest in MI-3 (1.0). Abundance decreased in MI-2, MI-3, and MI-5, and remained unchanged in MI-4, MI-6, and MI-7. Sea lamprey *Petromyzon marinus* wounding (number of wounds per 100 fish) on mature-sized leans was highest in MI-7 (28.7) and lowest in MI-2 (10.8). Wounding on commercial-sized lake trout in MI-2 through MI-7 increased during 1988-90 then decreased, except in MI-3 where it continued to increase. Average total annual mortality of wild leans exceeded 50% in MI-3 through MI-7, and averaged 49% in MI-7. Growth (as measured by total length of age-7 wild leans) increased in MI-5, decreased in MI-2, and remained unchanged in other areas. Wild lake trout made up 80-90% of leans collected in the pre-recruit assessment during 1988-92. Abundance of pre-recruit (<17 in, total length) wild leans decreased in MI-2, MI-4, and MI-5, remained unchanged in MI-3 and MI-6, and increased in MI-7. Pre-recruit wild leans were most abundant in MI-4 (13.3) and least abundant in MI-7 (2.8). Pre-recruit siscowets increased in abundance in MI-2 and MI-3, were without trend in MI-4 and MI-5, and decreased in MI-6 and MI-7. Abundance of pre-recruit siscowets was highest in MI-3 (14.4) and lowest in MI-7 (2.0). Total annual mortality calculated for leans in the pre-recruit assessment always exceeded 50% and often exceeded 60%, but mortality of siscowets was 30-46%. Sport harvest of lake trout in surveyed management areas (MI-2, MI-4, MI-5, and MI-6) averaged about 27,000 fish each year, with decreasing catches in MI-2 and MI-4 and increasing catches in MI-5 and MI-6. Siscowets made up 1%-43% of the sport harvest among management areas. Tribal commercial fisheries harvested about 307,000 lb (dressed weight) of lean lake trout and 134,000 lb of siscowets annually in Michigan waters. Although wild self-sustaining populations of leans have been re-established in Michigan waters, mortality rates in excess of 50% and decreasing abundance in recent years indicate the need for reduced harvest and/or further reduction of sea lamprey abundance. Assessment-program recommendations are 1) continue current commercial-sized assessment in MI-2 through MI-7 and re-establish the assessment in MI-8; 2) continue current pre-recruit assessment in MI-2 through MI-7 and assess pre-recruits in MI-8; 3) continue current creel survey in MI-2, MI-4, MI-5, and MI-6, and initiate surveys in MI-7 and MI-8; 4) locate and assess siscowet spawning populations; and 5) continue to evaluate otoliths for aging leans and siscowets. Management recommendations are 1) complete update of total allowable catch (TAC) model for best TAC estimates; 2) continue to participate in interagency management of lake trout; 3) negotiate with tribal fisheries agencies to reduce commercial harvest in some areas and to change the status of populations in MI-7 and MI-8 from deferred rehabilitation to rehabilitation; 4) maintain or increase restrictions on the harvest of lean lake trout in state-licensed sport and commercial fisheries; 4) support United States Fish and Wildlife Service efforts to reduce sea lamprey abundance; 5) develop criteria for the discontinuance of stocking of hatchery lake trout; and 6) support strategies to increase survival of hatchery lake trout in areas where stocking is justified.

Restoration of lake trout *Salvelinus namaycush* populations in Lake Superior has been the primary goal of resource agencies since the late 1950s. Stocking hatchery fish, controlling sea lamprey *Petromyzon marinus* abundance, and regulating fisheries have been the major efforts. Hansen et al. (in press) presented a critical assessment of lake trout restoration efforts in Lake Superior from 1959 to 1993. Abundance and biological assessment of commercial-sized (≥17 in, total length) lake trout stocks in Lake Superior was initiated in 1959 (Pycha and King 1975). This assessment has continued on an annual basis and has been complemented with periodic assessments of spawning lake trout since 1973 and pre-recruit (<17 in, total length) lake trout since 1975. Annual assessment of the sport fishery began in 1967 (G. C. Jamsen, Michigan Department of Natural Resources, personal communication). Pycha and King (1975) documented decline of lake trout populations, initial efforts to restore them, and assessment methods used to evaluate restoration in United States waters of Lake Superior during 1950-70. Peck and Schorfhaar (1991) described assessment and management of lake trout in Michigan waters of Lake Superior during 1970-87.

Lean lake trout (leans), siscowet lake trout (siscowets), and humper lake trout (humpers) are the three contemporary varieties of lake trout that exist in Lake Superior (Eschmeyer 1955; Rahrer 1965; Patriarche and Peck 1970; Peck 1975; Burnham-Curtis 1993). Leans are generally the most abundant variety in 40 fathoms (240 feet) and shallower, are preferred by sport and commercial fisheries, and the focus of assessment and restoration efforts by all agencies. Periodic assessments have been done on Michigan's offshore lean populations at Isle Royale (MI-1) and Stannard Rock (MI-5) and are documented by Curtis et al. (in press) and Curtis (1990), respectively, but other lean lake trout populations in offshore waters have not been studied (for example, Big Reef in MI-6). Siscowets are the most abundant variety at depths deeper than 40 fathoms, they have a high fat content (Eschmeyer and Phillips 1965) and the presence of contaminants (chlordane) in their flesh has restricted their use as a food fish in recent years.

There has been little effort made to assess siscowet populations and no efforts directed at restoration. However, siscowets likely benefited from sea lamprey control and restrictions on fishing implemented to restore leans. Humpers are a small slow-growing variety found on isolated reefs around Isle Royale (MI-1) and south of Caribou Island (MI-7) in Michigan waters. Humpers are rarely collected with leans in waters contiguous with Michigan's shoreline, and there has been little information gathered on their populations in the past 20 years.

In this report, we describe lean and siscowet lake trout assessment methods and results in Lake Superior management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 during 1988-92 (Figure 1). We make recommendations for future assessment and management of lean and siscowet lake trout in these waters. We also present data on lake trout stocking since 1978, lake trout sport fishing since 1984, and tribal commercial fishing during 1988-92. No lake trout assessment has been done in MI-8 since 1985, but data on stocking and tribal commercial harvest are presented. Lake trout restoration in MI-7 and MI-8 has been deferred under terms of the Agreement for Entry of Consent Order signed in March 1985 (1985 Negotiated Settlement) by representatives of Chippewa-Ottawa tribes included in an 1836 treaty, United States Fish and Wildlife Service (USFWS), and Michigan Department of Natural Resources (MIDNR). Lake Superior waters included in the 1836 treaty were all Michigan waters east of a line north from the mouth of the Chocolay River in MI-5 (Figure 1). The 1836-treaty portion of MI-5 and that portion of MI-6 west of Grand Island were designated as a primary lake trout rehabilitation area where commercial catch of lake trout was prohibited, but sport harvest was allowed. The area of MI-6 east of Munising was also designated as a primary lake trout rehabilitation area where sport harvest was allowed and one tribal gill-net fishery was permitted until 1990. All Michigan waters west of the treaty line in Figure 1 are included in the 1842 treaty, and lake trout harvest is allowed in the state-licensed sport fishery and tribal commercial and subsistence fisheries.

Methods

Most data described in this report are those collected and analyzed by the MIDNR, but commercial-sized assessment data in MI-2 were collected and analyzed by the Red Cliff Fisheries Department, Bayfield, Wisconsin, and some analyses on data from this and other management areas were performed by personnel from the U.S. Department of the Interior, National Biological Survey (NBS) in Ashland, Wisconsin and Ann Arbor, Michigan; the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Odanah, Wisconsin; and the Chippewa/Ottawa Treaty Fisheries Management Authority (COTFMA), Sault Ste. Marie, Michigan.

Assessment data presented in this report were collected at sites in MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 (Figures 2-7). Management areas presented in this report generally follow the boundaries of statistical districts described by Hile (1962). Exceptions were that statistical districts MS-3 and MS-4 were divided into two areas (MS-3 = MI-3 and MI-4; MS-4 = MI-5 and MI-6), and boundaries have been altered to encompass contemporary fishing grounds and to follow grid boundaries within Michigan waters. Grids are numbered squares bounded by 10 minutes of longitude and latitude (Figures 2-7) and are used to further subdivide management areas and statistical districts. Management areas MI-4, MI-5, and MI-6 have been subdivided into stations which represent former commercial fishing grounds. In MI-4, assessment netting sites in grids 1026, 1125, and 1126 make up Bete Grise station, sites in grid 1224 represent Traverse Island station, sites in grid 1323 are the Lower Entry station, and sites in grid 1325 represent Point Abbaye station (Figure 4). In MI-5, the assessment netting site in grid 1327 represents the Big Bay station, and sites in grids 1429, 1529, and 1530 make up Marquette station (Figure 5). In MI-6, netting sites in grids 1632 and 1533 make up Munising-west station, and sites in 1534 and 1535 make up Munising-east station (Figure 6). Management areas MI-2, MI-3, and MI-7 have not been subdivided into stations. Although most data presented in this report are presented by management area, some are presented for stations in areas MI-4, MI-5, and MI-6.

Commercial-sized and Pre-recruit Assessments

Marquette Fisheries Station assessed commercial-sized lake trout annually in MI-3, MI-4, MI-5, MI-6, and MI-7 during a 5-6 week period beginning as early as 23 April and ending as late as 11 June during 1988-92. Red Cliff Fisheries Department personnel did the commercial-sized assessment in MI-2 during the last week of April through first week of June during 1988-92 (Gallinat 1988; 1990; 1991; 1992a; 1992b). Abundance of lake trout (CPE), sea lamprey wounding, and mean total length of age-7 wild leans from the assessment in MI-2 are presented in this report. Assessment fishing was usually done under permits issued to state-licensed commercial fishers whose payment for fishing was the catch of lake trout which they could sell to wholesale or retail markets. Marquette Fisheries Station personnel accompanied these fishers and collected data from lake trout. However, the 1985 Negotiated Settlement eliminated state-licensed commercial fishing in MI-7, a dispute between the assessment commercial fisher and MIDNR resulted in no permit being issued in MI-6 in 1990, and decreased lake trout abundance was the basis for refusal by the state-licensed commercial fisher to do the assessments in MI-3 and MI-4 in 1992. As a consequence, assessments were done by Marquette Fisheries Station vessel and crew in MI-7 during 1988-91, in MI-6 in 1990, and in MI-3 and MI-4 in 1992. No assessment of commercial-sized lake trout was done in MI-7 in 1992 because MI-3 and MI-4 were determined to be of higher priority.

Assessment data were obtained from the catch in approximately 72-h (3-night) sets of one or two joined 1,500-ft gangs of 4.5-in stretch-measure multi-filament nylon mesh gill nets fished at depths of 20-40 fathoms. Sets were made until a quota of leans was captured or a quota of gear was fished at each station. Fish quotas were 500 leans per station during most of the 1970s and 1980s (Peck and Schorfhaar 1991). The 500-fish quota was continued into the 1988-92 period, but was not reached during the annual assessment period in MI-3 and MI-7 because of decreased abundance of lake trout. No quota was set on siscowets because they were not the targeted variety, and they were always less abundant than leans in the assessment. Assessment of leans was modified in MI-4 and MI-6 in 1990 based on recommendations presented in Peck and Schorfhaar (1991). In MI-4, the netting sites in grid 1323 representing the Lower Entry station (Figure 4) were not fished after 1989 because we judged that an adequate assessment could be obtained from the remaining three stations (Bete Grise, Traverse Island, Point Abbaye). This decreased the quota of leans in MI-4 from 2,000 to 1,500 fish. In MI-6, netting sites that had previously represented one station (Munising) were assigned to two stations after 1989, with sites west of Grand Island represented one station (Munising-west) and sites east of Grand Island representing the other (Munising-east) (Figure 6). This was because abundance of lake trout, wounding by sea lamprey, and fishing effort were different in the two areas, and dividing the area into two stations would provide for easier data analysis in case the two areas were to be managed separately. Number and location of netting sites did not change, but the 400-fish quota set for the two new stations increased the quota of leans in MI-6 from 500 to 800 fish.

Data collected for hatchery and wild leans from each 1,500-ft gang of nets included number of commercial-sized hatchery and wild leans, total length, sex, maturity, fin clip, and number and classification of sea lamprey marks. Otoliths and/or scales were collected from each fish for subsequent age determination. Similar data were obtained for siscowets, but these data have not been analyzed because siscowets have not been the focus of commercial-sized assessment. Individual total weights were obtained for 100 net-run leans from each of MI-3 through MI-7 in 1989 and 1991. Total dressed weight of leans and total dressed weight of siscowets from each 1,500-ft gang were recorded. These weight data were used in reports of total lake trout harvest, or to estimate weight of individual lake trout in those years when individual weights were not sampled. Stomach contents of a quota of 100 leans and 100 siscowets were examined and recorded in situ, and these data provided to the NBS, Ashland, Wisconsin.

Sea lamprey wounding is presented for the spring assessment of commercial-sized leans. Sea lamprey attack marks were classified according to King and Edsall (1979) with marks A1, A2, and A3 designated as wounds and reported as wounds per 100 lake trout (Eshenroder and Koonce 1984). These wounding data have provided the best means of estimating lake trout mortality due to sea lamprey in Lake Superior (Pycha 1980; Ebener et al. 1989b). Wounding is presented for the total commercial-sized sample, by 4-in size groups, and for mature-sized fish as a group to compare wounding among management areas and to illustrate the size-selective nature of sea lamprey predation.

Pre-recruit lake trout were assessed with 1,800-ft gangs of multi-filament nylon gradedmesh gill net (300-ft panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-in stretch-measure mesh) fished approximately 24 h (1 night) at depths of 15-40 fathoms at 25 sites in MI-2 through MI-7 during 1988-92 (Figures. 2-7). The assessment was conducted during the last week of July through the fourth week of August. This assessment was classified as a pre-recruit assessment because most lake trout captured in these small-mesh nets were less than 17 in long. Lake trout of this size were infrequently taken in the sport fishery or in 4.5in and larger mesh gill nets generally used in the tribal commercial fishery, and therefore were considered to be pre-recruits. In each 1,800-ft gang, the number of leans and siscowets were recorded as well as total length, sex, maturity, fin clip, and number and classification of sea lamprey marks. For age analysis, a scale sample was collected from all leans and siscowets, and otoliths were collected from leans 23 in total length and longer and from all siscowets. Individual total weights were collected from 50 net-run leans and 50 net-run siscowets per management area in 1990 and 1991.

In commercial-sized and pre-recruit assessments, number of lake trout per 1,000 ft of gill net (CPE) was assumed to be an index of relative abundance to evaluate trends over years and differences among management areas. This assumption is believed to provide a valid comparison among years in each management area because sampling was conducted the same way at the same sites each year. Comparisons of abundance among management areas were also based on the assumption that standardization of sampling conduct, distribution of netting sites, and level of netting effort provided an adequate representation of abundance in each area. The CPE of leans was calculated by origin (hatchery or wild) in both assessments, for mature-sized fish (≥25 in, total length) in the commercial-sized assessment, and for pre-recruit-sized fish in the pre-recruit assessment. The CPE of all siscowets and pre-recruit siscowets was calculated in the pre-recruit assessment.

Age of lake trout collected during the 1988-92 assessments was determined from scales and otoliths. Fin clips were used to verify scale or otolith ages of the hatchery fish in the assessment catches. Scales were determined to be suitable for aging young leans, but leans older than age 8 were apparently not growing sufficiently to form annuli on the scales (Johnson and MacCallum 1987). Lake trout growth slowed during the 1980s, which may have been due to increased age and abundance of wild lake trout and a decline in abundance of forage fish (Hansen 1990). It was the consensus of the Lake Superior Technical Committee (see Peck and Schorfhaar 1991 for a description of this committee) that otoliths (sagitta) should be used to age leans 23 in and larger, a size that would include most fish older than age 8. This protocol was followed in determining age of leans in most of the commercial-sized and pre-recruit catches during 1988-92. Age of leans and siscowets was determined from both scales and otoliths in the pre-recruit assessment in 1990 and commercial-sized assessment at Marquette in MI-5 during 1992. In these samples, age compositions determined from scales and from otoliths and mortality rates estimated from these age compositions were compared. To determine age from scales, acetate impressions of scales were made with a roller press and magnified on a micro-projector to facilitate counting of annuli. Annuli were identified based on criteria presented in Lagler (1956). Two methods were used to prepare otoliths for age determination during 1988-92. In 1988, otoliths were prepared by breaking the otolith along the transverse plane and applying a flame to the exposed surface to highlight the annuli ("crack and burn" method), but timing the burn in this method was difficult and some otoliths were destroyed when burned too long. In 1989, Marquette Fisheries Station personnel found that soaking whole otoliths in mineral oil for a few minutes highlighted the translucent and opaque zones on most otoliths, and that polishing on a fine grit paper was sufficient to highlight these zones on most of the remainder. Otoliths were then examined under a dissecting microscope at 10X power and the number of translucent zones counted as annuli. Since 1989, Marquette Fisheries Station personnel have used this "oil-soak of whole otoliths" method for determining age of leans 23 in and larger and all siscowets.

Total annual mortality rates were estimated using the method described by Robson and Chapman (1961) for wild and hatchery leans and siscowets in age groups that were considered to be fully vulnerable to assessment nets. Age-9 and older leans were considered to be fully vulnerable to the 4.5-in mesh used in the commercial-sized assessment. Age 6 and older or age 7 and older were used to estimate total annual mortality of wild leans in the pre-recruit assessment, and ages 11 and older were used to estimate mortality of siscowets in the pre-recruit assessment.

Stocking

Thousands of hatchery lake trout have been stocked annually in Michigan waters of Lake Superior (Table 1). All stocked lake trout are leans. Stocked leans are supposed to be fin-clipped, but some regeneration of fins and missed clips do occur. The percentage of stocked lake trout that have not been clipped has been low. Only 1-4% of the lake trout in assessment samples in Michigan waters during 1967-70 were not clipped (Pycha and King 1975) and some of these could have been wild. Most hatchery lake trout were stocked as yearlings, but a few (<10%) were stocked as fall fingerlings. Pycha and King (1967) determined that survival of yearlings was better than that of fingerlings, and survival in general was related to size of the stocked fish. In a previous report (Peck and Schorfhaar 1991), numbers of stocked fall fingerlings were converted to yearlings equivalents based on a survival rate of 55% determined by NBS personnel at Ashland, Wisconsin (unpublished data). However, recent unpublished studies by the Wisconsin Department of Natural Resources in Bayfield, Wisconsin have indicated that survival of stocked fall fingerlings to yearling in recent years has been 25% or less. In this report, numbers of fall fingerlings have been converted to yearling equivalents based on the 25% survival rate (Table 1). Few fall fingerlings have been stocked in recent years because of this reported low survival rate. Since 1986, the only management area receiving fall fingerlings has been MI-8 because stocking 150,000 fingerlings was specified in the 1985 Negotiated Settlement.

Sport Fishery

Lake trout sport catch in 1984-92 (Table 2) was assessed with a stratified-random, on-site creel survey conducted year-round in MI-5 during 1984-87 (Peck 1992), and during May-October in MI-2 and February-October in MI-4, MI-5, and MI-6 in 1988-92, except that only February and March in MI-4 were surveyed in 1989 (Rakoczy and Rogers 1988a; Rakoczy and Rogers 1988b; Rakoczy 1992; Charlevoix Fisheries Station, unpublished data). Requirement of mandatory reports of total catch by the charter-boat fishery was initiated in 1989, but full compliance was not established until 1990. Lake trout sport catch presented in Table 2 does not include catch by charter boats.

Commercial Fishery

Commercial catch of leans and siscowets by Chippewa-Ottawa tribal fishers operating under 1836 and 1842 treaties during 1988-92 is presented in Table 3. Tribal catch data for leans in each management area were obtained from unpublished lake trout extraction reports presented in minutes of the Great Lakes Fishery Commission Lake Superior Committee meetings held annually in March, 1989-93. Siscowet catch data were from GLIFWC administrative reports (Ebener et al. 1989a; Ebener et al. 1990; Shively et al. 1992a; Shively et al. 1992b; Shively et al. 1993), and from COTFMA (unpublished data). Lake trout catch in tribal subsistence fisheries are not well known and not included in Table 3.

Results

Commercial-sized Assessment

Abundance (CPE) of hatchery leans decreased in MI-3, MI-4, and MI-7, was variable without trend in MI-2 and MI-6, and increased in

MI-5 during 1988-92 (Table 4). Hatchery lean CPEs averaged highest in MI-2 (4.1) and lowest in MI-7 (1.0). Abundance of wild leans decreased in MI-2, MI-3, MI-5, and MI-6, and was variable without trend in MI-4 and MI-7 (Table 4). Wild lean CPEs averaged highest in MI-5 (33.1) and lowest in MI-3 (10.0). The CPE of mature-sized wild leans decreased in MI-2, MI-3, and MI-5, was variable without trend in MI-6 and MI-7, and increased slightly in MI-4. Mature-sized CPE averaged highest in MI-2 (5.2) and lowest in MI-3 (1.0). Percentage of wild leans in the assessment ranged from 82% (MI-5 in 1992) to 96% (MI-7 in 1990 and 1991), and averaged 88-93% in all areas during 1988-92 (Table 4). Percentage of wild leans decreased in MI-5, increased in MI-7, and was without trend elsewhere.

Examination of 1988-92 wild lean CPEs at individual stations presents a somewhat variable picture of abundance trends in MI-4 and MI-6, but not in MI-5. In MI-4, CPE decreased at Bete Grise since 1988, but at Traverse Island and Point Abbaye it increased during 1988-90 then decreased (Figure 8). In MI-6, CPE decreased from 52 to less than 30 at Munising-west during 1988-92, but remained fairly constant around 12 at Munising-east (Figure 9). In MI-5, CPE decreased from about 40-50 to less than 30 at both Big Bay and Marquette (Figure 10).

Sea lamprey wounding on commercial-sized leans increased in all areas between 1988 and 1989, except MI-2 where there was no trend (Table 4). In 1990-92, wounding decreased in MI-5 and MI-6, fluctuated without trend in MI-2, MI-4, and MI-7, and increased in MI-3. Wounding averaged highest in MI-7 (11.1) and lowest in MI-4 (3.9). Wounding in all areas exhibited the characteristic increase with increased fish size. Wounding on mature-sized leans increased during 1988-90 then decreased during 1991-92 in all areas except MI-3. In MI-3, wounding on mature-sized leans peaked at 38.5 in 1992. Wounding on mature-sized leans ranged from 0.0 in MI-5 in 1988 to 51.0 in MI-7 in 1990, and averaged highest in MI-7 (28.7) and lowest in MI-2 (10.8). Wounding on mature-sized leans at individual stations in MI-4, MI-5, and MI-6 generally followed the trends for wounding in the management area, except that wounding on mature-sized leans at Traverse Island in MI-4 did not decrease after 1990 (Figures 8-10).

Wild leans in MI-3 through MI-7 ranged in age from 4 to 26 years, with modal ages of 7-9 among areas and years (Tables 5-9). Age composition of wild leans in MI-3 was the oldest among management areas, with a modal age of 9 in three of the five years and a mean age of 8.7 years (Table 5). Total annual mortality estimated for age-9 and older wild leans in MI-3 ranged from 53% in 1989 to 63% in 1991. In MI-4, modal age of wild leans was 7 all years except 1989, and mean age was 8.0 with a range of 7.5 to 8.0 (Table 6). Total annual mortality of wild leans in MI-4 ranged from 54% in 1989 to 60% in 1990. In MI-5, modal age of wild leans ranged from age 9 in 1988 to age 7 in 1991 and 1992 (Table 7). Mean age was 7.9 with a range of 7.2 to 8.5. Total annual mortality of wild leans in MI-5 ranged from 42% in 1992 to 62% in 1990. In MI-6, modal age of wild leans ranged from age 9 in 1989 to age 7 in 1992, and mean age ranged from 9.1 in 1989 to 7.8 in 1990 and averaged 8.0 for 1989-92 (Table 8). Total mortality rate of wild leans ranged from 49% in 1992 to 58% in 1990. The number of wild leans aged in the 1988 catch in MI-6 was insufficient to determine age composition and mortality. In MI-7, modal age of wild leans ranged from age 9 in 1989 to age 7 by 1991 (Table 9). Mean age ranged from 9.0 in 1989 to 7.6 in 1991 and averaged 8.3 years for 1988-91. Total mortality of wild leans in MI-7 ranged from 44% in 1988 to 58% in 1990.

Age composition and mortality estimates for commercial-sized wild leans in all areas were affected somewhat by the increased use of otoliths for aging during 1988-92, so trends in these parameters may not be valid. Only scales were used to age fish in 1988 resulting in age distribution which truncated at age 12 or 13. Otoliths were used to age some fish 23 in and larger in 1989 and all fish of at least this size in 1990-92. The use of otoliths likely did not affect the modal age, but did result in an older age composition. Use of otoliths typically shifted some fish into younger age groups, but shifted many more into older age groups which resulted in higher mean age and lower estimated mortality rates. This is exemplified by data for the Marquette station in MI-5 in 1992 where all fish in the sample were aged by both scales and otoliths (Figure 11). The modal age was age 7 regardless of the structure used for aging, but mean age was 7.5±0.1 from scales and 8.1±0.2 from otoliths. The mortality rate of age-8 fish and older was 0.73±0.05 from scales, 0.40±0.04 from otoliths, and 0.51±0.05 from the combination of scales otoliths used elsewhere in 1992 (scales from fish 17- to 22-in long and otoliths from fish 23 in and longer).

Numbers of hatchery leans were too few to evaluate age composition and mortality on a management area basis, so annual catches in MI-3 through MI-7 were combined. Hatchery leans ranged in age from 2 to 24, but most were ages 4-12 (Table 10). Modal age was 7 in 1988 and 1991, and 8 in 1989, 1990, and 1992. Mean age ranged from 8.2 in 1989 to 6.7 in 1992. The effect of number stocked on age composition was illustrated by meager numbers of the 1983 year class stocked in 1984. Total annual mortality rate estimates were based on numbers in ages 8-15 adjusted with a multiplication factor which equated all year classes on the basis of number of yearlings stocked in Michigan waters (Table 1). For example, age 8 in 1992 represented the 1984 year class which was the most numerous year class stocked (1,745,000 yearlings stocked in 1985). This year class was assigned a factor of 1.00 and its representation in the age composition did not change. Far fewer of the 1983 year class were stocked (484,000 stocked in 1984), so the age 9 representation was increased by a factor of 3.61 (1,745,000,484,000). Older year classes were likewise adjusted by their number stocked compared to the 1984 year class. Total annual mortality of hatchery leans increased from 39% in 1988 to 60% in 1992. Validity of these mortality rates depends on the validity of our adjustment of age composition based on number stocked.

Mean total length of age-7 wild leans ranged from 19.0 in MI-3 to 22.5 in MI-2 during 1988-92 (Table 4). Mean length decreased in MI-2 from 22.5 to 20.9, increased in MI-5 from 20.9 to 21.5, and fluctuated slightly without trend in other areas. In 1992, mean total length of wild leans ranged from 20.4 in in MI-4 to 21.5 in in MI-5. Mean total length of age-7 hatchery leans in the combined sample from all management areas decreased from 22.3±0.7 in 1988 to 21.4±0.5 in 1992.

Wild and hatchery leans sampled for weight and length in 1991 were smaller than those sampled in 1989, but weight-length slope coefficients indicated that they may be more robust (Table 11). Mean weight and length for the combined sample from all management areas were 3.68 lb and 22.0 in in 1989, and 3.17 lb and 21.3 in in 1991. Mean weight and length were similar among management areas in 1989, but the means of 3.73 lb and 22.3 in for MI-7 in 1991 were larger than those for other areas in 1991. Slope and intercept weight-length coefficients calculated for the 1991 sample (-8.5413, 3.1565) were larger than those calculated for the 1989 sample (-7.9676 and 2.9805). There were no differences in weight-length coefficients among management areas in either year.

Efforts to develop a model to estimate total allowable catches (TACs) continued during 1988-92. Mark Ebener of the Inter-Tribal Fisheries Assessment Unit, COTFMA, has been the primary architect of this model, a preliminary version of which is described in Ebener et al. (1989b). The model estimates stock size, harvest, and number of mature females for cohorts of wild and hatchery lake trout in individual management areas. Average TACs (number of fish) calculated for 1990-94 were: MI-2 = 10,400; MI-3 = 7,600; MI-4 = 53,400; and MI-5 = 15,700 (Ebener et al. 1989b). According to Ebener et al. (1989b), the model simulated lake trout populations well in all areas except MI-5. A TAC of 8,300 fish was also calculated for MI-6, but none were calculated for MI-7 and MI-8 because both were deferred rehabilitation areas and data were lacking for MI-8. Work on this model since 1989 has been to increase and update the data base with area-specific input for years prior to 1984, and contemporary estimates of age, growth, and mortality based on otolith ages for fish 23 in and larger.

Pre-recruit Assessment

Wild leans made up around 90% of the lean catch in all areas, except in MI-5 where the contribution was closer to 80% (Table 12). Abundance of pre-recruit (<17 in), wild leans decreased in MI-2, MI-4, and MI-5, was variable without trend in MI-3 and MI-6, and increased in MI-7. Average CPE for pre-recruit wild leans was highest in MI-4 (13.3) and lowest in MI-7 (2.8). Average CPE for pre-recruit hatchery leans was highest in MI-5 (1.6) and lowest in MI-7 (0.1). Siscowet CPEs increased in MI-2 and MI-3 during 1988-92, but were variable and without trend in other areas (Table 12). Siscowet CPEs averaged highest in MI-3 (14.4) and lowest in MI-7 (2.0). Pre-recruit siscowet CPEs also increased in MI-2 and MI-3, were variable without trend in MI-4 and MI-5, but decreased in MI-6 and MI-7 during 1988-92. They averaged highest in MI-3 (8.4) and lowest in MI-7 (0.4).

Age and mortality data for leans in the pre-recruit assessment in 1988-92 should not have been affected by changes in aging methodology, because scales were the primary structure used for determining age. For wild leans, no age-1 fish were captured and age-2 fish were caught only in MI-4, so essentially the age composition was age-3 and older fish with modal age generally age 6 or 7 (Tables 13-18). Few wild leans older than age 8 were captured in the pre-recruit assessment, but the oldest fish was 23 years. Total annual mortality rates estimated for wild leans were quite high with most in excess of 50% and many exceeding 60% (Tables 13-18). Mortality rates decreased in MI-2 and MI-6, but were variable and without trend in other areas. Wild leans mean lengths-at-age for age groups 4-8 were generally less in 1992 than in 1988 or 1989 in all areas, although confidence intervals overlapped in most instances.

The age composition of hatchery leans was based on the combined sample from MI-2 through MI-7 each year during 1988-92. Age composition was mainly ages 3-8, but fish as young as age 2 were common and the oldest fish was age 20 (Table 19). The most-abundantly stocked 1984 year class was modal from 1988 (as age 4) through 1991 (as age 7), and the least-abundantly stocked 1983 year class had a correspondingly poor representation during this period. There was no trend in mean length for any age of hatchery leans during 1988-92. Hatchery leans in ages 5 and younger averaged heavier than wild leans of corresponding ages, but this difference was not significant (Table 20). Small numbers of hatchery fish even in the combined samples resulted in wide overlapping confidence intervals.

Age was not determined for siscowets in the pre-recruit assessment until the 1990s, and then not for all samples until 1992. Ages determined from limited otolith collections in 1990 and 1991 indicated that otoliths provided a much older age distribution than scales (Figure 12). Over 50% of the siscowets sampled in 1992 were ages 8-11, but some were as young as age 4 and as old as age 25 (Table 21). Mean age of siscowets ranged from 9.8 in MI-3 and MI-5 to 10.6 in MI-4. Total annual mortality rates ranged from 30% in MI-2 to 46% in MI-3. Too few siscowets were captured in MI-6 and MI-7 for an adequate assessment of age composition and mortality. Mean total length-at-age of siscowets appeared to be greater in MI-3 than in MI-5, but confidence intervals overlapped for most ages (Table 22).

Mean weights and mean lengths of leans (wild and hatchery combined) and those of siscowets were not different among years 1989-91 (Table 23). Weight-length intercept and slope coefficients for leans ranged from -8.3057 to -8.8500 and from 3.0882 to 3.2798, and there were no trends among years. Weight-length intercept and slope coefficients for siscowets increased from -8.6660 to -9.1000 and from 3.2451 to 3.3720 between 1989 and 1991, but the increase was not significant. Siscowet mean weight, mean length, and weight-length coefficients were consistently higher than those for leans, but significantly so only in 1991.

Stocking

The average number of hatchery yearling leans stocked annually in Michigan management areas ranged from 15,000 in MI-7 to 230,000 in MI-5 during 1978-92 (Table 1). These two areas were likewise lowest and highest in terms of number per square mile of lean lake trout habitat.

Numbers of 1981-91 year classes stocked in Michigan waters fluctuated considerably during the 1980s, reflecting the outbreak and subsequent elimination of Epithelial Epizootic Disease (EED) in state and federal hatcheries. Prophylactic measures eliminated EED from state and federal hatcheries, and stocking increased to between 700,000 and 800,000 yearlings 1992. In MI-2, stocking averaged 105,000 per year with, a high of 279,000 in 1985 and no stocking in 1984, 1987, and 1990. In MI-3, stocking averaged 21,000 during 1978-92, with none stocked since 1986. In MI-4, number of yearlings stocked averaged 187,000, with a high of 436,000 in 1985 and none stocked in 1990. The highest number of lake trout stocked in any management area was in MI-5 which averaged 230,000 and ranged from 460,000 in 1985 to none in 1990. Stocking was especially high in MI-5 on the basis of lean habitat, being more than twice as high (787/mi^2) as the second-place area (360/mi^2 in MI-6). The number of yearlings stocked in MI-6 averaged 104,000 and ranged from 298,000 in 1985 to none in 1990. Stocking in MI-7 was at a consistent and low level during 1978-85, but was discontinued after 1985 as a result of the 1985 Negotiated Settlement which deferred lake trout rehabilitation in this area. Lake trout have been stocked in MI-8 every year except 1988 with an average of 69,000 yearlings per year. This management area was also designated as a deferred lake trout rehabilitation area, but the 1985 Negotiated Settlement mandated that 150,000 fingerlings (38,000 yearling equivalents) be stocked annually.

Sport Fishery

Sport harvest of lake trout estimated by creel-survey in MI-2, MI-4, MI-5, and MI-6 increased from about 10,000 fish in 1984 to over 32,000 fish in 1992 (Table 2). Some of this increase can be explained by expansion of the area surveyed in MI-6, but an increase in CPE in MI-5 and MI-6 may also be a factor. The sport catch in 1988-92 fluctuated without trend between 16,500 and 34,400 fish annually, with an average catch of about 27,000 fish. Increases in lake trout sport catch in MI-5 and MI-6 were offset by decreases in MI-2 and MI-4 during 1988-92. Increased catch in MI-6 was largely due to the addition of a new survey site (AuTrain Bay) in 1991 which increased estimated catch by 2,000-4,000 fish and effort by 15,000-19,000 angler hours annually (Rakoczy 1992). Although lake trout CPE in MI-2 and MI-4 decreased in recent years, CPE in MI-5 and MI-6 increased. Decreased CPE in MI-2 probably indicates a decrease in abundance, because the fishery is mainly during open-water months and these months have been surveyed each year. In MI-4, winter creel surveys have been conducted during years when ice has formed on Keweenaw and Huron bays, and lake trout CPE has been higher in the winter ice fishery than in the summer open-water fishery (Rakoczy 1992). Data for winter and summer fishing has been combined in Table 2, but importance of winter fishing in MI-4 is indicated by low catch and CPE in 1987 when warm weather prohibited an ice fishery, compared with a high catch and CPE 1989 when only the ice fishery was surveyed. Mean dressed weight of lake trout in the sport catch was consistently around 3 lb in MI-2, MI-5, and MI-6 during 1988-92. However in MI-4, lake trout averaged smaller at about 1.75 lb. Based on these mean weights, the 1992 combined sport harvest of lake trout would have been around 90,000 lb dressed weight.

The lake trout sport catch reported for 1988-92 (Table 2) included siscowets. Efforts to assess the siscowet component of the sport catch began in 1989 in MI-4 and was expanded to other areas by 1991. It was found that siscowets contributed substantial numbers to the sport catch in MI-2 (17%) and MI-4 (43%), but not in MI-5 and MI-6 (1-2%).

The lake trout sport catch presented in Table 2 includes harvest by charter boats in surveyed areas during 1988-89, but not in 1990-92. Lake trout catch by charter boats in Michigan waters of Lake Superior ranged between 6,000 and 7,000 fish annually during 1990-92, with most of the catch (around 5,000 fish annually) coming from MI-1 (Isle Royale), MI-2, and MI-5 (Rakoczy and Rogers 1991; Rakoczy and Rogers 1992; Rakoczy and Svoboda 1993).

Tribal Commercial Fishery

Tribal commercial harvest of leans decreased in MI-2 through MI-8 during 1988-92, with annual catches over 300,000 lb in 1988-90 and under 300,000 lb in 1991-92 (Table 3). The tribal catch was highest MI-4 and lowest in MI-5. Siscowets were also harvested in tribal fisheries, and this catch increased from just under 100,000 lb in 1988 to just under 200,000 lb in 1992. The harvest of siscowets exceeded that of leans in MI-3, but was highest in MI-4 at 80,000 lb per year.

Discussion

Lean lake trout populations in most of Michigan inshore waters during 1988-92 were essentially wild, self-sustaining, and the most abundant in U. S. waters of Lake Superior, but these populations have not been fully restored and there are some potential impediments to further restoration. Abundance of wild leans increased during the 1970s and mid-1980s to nearly 80% of the abundance of native stocks present in 1929-43, but then decreased to 60% of that abundance by 1993 (Hansen et al. in press). Abundance of wild leans increased despite an established sport fishery and increasing tribal commercial fishery, but the subsequent decrease was most severe in those areas with the greatest amount of commercial fishing (Peck and Schorfhaar 1991, Hansen et al. in press). Despite this recent decrease, abundance of wild leans in Michigan in 1992 was about twice as high as abundance in Wisconsin and Minnesota (Hansen et al. 1994b; Hansen et al. in press).

Decreased abundance of mature-sized leans documented in the commercial-sized assessment in Michigan management areas very likely represents a serious impediment to restoration. Abundance of mature-sized fish increased to their maximum abundance in the 1970s, then decreased to less than 10% of this abundance by 1987 (Peck and Schorfhaar 1991). Abundance of mature-sized fish during 1988-92 remained near the low 1987 levels, but continued to decrease slightly in some areas. Hatchery lake trout made up most of the mature-sized population in the 1970s and early 1980s, so the major decrease coincided with decreased abundance of hatchery fish. Most mature-sized leans were wild fish by the mid 1980s, but this increased representation of wild fish was insufficient to reverse decreasing abundance of mature-sized fish. It is possible that a smaller proportion of these wild populations were reaching mature size due to decreased growth and increased mortality. Growth of wild leans decreased in Michigan waters during the 1980s (Hansen et al. 1994b), which could have slowed recruitment to mature size even though abundance of commercial-sized fish was increasing. Slower growing fish would be exposed to fishing and sea lamprey for a greater length of time before reaching 25 in. Total annual mortality in Michigan waters decreased from around 70% to near 50% between 1975 and 1981, then increased to over 60% between 1981 and 1985 (Hansen et al. 1994b). Mortality of mature-sized leans due to sea lamprey predation was very likely higher during 1988-92 than in the previous 5-year period, because wounding by sea lamprey was higher (Peck and Schorfhaar 1991). Pycha (1980) found that lake trout mortality was directly related to wounding. Mortality due to fishing was also likely greater in 1988-92 than in the previous 5-years. In 1842 treaty-ceded waters (MI-2, MI-3, MI-4, and western MI-5), lake trout harvest and fishing effort by tribal fishers was greater in 1988-92 than during 1983-87 (Ebener et al. 1989a; Ebener et al. 1990; Peck and Schorfhaar 1991; Shively et al. 1992a; Shively et al. 1992b; Shively et al. 1993; COTFMA, unpublished data). Effort increased from about 4 million feet in 1984 to over 12 million feet in 1990. In 1836 treaty-ceded waters, lake trout harvest was likewise greater in 1988-92 than in 1983-87 (Peck and Schorfhaar 1991, COTFMA, unpublished). Decreased abundance of pre-recruit lake trout in MI-4 and MI-5 does not bode well for future abundance of mature fish in these areas unless mortality can be significantly reduced.

Total mortality rates estimated for wild lean lake trout in the pre-recruit assessment were generally higher than those estimated in the commercial-sized assessment, and we suspect they may not be accurate. Total mortality rates for pre-recruit fish should not be higher because most fish in this assessment were too big to be preyed on by other fish and too small to be affected by fishing and sea lamprey predation. On the other hand, some of older fish in the pre-recruit assessment were commercial-sized. It is possible that fishing and sea lamprey predation on these larger fish affected a truncation of the age distribution which resulted in high mortality rate estimates. Our use of 3.5-in and smaller mesh sizes also could caused truncation of the age distribution.

After many years of doubt and controversy, the positive role of hatchery leans in the restoration of wild lean populations in inshore waters of Lake Superior has been established. But how could these poorly-imprinted, reproductively-inefficient, and "just plain dumb" hatchery fish possibly contribute anything to restoration of wild lake trout populations, let alone be a major component of restoration? Hansen et al. (in press) determined that hatchery lake trout were reproductively inefficient based on calculated stock-recruitment regression coefficients that were less than one. This indicated that individual pairs of hatchery parents were unable to replace themselves. Krueger et al. (1986) suspected that reproductive inefficiency of hatchery fish was due to their inability to locate suitable spawning micro-habitat on reefs. However, hatchery leans in Michigan inshore waters were able to overcome this inefficiency, because intensive stocking and protective regulations allowed them to reach densities during the late 1960s and 1970s that were much higher than former densities of self-sustaining native lake trout (Hansen et al. in press). Hatchery leans, not encumbered by imprinting, appeared to have some capabilities when it came to selecting suitable spawning substrate (Peck 1986; Marsden and Krueger 1991). Enough wild progeny from these high spawner densities survived to establish wild self-sustaining populations. Abundance of spawning leans on reefs in Michigan was less in the 1980s and 1990s than in the 1970s, but the composition changed from mostly hatchery fish to mostly wild fish (Peck and Schorfhaar 1991; Ebener 1990; Hansen et al. in press). Although abundance of these new mature-sized wild populations decreased to less than 10% of their hatchery parents by 1987, they were apparently much more reproductively efficient, because pre-recruit abundance has been maintained or only slightly decreased during 1988-92.

Although hatchery leans were responsible for establishing wild populations in much of Michigan waters, they contributed little to lean populations during 1988-92, and their future as a management option for population enhancement is in doubt. Abundance of hatchery leans decreased sharply, and they became outnumbered by wild leans in Michigan waters by the mid-1980s (Peck and Schorfhaar 1991). Although the decrease has slowed or ended, hatchery leans made up little more than 10% of lean populations in Michigan inshore waters during 1988-92. Hansen et al. (1994a) determined that the demise of hatchery fish was due to reduced survival during the first year after stocking beginning with the 1963 year class. Hansen et al. (1994a) did not determine the cause of this reduced survival, but suggested that it be evaluated, especially in the other Great Lakes lacking wild lake trout populations. Hansen et al. (in press) recommended that stocking be discontinued in some Michigan waters of Lake Superior to protect wild stocks from hatchery diseases and to maintain genetic diversity.

Abundance of siscowets has increased in some management areas in recent years, and this may represent another impediment to restoration of leans. Siscowets became more abundant than leans in pre-recruit population in MI-3 during 1988-92, and their numbers were increasing in MI-2 and MI-4. Increased siscowet abundance can only have a detrimental effect on lean populations. Although there were differences between the diets of siscowets and leans, there was dietary overlap as well (R. G. Schorfhaar, MIDNR, Marquette Fisheries Station, unpublished data). Competition exists between the two varieties and will likely increase as siscowet populations increase. Fishing has tended to exacerbate the situation, because siscowets have been exploited much less than lean lake trout. Although tribal commercial fisheries have harvested siscowets, they have harvested more lean lake trout. A state-licensed commercial fishery for siscowets that was increasing during the late 1980s was closed in 1990 because siscowets contained excessive levels of chlordane (D. Nelson, MIDNR, Lansing, personal communication), and sport anglers have been advised not to consume them (Michigan Department of Public Health, Public Health Advisory in MIDNR, Michigan Fishing Guide). Siscowets are less accessible to fisheries because their deeper depth distribution minimizes exposure to inshore fisheries and allows them to inhabit greater areas farther offshore that are much less intensively fished. No siscowets were observed in the non-target catch in the state-licensed trap net fishery for lake whitefish (Schorfhaar and Peck 1993). Although sea lamprey attack marks have been found on siscowets (R. G. Schorfhaar, MIDNR, Marquette Fisheries Station, unpublished data), their deeper distribution may afford some protection from sea lamprey predation. Siscowet populations in Michigan waters apparently were not reduced to the extent that lean lake trout populations were during the 1950s because some populations were sufficiently abundant to be fished commercially in Michigan offshore waters in the 1960s (Patriarche and Peck 1970).

Progress in lake trout management in Michigan waters during 1988-92 included improving estimates of sport harvest, determining non-target catch and mortality in trap nets used by the state-licensed commercial fishery for lake whitefish, and participating on the Lake Superior Technical Committee. Sport harvest estimates were improved in 1989 with the imposition of mandatory reporting of charter boat catch, and in 1991 with the addition of a major lake trout fishing port (AuTrain). Prior to 1990, catches by charter boats had been included in the general creel survey, but charter boats were difficult to survey, because they often operated from private docks. Although lake trout harvest in the state-licensed trap-net fishery for lake whitefish was not permitted, an estimated 414 (0.26/trap-net lift) were killed annually during 1983-89 (Schorfhaar and Peck 1993). Most lake trout captured in trap nets (96%) were released alive. The Lake Superior Technical Committee prepared reports describing the status of Lake Superior lake trout populations in 1989 and 1992 (Hansen et al. 1990, Hansen et al. 1994b), worked on updating input for a model that would calculate lake trout TACs, and began revision of the lake-wide inter-agency lake trout management plan. Part of the proposed lake trout plan were criteria to determine if lake trout stocking could be discontinued. The only change made to regulations affecting lean lake trout in the state-licensed commercial fishery during 1988-92 was the closure of the gill-net fishery for siscowets in 1990. This fishery operated in MI-3, MI-4, MI-5, and MI-6 and was restricted to water 60 fathoms and deeper, but was closed due to excessive levels of chlordane in siscowets. Non-target CPE of leans in this siscowet fishery was around one fish per 1,000 feet of gill net, so closure eliminated a harvest of about 1,300 fish at the 1989 level of effort (R. G. Schorfhaar, Marquette Fisheries Station, unpublished data). No changes were made to the sport-fishery regulations for lake trout during 1988-92.

Although self-sustaining wild lean populations have been established in Michigan waters of Lake Superior, the fate of these populations will ultimately depend on the ability of responsible state, tribal, and federal agencies to further restrict harvest by fisheries and reduce sea lamprey populations. Hansen et al. (1994a) recommended that the interagency lake trout management plan for Lake Superior be modified to recognize that hatchery lake trout stocking no longer supplements abundance in much of the lake, and that restoration of stocks may now depend on prudent management of naturally producing stocks through reduction of fishing and sea lamprey abundance. The decreased abundance of wild leans in some Michigan waters must not be allowed to persist if we expect to have wild lean populations in the future.

Recommendations

Assessment Recommendations

Continue assessment of commercial-sized leans in MI-2 through MI-7, and re-establish the commercial-sized assessment in MI-8. Lake trout have been stocked annually in this area under the terms of the 1985 Negotiated

Settlement, but no assessment has been done since 1985 (Peck and Schorfhaar 1991).

Continue assessment of pre-recruit lake trout in MI-2 through MI-7, and expand it to include MI-8. No pre-recruit assessment has been done in MI-8.

Continue the sport-fishery creel survey in MI-2, MI-4, MI-5 and MI-6, and expand it to include MI-1, MI-3, MI-7, and MI-8.

We do not recommend assessment of lean lake trout spawning populations for the immediate future. We do recommend that habitat studies be conducted on some established lean spawning reefs to determine characteristics of substrates where lake trout are known to deposit eggs and where survival to hatch is good.

Locate siscowet spawning grounds in Michigan waters and assess spawning populations. Only two siscowet spawning grounds have been identified in Michigan inshore waters (one in MI-3 and one in MI-4).

Continue to evaluate otoliths as the primary structure for aging lake trout. Some additional work needs to be done to determine if the 23-in break between the use of scales and the use of otoliths is appropriate for all lean populations, and if scales can be used for aging any size of siscowets. It is not certain that soaking whole otoliths in mineral oil is adequate preparation for correct aging. Some Lake Superior biologists believe that transverse sectioning is superior to soaking whole otoliths for aging lake trout. The former method may be better, but is more time consuming. The two methods have not been tested against each other.

Management Recommendations

Complete update of the TAC model so that reliable TACs can be used to manage tribal commercial fisheries and state-licensed sport fisheries in the management areas where lake trout restoration has not been deferred.

Continue interagency cooperation and negotiation in lake trout management. Peck and Schorfhaar (1991) documented some reasons for this that are as valid today. Interagency management of common lake trout populations provides an opportunity for an exchange of ideas, opinions, and data. It also provides a source of peer pressure for appropriate management of the resource. Revision of the lake-wide lake trout management plan should be completed and include criteria for discontinuance of hatchery lake trout stocking. Negotiations should continue between MIDNR and tribal fisheries agencies to reduce lake trout harvest in areas where lake trout abundance has decreased. Negotiations will also be required to allocate the updated TACs among state and tribal fisheries. The 1985 Negotiated Settlement should be renegotiated to foster restoration of lake trout populations in MI-7 and MI-8. Historic lake trout abundance in both areas was high, with the abundance in MI-7 the highest in Michigan waters (M. J. Hansen, NBS, Ann Arbor, personal communication).

Current sport and commercial fishing regulations affecting lake trout should not be relaxed. In fact, mortality rates in excess of 50% and the downturn in lake trout abundance in most management areas indicates the need for more stringent sport and commercial regulations to reduce harvest, unless abundance increases naturally or does so through reduction of mortality caused by sea lamprey.

Support U.S. Fish and Wildlife Service efforts to further reduce sea lamprey abundance. As indicated above, lake trout total mortality should be reduced in most areas, and it would be most beneficial to fisheries if the reduction was in mortality caused by sea lamprey.

Develop criteria for discontinuance of the stocking of hatchery lake trout, and cease stocking hatchery lake trout in areas that qualify under those criteria. Low survival of hatchery lake trout in Lake Superior and the potential disease and genetic effects of hatchery lake trout on wild lake trout populations (Hansen et al 1994b) may make them an impediment to restoration of self-sustaining populations.

Support and evaluate state and federal hatchery strategies to increase survival of stocked lake trout, such as stocking larger yearlings that are genetically most identical to lean lake trout populations in the stocked lake. Self-sustaining lake trout populations have not been established in the other Great Lakes, and those in Lake Superior may be lost unless fishing and sea lamprey predation is reduced. Stocking yearling hatchery lake trout has been the only documented strategy for restoration of self-sustaining lake trout populations in the Great Lakes. Therefore the need for hatchery lake trout still exists, and may increase in the future.

Acknowledgments

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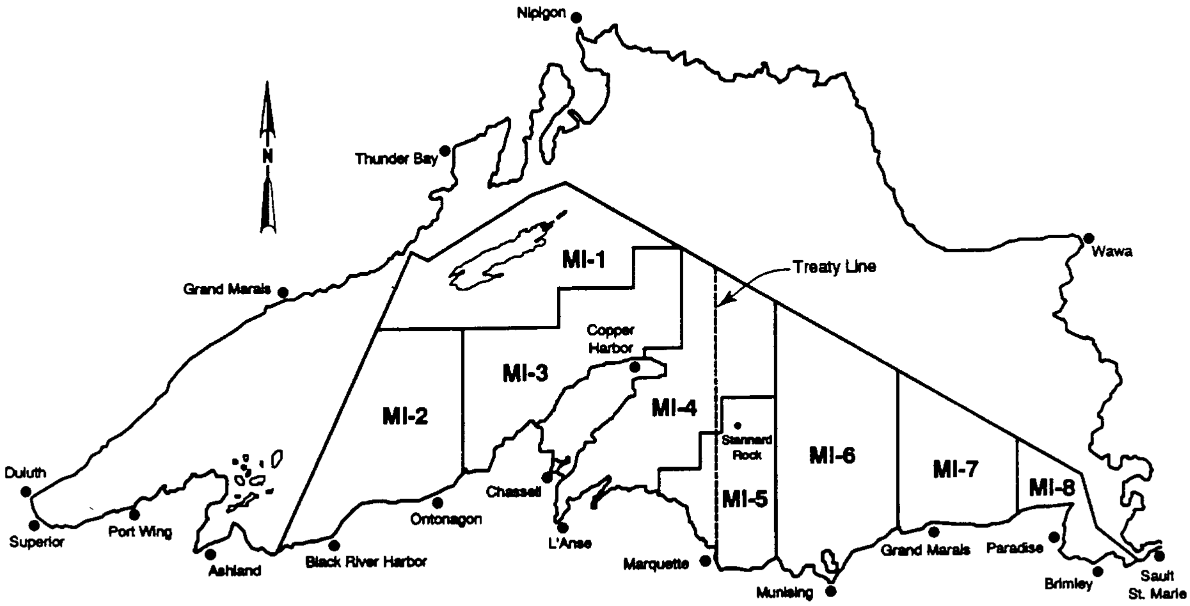

Figure 1.—Lake trout management areas in Michigan waters of Lake Superior, with line depicting boundary between 1836 and 1842 treaty areas.

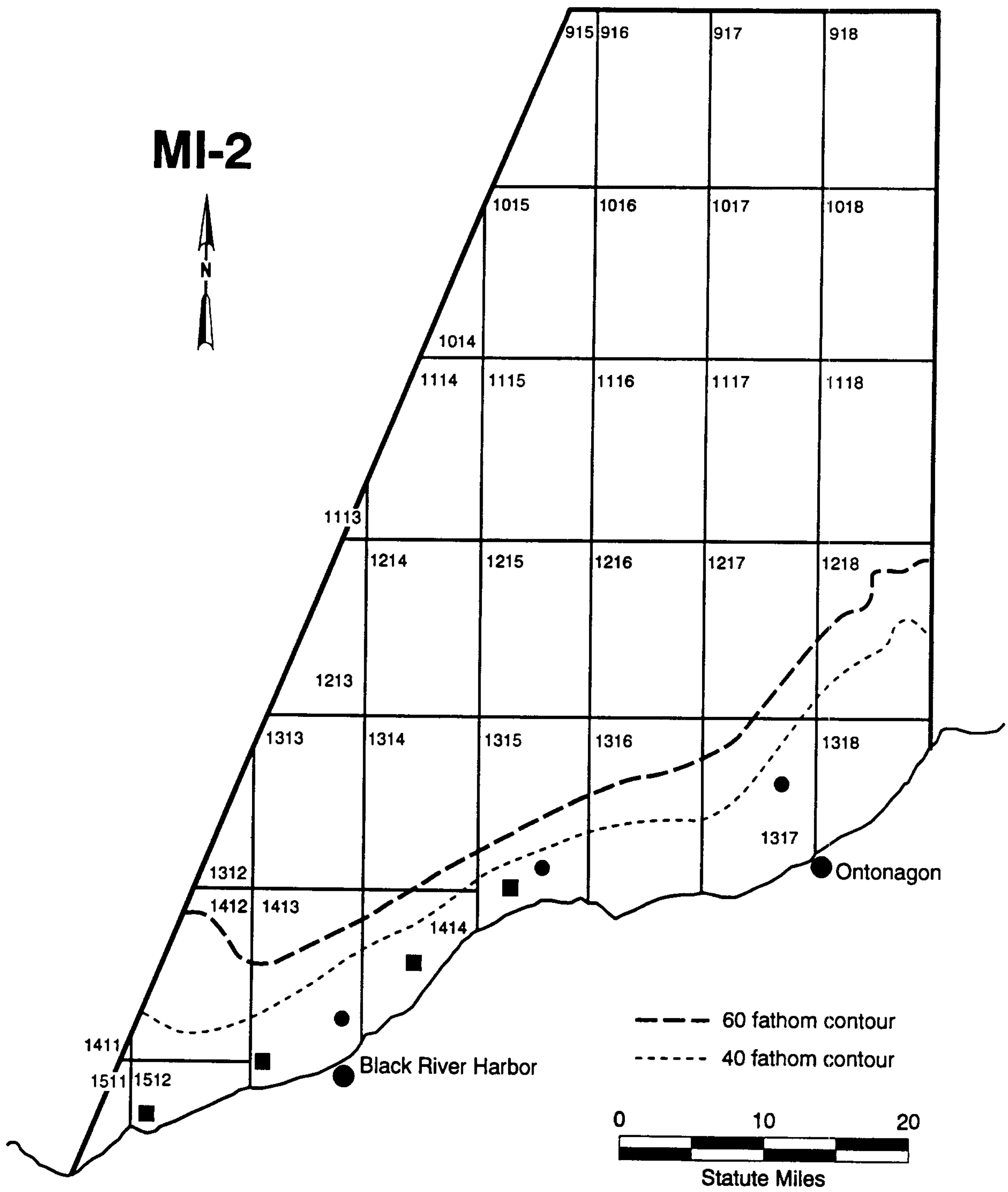

Figure 2.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-2, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

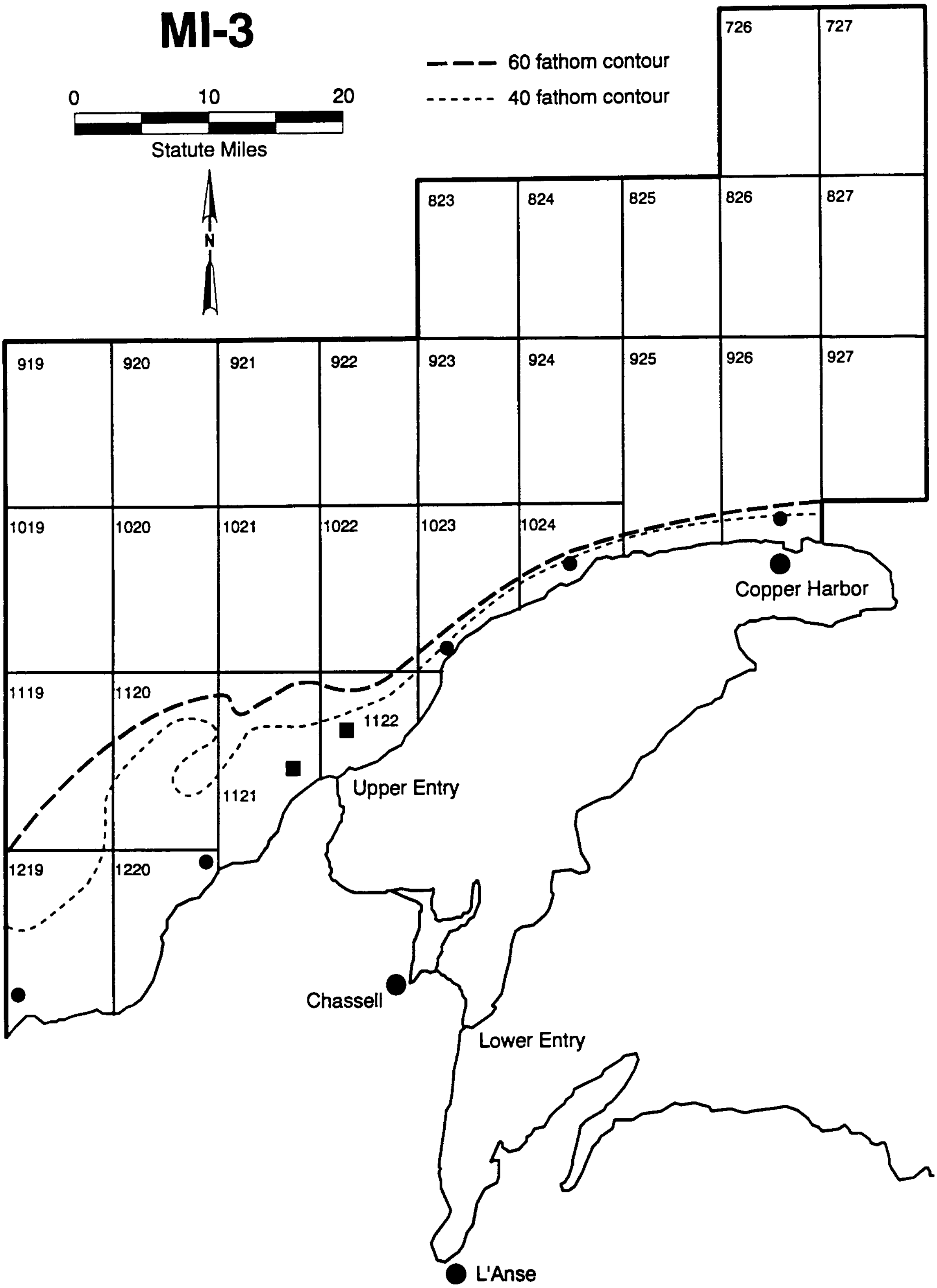

Figure 3.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-3, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

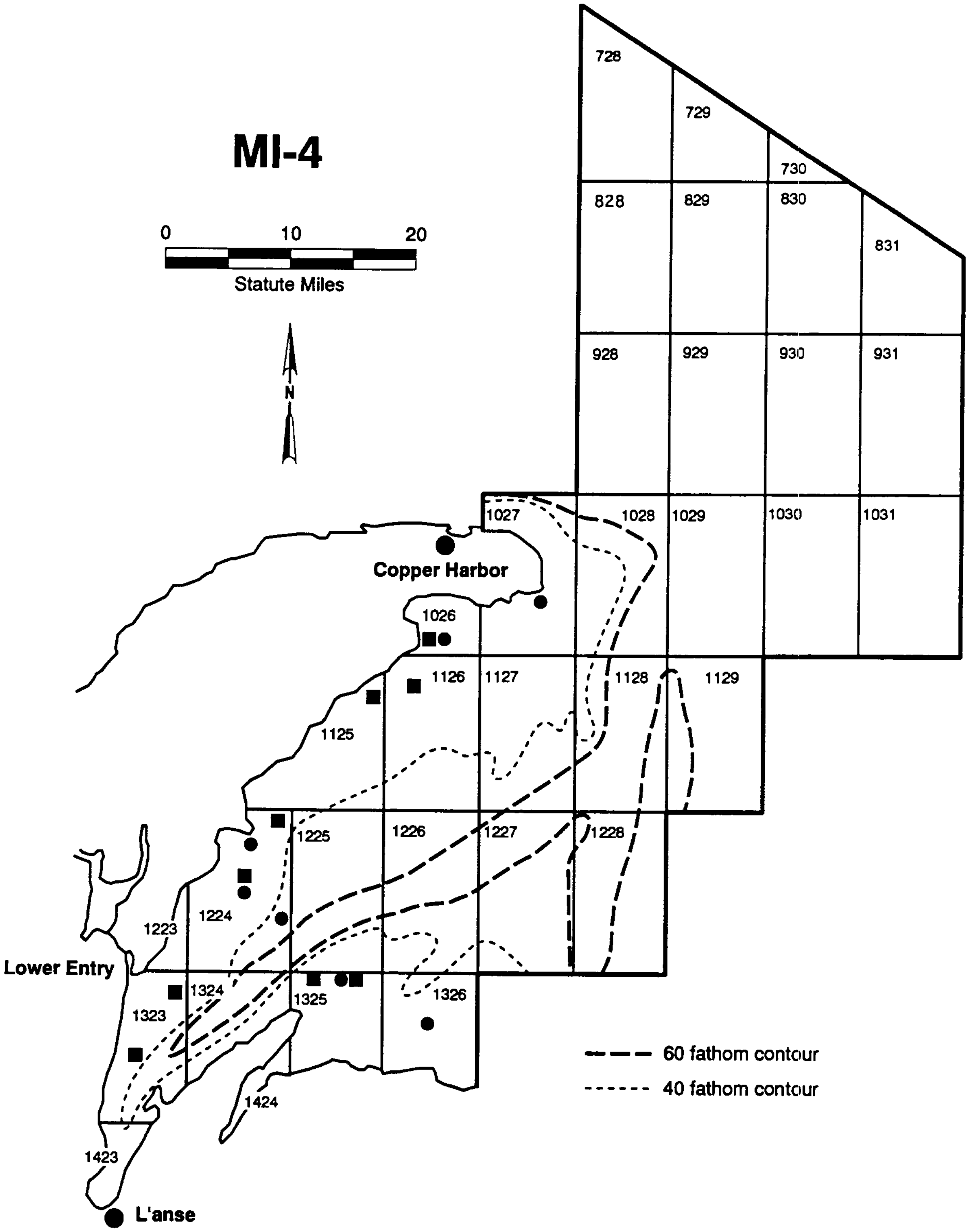

Figure 4.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-4, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

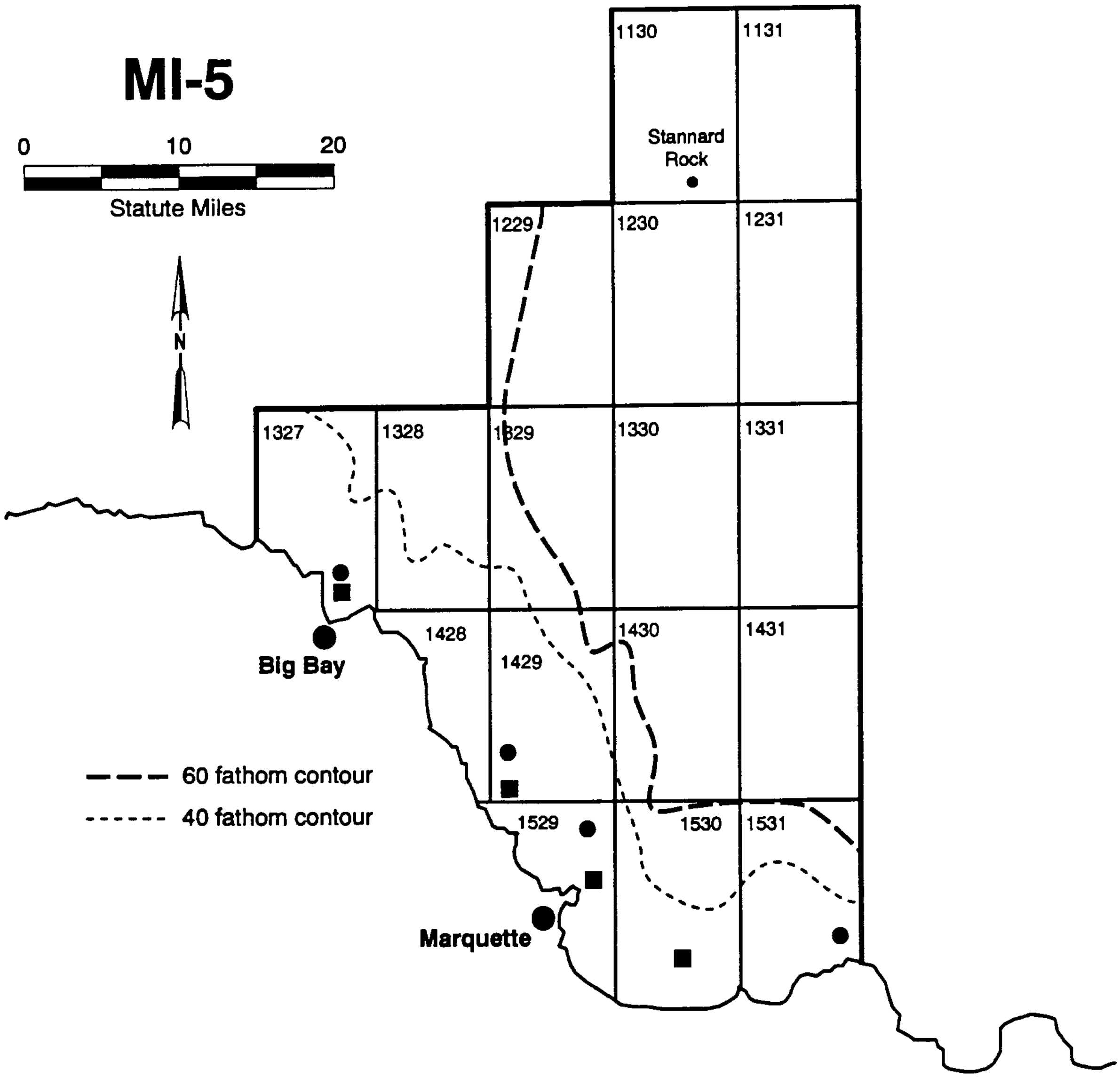

Figure 5.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-5, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

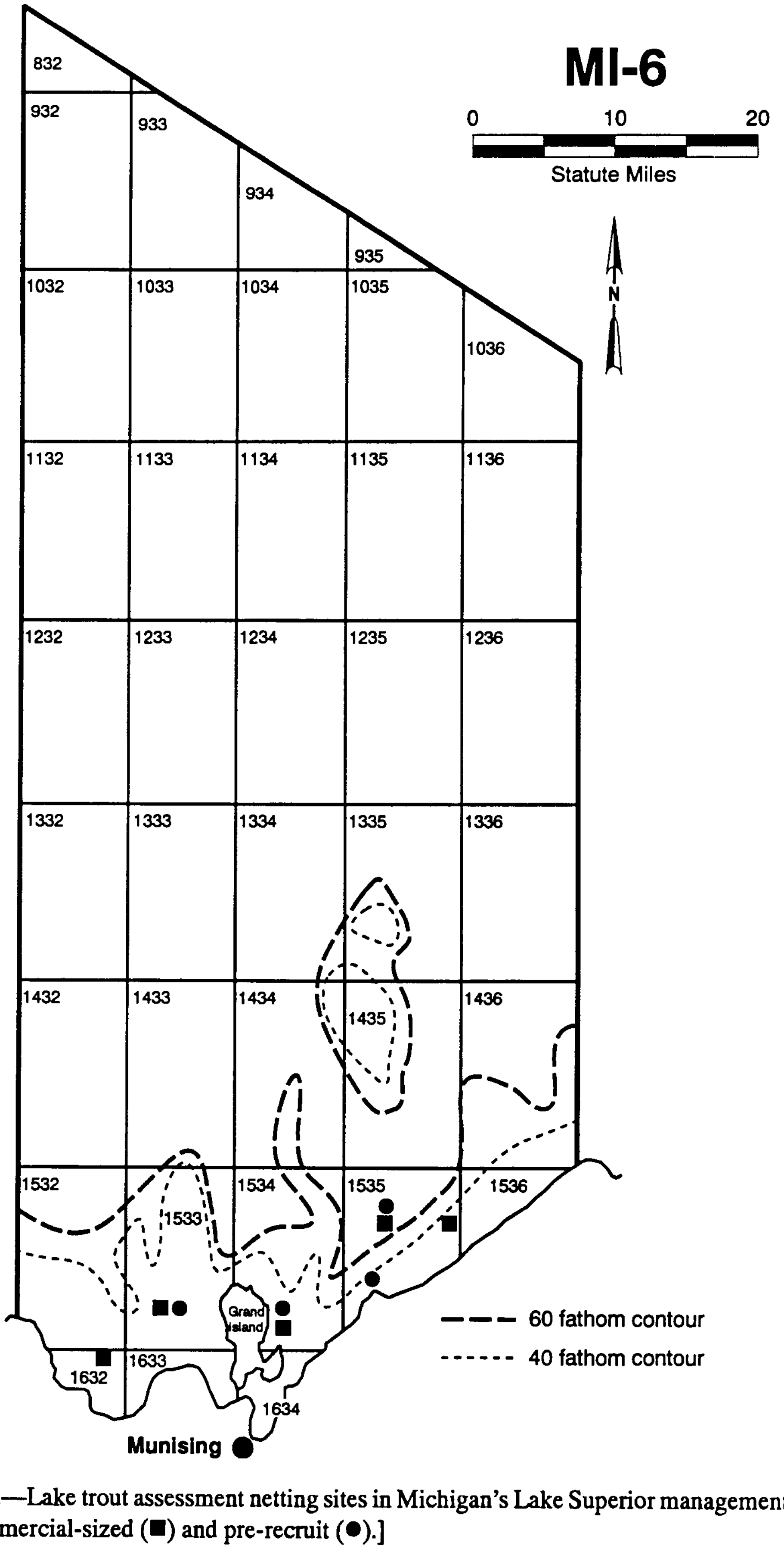

Figure 6.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-6, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

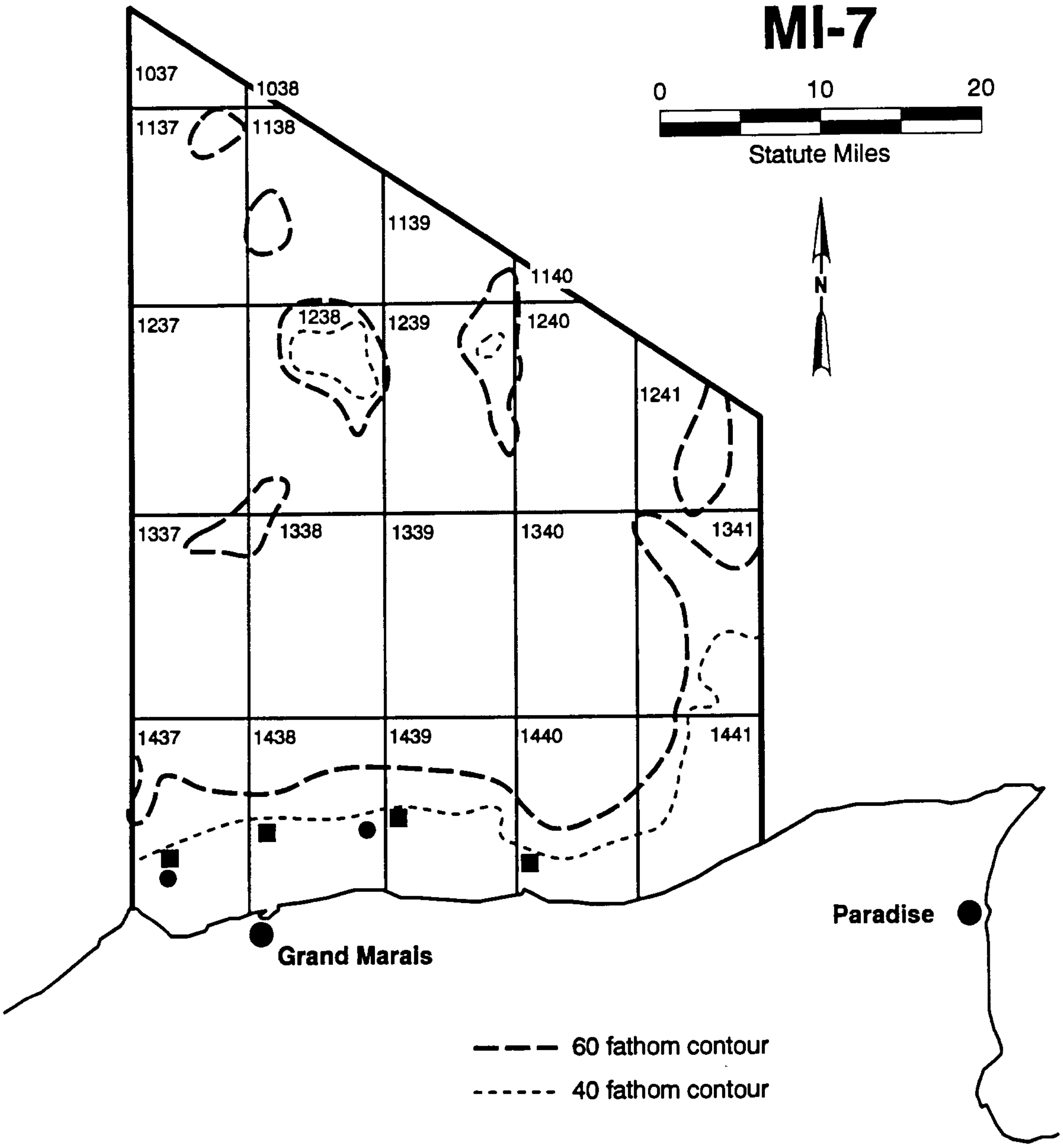

Figure 7.—Lake trout assessment netting sites in Michigan's Lake Superior management area MI-7, 1988-92 [Comercial-sized (■) and pre-recruit (●).]

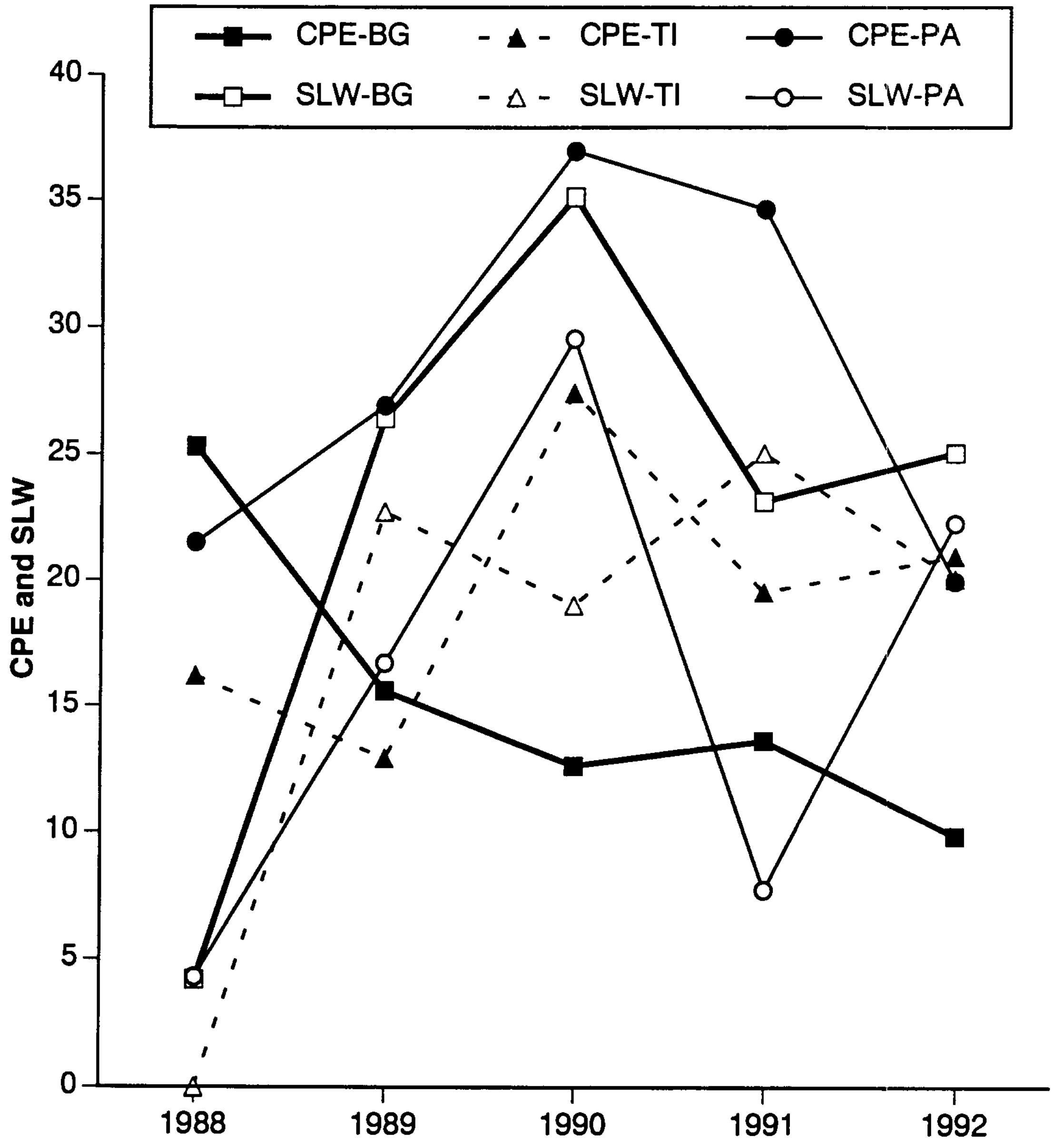

Figure 8.—Number of commercial-sized (≥17 inches, total length) wild lean lake trout per 1,000 feet of 4.5-inch mesh gill net (CPE), and number of sea lamprey wounds (SLW) per 100 mature-sized (≥25 inches, total length) lean lake trout at Bete Grise (BG), Traverse Island (TI), and Point Abbaye (PA) stations in Michigan's Lake Superior management area MI-4, 1988-92.

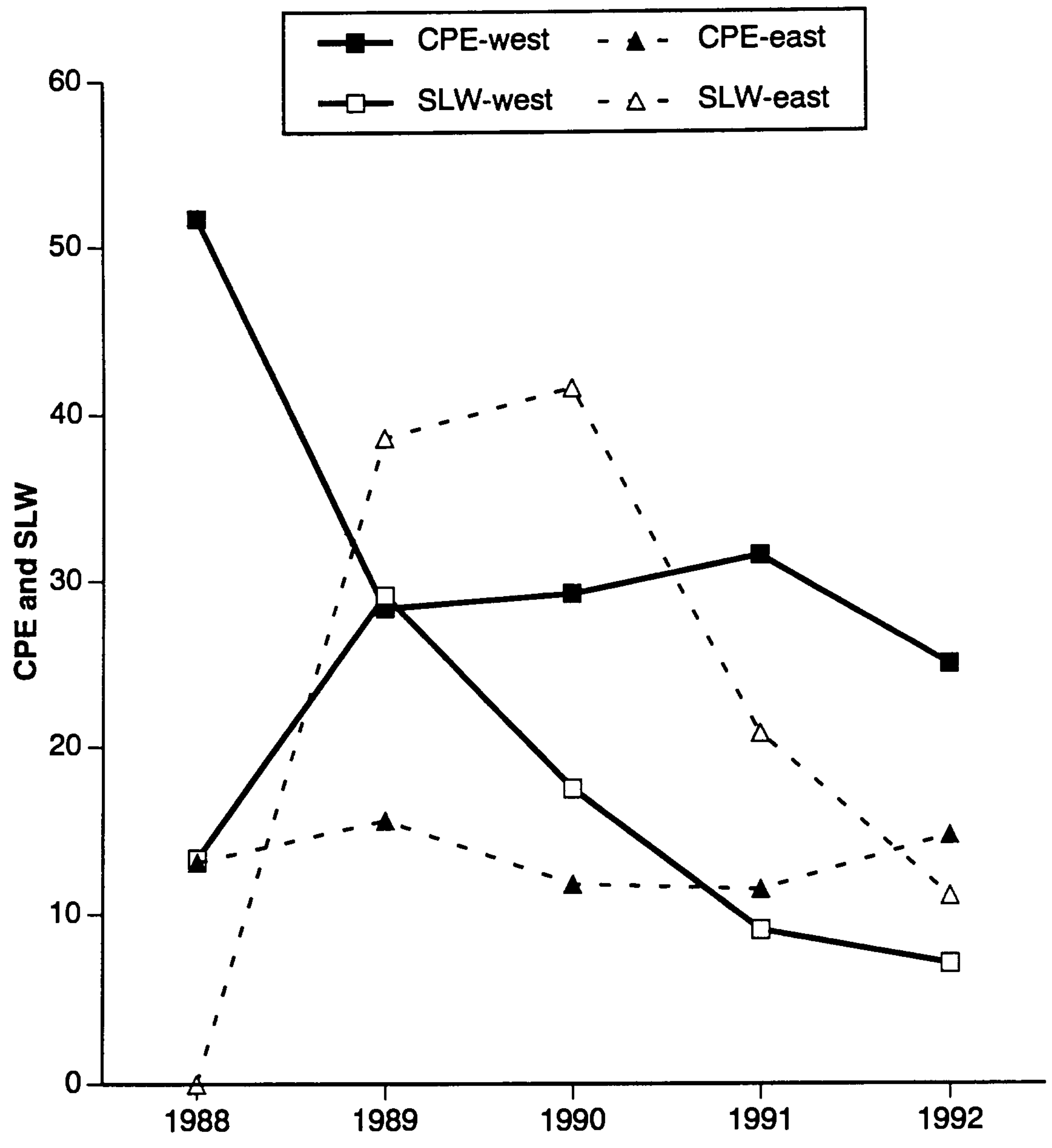

Figure 9.—Number of commercial-sized (≥17 inches, total length) wild lean lake trout per 1,000 feet of 4.5-inch mesh gill net (CPE), and number of sea lamprey wounds (SLW) per 100 mature-sized (≥25 inches, total length) lean lake trout at Munising-west and Munising-east stations in Michigan's Lake Superior management area MI-6, 1988-92.

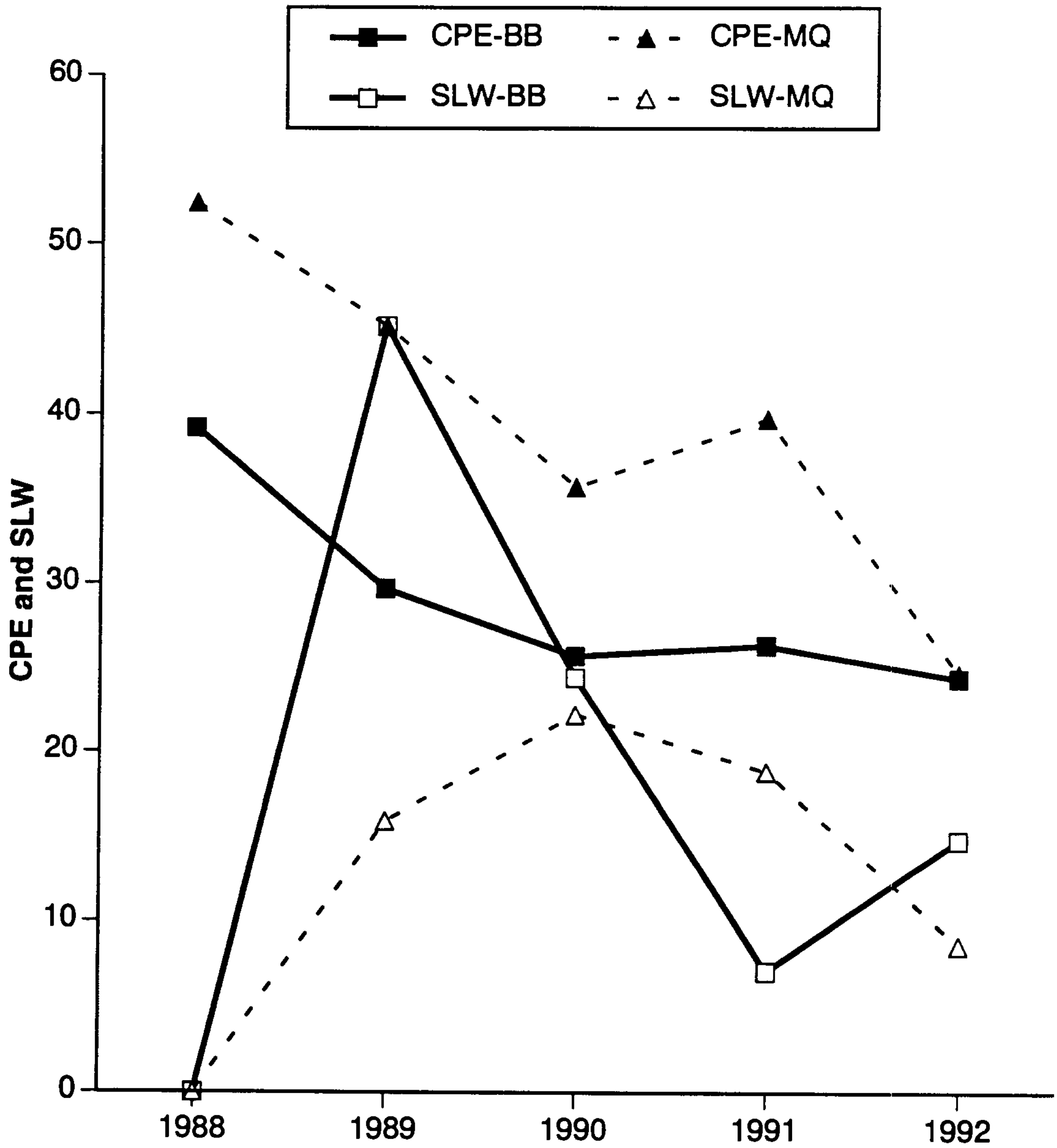

Figure 10.—Number of commercial-sized (≥17 inches, total length) wild lean lake trout per 1,000 feet of 4.5-inch mesh gill net (CPE), and number of sea lamprey wounds (SLW) per 100 mature-sized (≥25 inches, total length) lean lake trout at Big Bay (BB) and Marquette (MQ) stations in Michigan's Lake Superior management area MI-5, 1988-92.

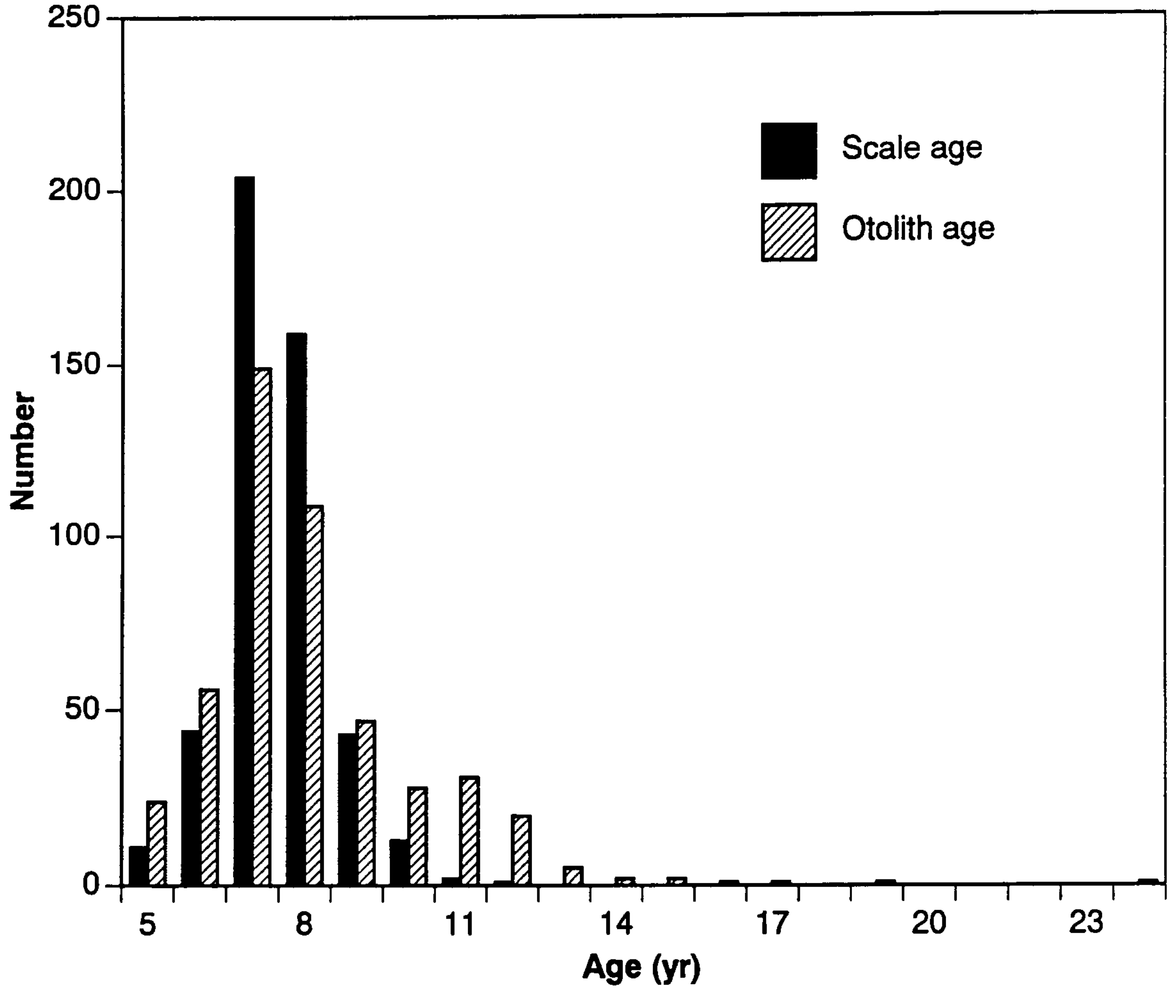

Figure 11.—Age composition of wild lean lake trout from the commercial-sized assessment at Marquette (MI-5) in 1992 aged by scales and otoliths.

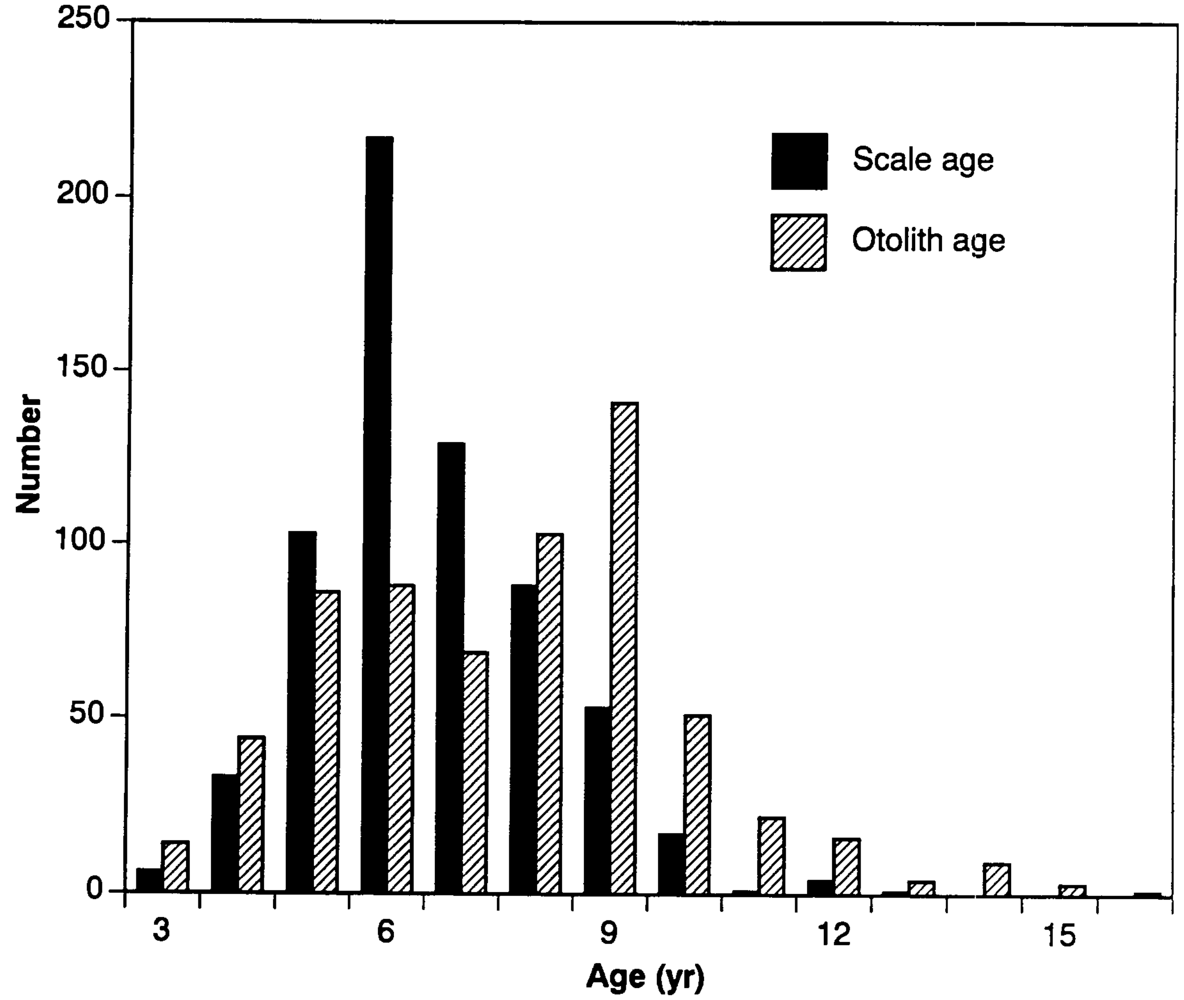

Figure 12.—Age composition (number) of siscowet lake trout from the pre-recruit assessment in Michigan waters of Lake Superior in 1990 aged by scales and otoliths.

Table 1.—Number of lake trout yearlings[a] (thousands) stocked, and number stocked per square mile of water 40 fathoms and shallower (in parentheses) in Michigan's Lake Superior management areas[b] during 1978-92.

Year planted	Management areas and square miles 40 fathoms (240 feet)							Total
	MI-2 449	MI-3 284	MI-4 552	MI-5 292	MI-6 289	MI-7 144	MI-8 582	2,484
1978	149 (332)	27 (153)	267 (484)	149 (510)	85 (294)	25 (144)	28 (48)	730 (294)
1979	179 (399)	0 (0)	236 (428)	297 (1,017)	95 (329)	50 (287)	20 (34)	877 (353)
1980	88 (196)	26 (148)	140 (254)	231 (791)	92 (318)	28 (161)	28 (48)	633 (255)
1981	75 (167)	25 (142)	177 (321)	228 (781)	106 (367)	25 (144)	25 (43)	661 (266)
1982	75 (167)	50 (284)	222 (402)	228 (781)	88 (304)	25 (174)	27 (145)	714 (287)
1983	80 (178)	75 (426)	169 (306)	338 (1,158)	112 (388)	33 (229)	32 (55)	839 (338)
1984	0 (0)	0 (0)	12 (22)	154 (527)	30 (104)	30 (208)	258 (443)	484 (195)
1985	279 (621)	91 (517)	436 (790)	460 (1,575)	298 (1,031)	10 (69)	171 (294)	1,745 (702)
1986	117 (261)	26 (148)	327 (592)	303 (1,038)	135 (467)	0 (0)	156 (268)	1,064 (428)
1987	0 (0)	0 (0)	313 (567)	286 (979)	159 (550)	0 (0)	136 (234)	894 (360)
1988	64 (143)	0 (0)	121 (219)	146 (500)	63 (218)	0 (0)	0 (0)	394 (159)
1989	86 (192)	0 (0)	54 (98)	280 (959)	103 (356)	0 (0)	38 (65)	561 (226)
1990	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	38 (65)	38 (15)
1991	179 (399)	0 (0)	136 (246)	160 (548)	94 (325)	0 (0)	38 (65)	607 (244)
1992	204 (454)	0 (0)	192 (348)	185 (634)	100 (346)	0 (0)	38 (65)	719 (289)
Average	105 (234)	21 (121)	187 (338)	230 (787)	104 (360)	15 (105)	69 (118)	731 (294)

[a] Includes number of stocked fall fingerlings adjusted to yearling equivalents based on a 25% survival rate.

[b] No lake trout stocked in area MI-1.

Table 2.—Lake trout sport catch[a] (C = thousands of fish), effort (E = thousands of angler-hours), and catch per unit of effort (CPE = number of fish per angler-hour) in creel-surveyed management areas[b] in Michigan waters of Lake Superior, 1984-92.

Year		MI-2	MI-4	MI-5	MI-6	Total
1984	C			9.7		9.7
	E			83		83
	CPE			0.12		0.12
1985	C			8.7		8.7
	E			106		106
	CPE			0.08		0.08
1986	C			14.0		14.0
	E			146		146
	CPE			0.10		0.10
1987	C	8.5	5.8	10.2	1.1	25.6
	E	51	29	105	50	235
	CPE	0.17	0.20	0.10	0.02	0.11
1988	C	8.0	15.5	5.2	3.2	31.9
	E	49	107	67	72	295
	CPE	0.16	0.14	0.08	0.04	0.11
1989	C		26.4			26.4
	E		83			83
	CPE		0.32			0.32
1990	C	3.7	4.2	7.6	1.0	16.5
	E	36	17	48	14	115
	CPE	0.10	0.25	0.16	0.07	0.14
1991	C	2.7	9.6	9.8	6.4	28.5
	E	46	53	92	72	263
	CPE	0.06	0.18	0.11	0.09	0.11
1992	C	3.9	8.4	15.8	4.3	32.4
	E	46	62	89	91	288
	CPE	0.08	0.14	0.18	0.05	0.11

[a] Includes lean and siscowet varieties, but does not include charter boat catch in 1990-92.
[b] On-site creel surveys conducted only in MI-5 prior to 1987, only in MI-2, MI-4, MI-5, and MI-6 during 1987-92, and only a winter survey in MI-4 in 1989. No creel surveys conducted in MI-1, MI-3, MI-7, and MI-8.

Table 3.—Lake trout catch (thousands of pounds dressed weight) by tribal commercial fisheries[a] in Michigan's Lake Superior management areas during 1988-92.

		Management areas							
Year	Variety	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	MI-8	Total
1988	Lean	30	21	131	21	20	40	78	341
	Siscowet	12	28	57	2		<1		99
1989	Lean	32	10	119	8	29	36	74	308
	Siscowet	12	14	58	2				86
1990	Lean	20	12	145	13	29	71	73	363
	Siscowet	22	20	84	8	4			138
1991	Lean	10	19	108	4	23	61	59	284
	Siscowet	7	24	102	4	9	3		149
1992	Lean	5	18	87	8	26	45	48	237
	Siscowet	28	28	97	7	3	14	21	198
Mean	Lean	19	16	118	11	25	51	66	307
	Siscowet	16	23	80	5	3	3	4	134

[a] Lake trout catch from Great Lakes Fishery Commission, Lake Superior Committee Meeting annual extraction reports (unpublished); Ebener et al. (1989a; Ebener et al. (1990); Shively et al. (1992a); Shively et al. (1992b); Shively et al. (1993); and unpublished data from the Chippewa/Ottawa Treaty Fisheries Management Authority Inter-tribal Fisheries Assessment.

Table 4.—Commercial-sized lean lake trout abundance (CPE[a]), mean total length of age-7 wild lake trout, and sea lamprey wounding[b] in Michigan's Lake Superior management areas MI-2[c], MI-3, MI-4, MI-5, MI-6, and MI-7, 1988-92.

Area and year	CPE[a] Hatchery	Wild (% wild)	Wild ≥25 in	Mean total length (in) Wild age-7	Sea lamprey wounding[b] by inch group All ≥17	17-20	21-24	25-28	≥29	All ≥25
MI-2										
1988	2.6	21.8 (89)	5.7	22.5	7.7	2.0	8.2	7.8	27.8	13.0
1989	6.6	49.7 (88)	6.7	22.2	5.5	3.1	6.4	8.0	25.0	8.7
1990	4.3	35.0 (89)	4.8	21.5	4.4	1.7	4.0	12.3	100.0	13.6
1991	4.2	30.2 (88)	5.0	20.4	6.3	0.0	10.1	10.0	0.0	9.1
1992	2.9	26.0 (90)	3.8	20.9	4.4	0.6	6.0	4.2	60.0	9.4
MI-3										
1988	2.1	11.2 (84)	0.7	20.5	2.1	0.0	3.4	7.5	11.1	9.8
1989	1.9	13.8 (88)	2.2	21.0	6.2	0.9	6.7	18.0	12.5	17.4
1990	1.1	11.8 (91)	0.9	19.0	4.2	0.0	6.4	28.1	12.5	25.0
1991	0.9	8.3 (90)	1.0	20.2	7.0	1.9	11.6	13.3	12.5	13.2
1992	0.4	3.3 (89)	0.3	21.0	15.9	9.3	18.2	9.1	200.0	38.5
MI-4										
1988	2.2	21.6 (91)	1.0	20.7	1.1	0.2	1.9	3.0	0.0	2.6
1989	2.1	15.6 (88)	0.9	20.6	6.0	1.7	11.2	18.8	50.0	19.2
1990	1.8	22.5 (93)	1.5	20.5	3.5	1.0	3.0	24.8	83.3	29.8
1991	1.5	20.2 (93)	1.2	20.7	3.0	0.7	5.0	17.6	28.6	19.3
1992	1.8	15.6 (90)	1.2	20.4	5.7	1.8	7.1	20.0	50.0	22.7
MI-5										
1988	3.0	44.9 (94)	3.1	20.9	0.7	0.7	0.8	0.0	0.0	0.0
1989	3.9	33.8 (90)	2.7	21.2	9.4	3.3	10.8	21.3	83.3	23.0
1990	3.1	30.3 (91)	3.2	22.1	5.4	1.5	4.7	26.2	0.0	24.8
1991	4.5	32.3 (88)	2.0	21.6	2.6	0.0	3.3	13.5	12.5	13.3
1992	5.2	24.4 (82)	1.9	21.5	2.6	1.0	2.8	9.5	20.0	10.1
MI-6										
1988	2.9	26.1 (90)	1.9	20.7	3.4	1.2	4.9	6.1	28.6	7.5
1989	2.1	19.2 (90)	2.1	20.9	18.1	5.5	24.6	45.4	16.7	42.0
1990	1.9	16.1 (89)	1.6	20.6	11.4	3.8	14.3	31.5	62.5	35.4
1991	1.6	17.2 (91)	2.4	21.0	8.1	2.0	11.0	18.3	40.0	20.4
1992	2.4	18.6 (89)	1.9	20.8	4.5	1.3	7.0	9.1	8.3	9.0
MI-7										
1988	1.0	10.2 (91)	1.5	20.9	3.6	0.6	5.0	6.8	9.1	7.1
1989	1.9	16.4 (90)	2.1	20.9	15.8	4.2	17.6	46.4	54.6	47.8
1990	0.4	10.2 (96)	1.9	21.1	23.2	2.5	24.6	46.8	200.0	51.0
1991	0.5	12.3 (96)	1.5	21.1	12.9	2.0	13.4	37.7	37.5	37.7
1992	Not sample									

[a] Number of lean lake trout 17 inches and larger captured per 1,000 feet of 4.5-inch extension-measure multifilament nylon mesh gill net fished 72 hours during 23 April-11 June.
[b] Number of stage A1, A2, and A3 sea lamprey attack marks per 100 lean lake trout.
[c] Data for MI-2 from Gallinat (1988; 1990; 1991; 1992a; 1992b).

Table 5.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] for wild lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management area MI-3, 1988-92.

Age (years)	1988	1989	1990	1991	1992	Total
4				1		1
5						0
6	59	17	8	33	15	132
7	30	38	62	64	49	243
8	88	114	122	114	43	481
9	118	131	124	109	23	505
10	59	80	38	48	7	232
11	30	30	35	28	7	130
12	15	13	7	13	7	55
13		4	2	9	3	18
14		8	1		1	10
15				5		5
16					1	1
17			1			1
18				2		2
25				1		1
Total	399	435	400	427	156	1,817
Mean age	8.6	9.0	8.7	8.7	8.2	8.7
CI	0.2	0.1	0.1	0.2	0.3	0.1
Total mortality rate (A)						
Ages	9-12	9-14	9-17	9-25	9-16	9-25
A	0.57	0.53	0.58	0.63	0.55	0.53
X^2	3.8044	3.1679	0.5347	2.4050	0.7717	1.0250

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 6.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] for wild lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management area MI-4, 1988-92.

Age (years)	1988	1989	1990	1991	1992	Total
4				31	2	33
5	32	44		90	12	178
6	292	146	117	200	53	808
7	535	286	501	538	332	2,192
8	502	559	487	304	299	2,151
9	308	413	246	211	103	1,281
10	130	235	180	70	16	631
11	113	89	44	25	12	283
12		32	3	17	8	60
13	32	38	8	7	5	90
14		6	2	4	3	15
15					1	1
16			1			1
18				1		1
22		1				1
Total	1,944	1,849	1,589	1,498	846	7,726
Mean age	7.9	8.4	8.0	7.5	7.7	8.0
CI	0.1	0.1	0.1	0.1	0.1	0.03
Total mortality rate (A)						
Ages	9-13	9-22	9-16	9-18	9-15	9-22
A	0.55	0.54	0.60	0.59	0.58	0.56
X^2	1.6093	5.7327	39.1292	4.2936	18.2123	8.2306

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 7.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] for wild lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management area MI-5, 1988-92.

Age (years)	1988	1989	1990	1991	1992	Total
4				4	1	5
5	30		1	67	25	123
6	179	4	115	162	117	577
7	150	264	309	494	313	1,530
8	164	408	346	138	201	1,257
9	179	243	142	72	80	716
10	150	99	66	25	50	390
11	30	46	9	21	48	154
12	45	25	3	4	30	107
13	15	18	2	3	9	47
14		4	2	1	3	10
15			1		2	3
16					1	1
17		4	1	1		6
20			1			1
22				1		1
Total	942	1,115	998	993	880	4,928
Mean age	8.2	8.5	7.8	7.2	7.9	7.9
CI	0.1	0.1	0.1	0.1	0.1	0.04
[a] Total mortality rate (A)						
Ages	9-13	9-17	9-20	9-22	9-16	9-22
A	0.51	0.53	0.62	0.52	0.42	0.51
X^2	22.0480	2.2407	0.0039	1.8506	5.9484	2.9937

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 8.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] for wild lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management area MI-6, 1988-92.

Age (years)	1988	1989	1990	1991	1992	Total
4	No			4		4
5	data	3	14	18	1	36
6		7	146	82	66	301
7		47	188	316	254	805
8		90	191	194	227	702
9		110	121	85	96	412
10		73	61	43	38	215
11		50	28	31	8	117
12		20	6	10	17	53
13		3	1	2	8	14
14			1	3	7	11
15					1	1
16					1	1
23			1			1
26				1		1
Total		403	758	789	724	2,674
Mean age		.9.1	7.8	7.7	8.0	8.0
CI		0.1	0.1	0.1	0.1	0.1
Total mortality rate (A)						
Ages		9-13	9-23	9-26	9-16	9-26
A		0.51	0.58	0.52	0.49	0.52
X^2		13.3531	1.5728	2.1408	4.7604	2.9511

[a] Mortality determine by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 9.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] for wild lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management area MI-7, 1988-92.

Age (years)	1988	1989	1990	1991	1992	Total
4					Not sampled	
5	23		2			25
6	34	22	12	95		163
7	102	47	52	154		355
8	102	126	65	118		411
9	45	149	62	47		303
10	34	44	38	22		138
11	34	44	5	9		92
12	23	16	4	7		50
13		3	3	7		13
14		3				3
15		6				6
16		3				3
17			1			1
20		3				3
Total	397	466	244	459		1,566
Mean age	8.2	9.0	8.4	7.6		8.3
CI	0.2	0.2	0.2	0.1		0.1
Total mortality rate (A)						
Ages	9-12	9-20	9-17	9-13		9-20
A	0.44	0.48	0.58	0.51		0.49
X^2	11.7941	11.1409	1.3102	0.0205		0.1453

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 10.—Age composition (number), mean age ± 95% confidence interval (CI), and total annual mortality rate[a] based on age composition in vulnerable ages 8-15 adjusted for number stocked (numbers in parentheses) for the combined sample of hatchery lean lake trout from the commercial-sized assessment[b] in Michigan's Lake Superior management areas MI-3, MI-4, MI-5, MI-6, and MI-7 in 1988-92.

Age (years)	1988	1989	1990	1991	1992
2		1			
3	1				5
4	10	18	15	12	11
5	6	37	50	33	97
6	25	12	113	55	68
7	61	36	25	142	54
8	32 (43)	56 (69)	56 (56)	22 (40)	126 (126)
9	35 (49)	29 (39)	32 (38)	50 (52)	12 (43)
10	20 (20)	20 (28)	38 (48)	9 (11)	18 (37)
11	11 (13)	14 (14)	9 (12)	8 (11)	
12	10 (13)	10 (12)		2 (3)	1 (2)
13	5 (6)	7 (9)		1 (1)	1 (3)
14	1 (1)	3 (3)		1 (1)	
15	1 (1)	2 (2)			
16		3			
17		1			
20		1			
21		1			
22	1			1	
24		1			
Total	219	252	338	336	393
Mean age	8.1	8.2	7.0	7.2	6.7
CI	0.3	0.4	0.2	0.2	0.2
Total annual mortality rate (A) from age composition adjusted for the number of yearlings stocked in age groups used in calculation (in parentheses).					
Ages	8-15	8-15	8-11	8-14	8-13
A	0.39	0.39	0.47	0.54	0.60
X^2	10.5490	0.1095	14.2509	3.9180	7.1335

[a] Mortality rate determined by the method described by Robson and Chapman (1961).

[b] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 11.—Mean total weight, mean total length, and the weight-length coefficients for lean lake trout captured in the commercial-sized assessment[a] in Michigan management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 in Lake Superior during 1989 and 1991, with 95% confidence intervals (CI) on the means for weight and length and the weight-length intercept and slope coefficients.

					Log$_e$ total weight(lb)-log$_e$ total length(in) coefficients ± 95% CI		
Year	Area	N	Mean total weight ± 95% CI, and (range)	Mean total length ± 95% CI, and (range)	a	b	R^2
1989	MI-3	95	3.65 ± 0.29, (1.35-7.51)	22.2 ± 0.5, (17.0-27.5)	-8.36 ± 0.62	3.10 ± 0.20	0.91
	MI-4	142	3.67 ± 0.26, (1.77-9.89)	21.8 ± 0.5, (17.3-31.3)	-7.96 ± 0.32	2.99 ± 0.10	0.96
	MI-5	105	3.91 ± 0.24, (2.22-7.46)	22.7 ± 0.5, (18.5-29.3)	-7.59 ± 0.55	2.86 ± 0.18	0.91
	MI-6	100	3.34 ± 0.27, (1.54-8.33)	21.7 ± 0.5, (17.4-29.6)	-7.98 ± 0.50	2.97 ± 0.16	0.93
	MI-7	102	3.84 ± 0.41, (1.50-17.73)	22.0 ± 0.6, (17.3-37.5)	-8.05 ± 0.50	3.02 ± 0.16	0.93
	Total	544	3.68 ± 0.13, (1.35-17.73)	22.0 ± 0.2, (17.0-37.5)	-7.97 ± 0.21	2.98 ± 0.07	0.93
1991	MI-3	92	2.93 ± 0.25, (1.29-6.57)	20.8 ± 0.5, (17.0-28.2)	-8.99 ± 0.47	3.30 ± 0.16	0.95
	MI-4	78	3.02 ± 0.29, (1.44-8.19)	20.6 ± 0.6, (17.0-29.9)	-8.12 ± 0.48	3.03 ± 0.16	0.95
	MI-5	106	2.97 ± 0.14, (1.53-6.90)	21.3 ± 0.3, (17.1-27.7)	-8.63 ± 0.57	3.17 ± 0.19	0.92
	MI-6	100	3.16 ± 0.25, (1.40-8.38)	21.2 ± 0.5, (17.0-27.9)	-8.70 ± 0.61	3.21 ± 0.20	0.91
	MI-7	96	3.73 ± 0.27, (1.50-8.02)	22.3 ± 0.5, (17.6-29.4)	-8.36 ± 0.62	3.10 ± 0.20	0.91
	Total	472	3.17 ± 0.11, (1.29-8.38)	21.3 ± 0.2, (17.0-29.9)	-8.54 ± 0.25	3.16 ± 0.08	0.93

[a] Lean lake trout 17 inches and larger captured in 4.5-inch multifilament nylon mesh gill nets fished during April-June.

Table 12.—Lean and siscowet lake trout abundance (CPE)[a] in the assessment of pre-recruit lake trout[b] in Michigan's Lake Superior management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 during 17 July-27 August 1988-92.

				CPE (All meshes)					CPE (2.0- and 2.5-inch mesh		
				All sizes			< 17 inches			< 17 inches	
Area	Year	Effort (ft x 1,000)	Variety	Total (% wild)	Wild	Hatchery	Wild	Hatchery	Effort (ft x 1,000	Wild	Hatchery
MI-2	1988	No assessment									
	1989	10.8	Lean	13.6 (81)	11.0	2.6	6.2	1.7	3.6	5.4	1.9
			Siscowet	0.3			0.0				
	1990	10.8	Lean	12.3 (93)	11.4	0.9	6.4	0.3	3.6	6.4	0.0
			Siscowet	2.6			0.6				
	1991	10.8	Lean	6.2 (85)	5.3	0.9	2.4	0.5	3.6	1.1	0.6
			Siscowet	3.6			0.6				
	1992	10.8	Lean	9.7 (91)	8.8	0.9	5.0	0.5	3.6	6.2	1.2
			Siscowet	5.5			1.4				
MI-3	1988	No assessment.									
	1989	14.4	Lean	8.2 (87)	7.1	1.1	3.7	0.5	4.8	3.9	0.7
			Siscowet	2.7			1.2				
	1990	14.4	Lean	7.6 (88)	6.7	0.9	5.4	0.3	4.8	8.2	0.6
			Siscowet	11.0			5.8				
	1991	14.4	Lean	3.7 (88)	3.3	0.4	1.7	0.3	4.8	1.7	0.2
			Siscowet	15.1			9.9				
	1992	14.4	Lean	9.2 (95)	8.7	0.5	5.9	0.2	4.8	4.5	0.7
			Siscowet	28.6			16.5				
MI-4	1988	25.2	Lean	29.2 (94)	27.4	1.8	22.0	1.3	8.4	22.8	1.6
			Siscowet	5.1			2.7				
	1989	25.2	Lean	17.8 (91)	16.2	1.6	12.9	1.1	8.4	13.7	1.8
			Siscowet	5.8			3.6				
	1990	25.2	Lean	20.5 (93)	19.0	1.5	13.1	1.2	8.4	11.6	1.5
			Siscowet	3.2			1.8				
	1991	25.2	Lean	15.9 (91)	14.5	1.4	9.9	0.9	8.4	10.6	0.8
			Siscowet	4.3			1.6				
	1992	25.2	Lean	17.7 (90)	15.9	1.8	8.8	1.0	8.4	12.8	1.2
			Siscowet	9.9			4.3				

Table 12.—Continued.

				CPE (All meshes)					CPE (2.0- and 2.5-inch mesh		
				All sizes			< 17 inches			< 17 inches	
Area	Year	Effort (ft x 1,000)	Variety	Total (% wild)	Wild	Hatchery	Wild	Hatchery	Effort (ft x 1,000	Wild	Hatchery
MI-5	1988	18.0	Lean	20.2(82)	16.4	3.7	11.8	2.5	6.0	8.8	2.7
			Siscowet	7.9			5.2				
	1989	14.4	Lean	16.5 (85)	14.0	2.5	7.6	1.6	4.8	7.0	2.3
			Siscowet	4.9			2.4				
	1990	14.4	Lean	18.5 (82)	15.2	3.4	8.6	2.0	4.8	9.1	1.6
			Siscowet	7.7			3.6				
	1991	14.4	Lean	11.9 (76)	9.0	2.9	5.2	1.1	4.8	15.5	3.2
			Siscowet	5.8			1.7				
	1992	14.4	Lean	15.3 (85)	13.1	2.8	8.1	0.8	4.8	11.0	1.2
			Siscowet	11.7			4.9				
MI-6	1988	14.4	Lean	9.2 (79)	7.2	1.9	4.5	1.1	4.8	5.0	1.1
			Siscowet	7.6			3.0				
	1989	14.4	Lean	6.9 (91)	6.3	0.6	2.8	0.3	4.8	2.9	0.4
			Siscowet	1.1			0.3				
	1990	14.4	Lean	7.7 (88)	6.8	0.9	3.3	0.7	4.8	3.3	0.5
			Siscowet	1.6			0.0				
	1991	14.4	Lean	7.7 (82)	6.3	1.4	2.4	0.7	4.8	2.5	0.2
			Siscowet	4.8			0.9				
	1992	14.4	Lean	9.6 (92)	8.8	0.8	4.0	0.1	4.8	5.1	0.0
			Siscowet	3.8			0.8				
MI-7	1988	7.2	Lean	4.8 (93)	4.5	0.3	2.5	0.2	2.4	2.5	0.0
			Siscowet	3.3			1.3				
	1989	7.2	Lean	3.2 (87)	2.8	0.4	0.6	0.0	2.4	0.0	0.0
			Siscowet	0.0			0.0				
	1990	7.2	Lean	4.0 (91)	3.7	0.3	1.6	0.0	2.4	2.4	0.0
			Siscowet	1.6			0.5				
	1991	7.2	Lean	8.6 (99)	8.5	0.1	5.3	0.1	2.4	4.6	0.4
			Siscowet	1.4			0.3				
	1992	7.2	Lean	10.0 (95)	9.5	0.5	4.2	0.2	2.4	6.3	0.0
			Siscowet	3.7			0.0				

[a] Number of lake trout per 1,000 feet of gill net.

[b] Pre-recruit lake trout were less than 17 inches total length, and assessment gill nets were made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch multifilament nylon mesh.

Table 13.—Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management area MI-2, 1988-92.

Year and parameters	Age (yr)										
	2	3	4	5	6	7	8	9	10	11	12
1988	No assessment.										
1989											
Number			13	23	28	15	1	1	2		
Length			13.9	15.7	17.2	18.6	20.7	25.4	24.4		
CI			0.6	0.5	0.6	0.7			0.4		
Mortality				A = 0.62, chi-square = 0.3346, ages 6-10							
Number			7	9	12	7	1	1	2		
Weight			0.76	1.06	1.63	2.20	2.75	5.62	5.40		
CI			0.07	0.22	0.35	0.65			4.95		
1990											
Number		1	3	17	28	8	14	4			
Length		10.5	13.7	14.5	16.3	18.4	20.6	23.5			
CI			3.6	0.6	0.6	2.4	1.6	1.9			
Mortality				A = 0.52, chi-square = 0.0169, ages 6-9							
Number		1	1	9	12	6	10	4			
Weight		0.15	0.25	1.09	1.35	1.71	3.18	3.96			
CI				0.24	0.22	0.36	1.01	0.56			
1991											
Number			2	10	14	11	10	7	2	1	
Length			12.7	15.3	15.8	18.0	21.1	22.1	26.9	28.9	
CI			9.9	0.9	0.8	0.6	1.6	3.1	21.6		
Mortality				A = 0.40, chi-square = 2.5446, ages 6-11							
Number			1	9	11	9	9	6	2	1	
Weight			0.50	1.08	1.27	1.67	3.22	3.17	6.88	8.00	
CI				0.22	0.29	0.24	0.86	1.26	23.58		
1992											
Number		2	8	16	15	13	7	5		1	
Length		12.2	12.9	14.1	16.3	18.2	18.7	23.1		24.1	
CI		10.8	1.1	0.6	0.8	1.2	2.5	4.2			
Mortality				A = 0.46, chi-square = 2.5369, ages 6-11							

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 14.–Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management area MI-3, 1988-92.

Year and	Age (yr)										
parameters	2	3	4	5	6	7	8	9	10	11	12
1988	No assessment.										
1989											
Number		3	6	14	33	18	8	2	1		
Length		14.0	13.4	15.8	16.8	18.2	19.6	19.3	21.5		
CI		0.9	0.7	0.8	0.4	0.7	1.2	10.8			
Mortality	A = 0.58, chi-square = 1.3824 (ages 6-10)										
Number		2	5	11	22	11	6	1	1		
Weight		0.80	0.77	1.29	1.48	2.01	2.70	1.93	3.52		
CI		0.74	0.16	0.29	0.16	0.42	1.22				
1990											
Number		3	3	25	19	16	4				1
Length		13.3	12.5	14.1	15.1	16.8	17.9				26.8
CI		6.5	1.3	0.4	0.6	0.6	2.5				
Mortality	A = 0.57, chi-square = 2.8578 (ages 6-12)										
Number		3	3	18	18	13	3				1
Weight		0.67	0.58	0.73	0.94	1.36	1.42				5.50
CI		1.06	0.29	0.19	0.18	0.22	0.77				
1991											
Number		1	3	4	13	18	6	1			
Length		12.0	12.4	14.4	16.5	17.8	17.9	20.2			
CI			1.1	3.0	0.8	0.8	1.2				
Mortality	A = 0.75, chi-square = 0.4353, (ages 7-9)										
Number		1	3	4	13	17	6	1			
Weight		0.50	0.67	0.88	1.40	1.76	1.83	2.00			
CI			0.29	0.44	0.27	0.22	0.49				
1992											
Number		1	8	15	14	19	12	3	3		
Length		11.5	12.2	14.8	16.7	17.0	19.0	21.5	18.6		
CI			0.6	0.6	1.2	0.7	2.1	8.7	6.3		
Mortality	A = 0.57, chi-square = 1.1031, (ages 7-10)										

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 15.–Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management area MI-4, 1988-92.

Year and parameters	Age (yr) 2	3	4	5	6	7	8	9	10	11	12
1988											
Number	1	25	115	209	157	43	11	2			
Length	11.7	12.1	13.1	14.9	16.6	18.2	20.4	21.6			
CI		0.5	0.2	0.2	0.2	0.6	1.8	6.3			
Mortality				A = 0.75, chi-square = 0.6452 (ages 6-9)							
1989											
Number	1	12	57	148	90	36	10	1		2	
Length	11.1	12.3	13.6	14.8	16.2	17.4	20.0	22.8		24.0	
CI		0.8	0.3	0.2	0.3	0.4	1.6			6.7	
Mortality				A = 0.67, chi-square = 0.6776 (ages 6-11)							
Number			11	22	10	2	2	1		1	
Weight			0.87	1.15	1.43	1.76	3.41	5.62		4.41	
CI			0.25	0.14	0.13	0.00	6.93				
1990											
Number		16	18	103	145	73	15	4	3	2	
Length		12.3	13.9	14.9	16.4	17.5	18.4	20.4	23.6	18.8	
CI		0.4	0.6	0.2	0.2	0.3	1.0	2.0	11.1	1.4	
Mortality				A = 0.71, chi-square = 3.3698 (ages 7-11)							
Number		1	3	6	23	9	6	2	1	1	
Weight		0.30	0.87	1.10	1.57	1.81	2.21	2.30	1.75	2.00	
CI			0.82	0.19	0.15	0.18	0.55	1.80			
1991											
Number		5	34	90	136	69	18	10			
Length		11.4	13.5	14.6	16.3	17.7	19.8	23.8			
CI		1.8	0.6	0.3	0.2	0.4	1.1	1.5			
Mortality				A = 0.69, chi-square = 0.0678 (ages 7-9)							
Number			4	13	27	25	12	4			
Weight			1.08	0.93	1.31	1.97	2.58	4.65			
CI			1.08	0.33	0.13	0.31	0.63	1.91			
1992											
Number		12	42	76	71	80	29	4	7	3	2
Length		11.8	13.7	14.7	16.5	18.2	19.8	19.9	20.9	24.4	22.4
CI		0.7	0.4	0.3	0.4	0.4	0.6	2.3	2.8	9.2	5.4
Mortality				A = 0.61, chi-square = 1.3543 (ages 7-12)							

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 16.–Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management area MI-5, 1988-92.

Year and	Age (yr)										
parameters	2	3	4	5	6	7	8	9	10	11	12
1988											
Number	15	55	88	73	31	11	1				
Length	12.3	14.0	15.5	16.9	18.9	22.1	29.4				
CI	0.8	0.3	0.3	0.4	0.9	2.3					
Mortality				A = 0.67, chi-square = 2.9342 (ages 6-9)							
1989											
Number	3	27	51	50	26	11	5	1			
Length	12.7	14.4	15.6	17.7	18.5	20.3	22.7	27.0			
CI	2.2	0.5	0.3	1.0	0.7	1.3	2.3				
Mortality				A = 0.58, chi-square = 1.4787 (ages 6-11)							
Number		6	16	10	10	4	1				
Weight		1.06	1.11	1.41	1.74	2.42	2.97				
CI		0.15	0.14	0.18	0.35	0.83					
1990											
Number	1	13	43	61	40	15	1		1		
Length	14.7	14.4	15.7	16.7	17.7	19.3	25.0		31.1		
CI		1.0	0.5	0.4	0.5	1.3					
Mortality				A = 0.73, chi-square = 0.6552 (ages 7-11)							
Number	1	8	12	10	5	3					
Weight	0.60	1.09	1.63	1.55	1.79	3.17					
CI		0.18	0.54	0.33	0.62	2.79					
1991											
Number	10	22	33	39	33	14	5	3	1		
Length	11.9	14.4	15.5	16.7	17.7	20.8	22.0	26.4	35.4		
CI	1.0	0.6	0.5	0.6	0.6	1.7	2.4	4.5			
Mortality				A = 0.60, chi-square = 0.0403 (ages 7-11)							
Number	4	7	13	9	8	2	1				
Weight	0.38	0.82	1.08	1.39	1.66	2.63	2.25				
CI	0.20	0.20	0.12	0.60	0.21	5.62					
1992											
Number	12	29	28	34	35	23	10	5	4	2	
Length	11.8	13.6	14.8	16.4	18.4	19.3	21.7	23.7	24.4	34.1	
CI	0.7	0.6	0.5	0.7	0.8	1.0	1.8	3.9	6.5	27.8	
Mortality				A = 0.48, chi-square = 0.8739 (ages 7-12)							

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 17.–Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management zone MI-6, 1988-92.

Year and parameters	Age (yr)										
	2	3	4	5	6	7	8	9	10	11	12
1988											
Number	3	4	36	25	10	6	2	1			
Length	12.0	14.1	15.8	17.0	18.3	21.7	21.6	30.4			
CI	1.2	0.4	0.6	0.7	0.8	4.0	1.4				
Mortality				A = 0.57, chi-square = 0.0106 (ages 6-10)							
1989											
Number	2	8	33	28	13	3	1	1			
Length	12.3	13.0	16.6	18.2	18.7	20.3	21.0	22.9			
CI	15.3	1.1	0.6	0.6	1.2	2.6					
Mortality				A = 0.64, chi-square = 0.3224 (ages 6-10)							
Number		5	24	17	8	3	1	1			
Weight		0.72	1.56	2.12	2.15	2.96	2.70	4.63			
CI		0.31	0.27	0.35	0.67	1.22					
1990											
Number	2	14	28	11	10	10	4				
Length	14.7	14.4	15.7	16.7	17.7	19.3	25.0				
CI	19.8	0.7	0.5	1.2	1.1	1.6	1.4				
Mortality				A = 0.45, chi-square = 4.226 (ages 6-9)							
Number		10	19	7	6	5	4				
Weight		1.60	1.84	2.00	2.08	2.70	2.31				
CI		0.18	0.21	0.62	0.60	1.17	0.43				
1991											
Number	1	7	18	32	22	2	4	2		1	
Length	14.5	14.5	17.0	17.5	18.2	21.8	21.1	19.6		19.3	
CI		2.2	0.7	0.7	0.7	23.8	2.8	13.9			
Mortality				A = 0.54, chi-square = 0.6900 (ages 6-12)							
Number		3	12	19	9	1	1				
Weight		1.25	1.81	1.93	2.17	4.75	3.75				
CI		0.51	0.30	0.22	0.38						
1992											
Number	7	11	13	26	26	12	6	1	1		
Length	11.2	14.3	16.8	18.2	18.3	18.8	19.9	21.2	28.5		
CI	0.8	1.0	0.7	1.4	0.7	0.8	1.3				
Mortality				A = 0.59, chi-square = 0.3191 (ages 7-11)							

[a] Mortality determined by the method described by Robson and Chapman (1961).
[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 18.–Age composition, mean total length (in) and mean total weight (lb) ± 95% confidence intervals (CI), and total annual mortality[a] (A) of wild lean lake trout in the pre-recruit assessment[b] in Michigan's Lake Superior management area MI-7, 1988-92.

Year and	Age (yr)										
parameters	2	3	4	5	6	7	8	9	10	11	12
1988											
Number		2	14	8	1	2					
Length		14.6	16.1	17.2	20.2	24.7					
CI		2.2	0.8	0.8		11.7					
Mortality				A = 0.67, chi-square = 0.4383 (ages 6-8)							
1989											
Number			5	9	5						
Length			17.1	18.9	20.2						
CI			0.5	1.6	1.3						
Mortality				A = 0.72, chi-square = 1.3423 (ages 6-7)							
Number			5	9	5						
Weight			1.55	2.21	3.93						
CI			0.14	0.68	2.90						
1990											
Number		2	6	3	6	2	2	2			
Length		13.6	15.4	19.0	16.9	21.0	20.8	27.8			
CI		0.9	1.2	5.3	1.7	3.1	1.4	47.2			
Mortality				A = 0.48, chi-square = 1.0353 (ages 7-10)							
Number		2	6	3	6	2	2	2			
Weight		1.00	1.33	2.58	1.71	3.50	3.38	6.63			
CI		0.00	0.25	2.11	0.46	0.00	3.37	34.81			
1991											
Number		8	11	32	4	3					
Length		14.4	16.1	16.8	18.2	19.4					
CI		1.2	0.8	0.4	1.6	2.6					
Mortality				A = 0.79, chi-square = 0.8868 (ages 6-8)							
Number		6	9	24	2	1					
Weight		0.88	1.23	1.45	2.00	2.25					
CI		0.33	0.21	0.15	4.49						
1992											
Number	1	1	7	16	11	11	3	2	1	1	
Length	10.5	12.2	15.4	16.7	17.4	19.4	20.7	19.2	20.1	23.6	
CI			0.7	0.8	1.0	1.0	2.9	4.0			
Mortality				A = 0.42, chi-square = 1.2149 (ages 6-12)							

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 19.–Age composition (number), and mean total length (in) ± 95% confidence intervals (CI), for the combined sample of hatchery lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7, 1988-92.

Year and	Age (yr)										
parameters	2	3	4	5	6	7	8	9	10	11	12
1988											
Number	2	23	50	4	18	8	12	2			
Length	11.0	14.8	15.5	16.6	16.9	18.4	18.8	19.1			
CI	7.6	0.6	0.7	2.0	1.2	1.8	2.7	9.9			
Length range	10-12	12-17	11-20	14-18	14-22	15-22	15-28	18-20			
1989											
Number	5	9	12	50	6	16	6	3			1
Length	9.9	13.3	14.3	15.7	16.4	18.4	17.5	19.5			31.2
CI	1.0	0.7	1.4	0.6	1.7	0.9	2.2	4.0			
Length range	9-11	11-14	11-19	12-21	14-18	15-21	13-19	18-22			
1990											
Number		9	17	21	34	3	5	4	1	2	1
Length		13.1	15.4	16.7	16.3	19.2	26.7	23.9	23.5	23.3	33.1
CI		1.1	0.8	1.3	0.6	16.8	5.0	7.6		27.0	
Length range		10-15	12-18	13-23	13-20	14-28	21-32	18-31		22-28	
1991											
Number	4		32	19	18	39	6	4	1		1
Length	13.1		16.0	17.8	16.4	18.7	19.4	21.8	27.8		23.2
CI	2.6		0.9	1.0	1.3	1.1	2.3	5.1			
Length range	11-16		12-22	14-22	13-21	14-25	15-22	18-26			
1992											
Number	4	8	8	38	13	7	10	1	4		1
Length	11.7	14.8	16.4	17.5	18.4	19.6	18.7	21.1	27.2		21.0
CI	1.2	1.7	1.4	0.8	1.9	2.0	1.8		8.0		
Length range	10-12	12-19	14-19	13-25	13-24	16-22	16-25		19-33		

[a] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 20.–Mean total weight (lb), with ± 95% confidence intervals (CI), for ages of wild and hatchery lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 in 1989-91.

Year and parameters	Age (yr) 2	3	4	5	6	7	8	9	10	11	12
1989 **Wild**											
Number		2	34	88	80	43	16	5	4	1	
Weight		0.80	0.84	1.28	1.70	2.22	2.77	3.77	4.74	4.41	
CI		0.74	0.09	0.10	0.14	0.29	0.47	1.92	1.37		
Weight range		0.7-0.9	0.1-1.6	0.6-3.6	0.9-4.4	1.1-8.6	1.3-5.1	1.9-5.6	3.5-6.0		
Hatchery											
Number	2	2	7	13	5	7	4				
Weight	0.33	0.91	0.92	1.45	1.31	1.56	2.30				
CI	0.50	0.25	0.24	0.45	0.43	0.70	0.74				
Weight range	0.3-0.4	0.9-1.0	0.6-1.3	0.4-3.2	0.9-1.8	1.0-2.2	1.7-3.0				
1990 **Wild**											
Number		6	27	70	73	45	29	12	3	1	1
Weight		0.51	1.16	1.32	1.46	1.69	2.73	3.04	5.00	2.00	5.50
CI		0.38	0.18	0.15	0.14	0.14	0.45	0.52	9.71		
Weight range		0.2-1.3	0.3-2.0	0.3-4.3	0.5-3.8	1.0-3.3	1.0-5.5	2.0-4.3	1.8-10.5		
Hatchery											
Number		4	10	8	9	2	2		1	2	
Weight		0.79	1.46	2.21	1.54	0.88	4.00		4.00	6.00	
CI		0.30	0.37	0.99	0.39	1.12	6.74			15.72	
Weight range		0.5-1.0	0.8-2.5	0.5-4.5	1.0-2.8	0.8-1.0	3.3-4.8			4.3-7.8	
1991 **Wild**											
Number		5	24	60	98	70	30	14	2	1	
Weight		0.40	0.90	1.20	1.48	1.87	2.62	3.60	6.88	8.00	
CI		0.15	0.17	0.13	0.09	0.14	0.39	0.78	23.58		
Weight range		0.3-0.5	0.5-2.2	0.5-2.5	0.5-3.0	1.0-4.4	1.3-5.0	1.5-5.9	4.3-9.5		
Hatchery											
Number	3	9	4	13	17	3	1	1			
Weight	0.87	1.08	2.59	1.49	2.07	2.25	2.00	8.50			
CI	1.12	0.43	1.40	0.50	0.69	1.34					
Weight range	0.5-1.5	0.6-2.5	2.0-4.1	0.8-3.2	0.5-4.8	1.5-2.8					

[a] Lake trout captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

Table 21.—Siscowet lake trout age composition, mean age ± 95% confidence intervals (CI), and total annual mortality[a] from the pre-recruit assessment[b] in Michigan's Lake Superior management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7, 28 July - 20 August, 1992.

Age (yr)	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	Total
4				1			1
5	2	2	6	8			18
6		7	7	5			19
7	1	16	4	11			32
8	4	42	10	16			72
9	7	47	8	6			68
10	9	26	11	21	2		69
11	7	28	21	18			74
12		22	18	13	2	1	56
13	3	15	7	13		1	39
14	2	8	6	5			21
15	1	2	5	2	1		11
16		1	3	1		1	6
18			1				1
20			1				1
25	1						1
Total	37	216	108	119	5	3	489
Mean age	10.4	9.8	10.6	9.8	11.8	13.7	10.0
CI	1.1	0.3	0.6	0.5	2.5	5.2	0.2
Total annual mortality rate (A).							
Ages	11-25	11-16	11-20	11-16	[c]	[c]	11-25
A	0.30	0.46	0.38	0.43			0.41
Chi-square	3.1343	4.3168	0.5834	2.6361			4.7954

[a] Mortality determined by the method described by Robson and Chapman (1961).

[b] Lake trout were captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh.

[c] Numbers insufficient for estimate.

Table 22.—Mean total length (in) ± 95% confidence intervals (CI) and total length range for siscowet lake trout ages 4-16 in the pre-recruit lake trout assessment[a] in Michigan's Lake Superior management areas[b] MI-2 through MI-5 and in the total sample from areas MI-2 through MI-7, 28 July-20 August 1992.

Area and	Age (yr)												
parameters	4	5	6	7	8	9	10	11	12	13	14	15	16
MI-2													
Number		2		1	4	7	9	7		3	2	1	
Length		11.0		14.7	16.7	17.1	18.2	20.2		18.9	23.0	21.7	
CI		14.4			2.0	0.8	1.0	1.0		3.0	27.4		
Length range		9.4-12.6			15.0-17.9	15.7-18.5	16.7-20.0	18.0-21.5		17.9-20.6	20.0-26.1		
MI-3													
Number		2	7	16	42	47	26	28	22	15	8	2	1
Length		11.1	13.1	14.6	15.6	16.1	17.1	18.6	18.9	19.4	20.4	21.4	20.8
CI		1.8	0.6	0.6	0.4	0.5	0.7	1.0	1.0	1.0	1.1	13.0	
Length range		10.9-11.3	11.7-13.9	12.6-16.7	12.4-18.2	13.5-21.9	14.3-20.8	12.8-26.5	15.3-22.8	15.1-22.4	18.0-21.9	20.0-22.9	
MI-4													
Number		6	7	4	10	8	11	21	18	7	6	5	3
Length		11.5	13.0	12.8	14.3	15.3	17.3	19.8	21.0	20.4	23.7	26.2	24.5
CI		0.5	1.3	0.4	0.9	1.2	1.3	1.0	1.6	2.4	4.0	2.7	5.4
Length range		11.0-12.4	12.0-16.3	12.5-13.1	12.6-16.6	13.5-18.0	14.5-21.5	15.5-23.6	16.5-28.0	16.8-25.0	17.5-28.7	23.4-29.4	21.5-26.6
MI-5													
Number	1	8	5	11	16	6	21	18	13	13	5	2	1
Length	9.2	10.7	13.2	13.3	11.6	13.9	14.5	16.1	13.2	17.9	20.2	24.3	25.5
CI		0.7	0.6	0.7	0.6	2.1	0.8	0.6	1.5	1.6	2.6	0.4	
Length range		10.7-12.9	13.2-14.7	13.3-17.2	11.6-17.1	13.9-19.7	14.5-21.6	16.1-20.3	13.2-22.9	17.9-26.8	20.2-25.7	24.3-24.4	
Areas 2-7													
Number	1	18	19	32	72	68	69	74	56	39	21	11	6
Length	9.2	11.5	13.3	14.6	15.3	16.2	17.6	19.1	20.0	20.5	22.0	24.3	24.0
CI		0.4	0.5	0.4	0.3	0.4	0.4	0.5	0.8	0.8	1.3	1.7	2.3
Length range		9.4-12.9	11.7-16.3	12.5-17.2	11.6-18.2	13.5-21.9	14.3-21.6	12.8-26.5	13.2-28.0	15.1-26.8	17.5-28.7	20.0-29.4	20.8-26.6

[a] Lake trout were captured in multifilament nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh.

[b] Number of siscowets caught in MI-6 and MI-7 too few for analysis by individual area.

Table 23.—Mean total weight (lb), mean total length (in), and the weight-length coefficients for lean and siscowet lake trout captured in the pre-recruit assessment[a] in Michigan management areas MI-2, MI-3, MI-4, MI-5, MI-6, and MI-7 of Lake Superior during 1989-91, with 95% confidence intervals (CI) on the means for weight and length and the weight-length intercept and slope coefficients.

Year	Variety	N	Mean total weight ± 95% CI, and (range)	Mean total length ± 95% CI, and (range)	Log_e total weight(lb)-log_e total length(in) coefficients ± 95% CI		R^2
					a	b	
1989	Lean	321	1.71 ± 0.12, (0.28-7.87)	17.0 ± 0.4, (9.0-28.2)	-8.31 ± 0.23	3.09 ± 0.08	0.95
1989	Siscowet	157	2.06 ± 0.22, (0.39-7.71)	17.3 ± 0.5, (10.4-26.8)	-8.67 ± 0.39	3.25 ± 0.14	0.93
1990	Lean	309	1.72 ± 0.12, (0.15-10.50)	16.9 ± 0.3, (10.5-33.0)	-8.85 ± 0.44	3.28 ± 0.16	0.85
1990	Siscowet	208	1.99 ± 0.20, (0.25-12.50)	17.5 ± 0.4, (11.0-29.9)	-8.96 ± 0.48	3.32 ± 0.17	0.88
1991	Lean	365	1.74 ± 0.11, (0.25-9.50)	17.1 ± 0.4, (10.0-29.3)	-8.52 ± 0.26	3.16 ± 0.09	0.93
1991	Siscowet	281	2.19 ± 0.16, (0.25-7.50)	18.1 ± 0.4, (10.0-26.2)	-9.10 ± 0.28	3.37 ± 0.10	0.94

[a] Lake trout were captured in multifiliment nylon gill nets made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch mesh fished during July-August.

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