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ASSESSMENT AND MANAGEMENT OF LAKE TROUT STOCKS IN MICHIGAN WATERS OF LAKE SUPERIOR, 1970-87[1]

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[1]A contribution from Dingell-Johnson Project F-53-R, Michigan.

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Assessment and Management of Lake Trout Stocks in Michigan Waters of Lake Superior, 1970-87

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Abstract.—Eighteen years (1970-87) of lake trout (*Salvelinus namaycush*) population assessment data from Lake Superior waters contiguous with Michigan's Upper Peninsula shoreline have been reviewed and summarized in this report. Commercial-size and pre-recruit lake trout populations in these waters shifted in composition from mostly hatchery to mostly wild during 1970-87. Wild lake trout abundance increased in all management zones during the late 1970s and early 1980s, but this increase was offset by a decrease in hatchery lake trout abundance. The initial decrease in hatchery lake trout abundance was attributed to a reduction in the number of yearlings planted, but abundance continued to decrease even though planting rates had remained relatively constant after 1971. Wild lake trout abundance also decreased in some zones during the 1980s. The decrease in lake trout abundance in most zones coincided more with increased lake trout catch by tribal fisheries than other factors. Factors such as planting rates since 1971, sea lamprey (*Petromyzon marinus*) predation, and catch in the sport fishery had not changed appropriately in recent years to link them to changes in lake trout abundance. Large lake trout abundance decreased in all zones. The loss of large lake trout was evident on most spawning reefs where spawner abundance in the 1980s was less than in the 1970s. Planting yearlings on spawning reefs rather than shoreline sites provided a greater contribution than cohort strays to subsequent spawning populations, but contribution to the total spawning population was significant only on the reef where total spawner abundance was low and made up primarily of hatchery fish. Lake trout tagged on spawning reefs were recovered mainly within the zone where tagged, but some were recovered in zones over 100 miles away. Michigan's lake trout management efforts during 1970-87 included restricting gill-net fisheries to waters 60 fathoms and deeper, prohibiting retention of lake trout taken in trap nets, reducing the sport-fish creel from five to three, planting yearlings on spawning reefs, and participating in interagency efforts to manage lake trout stocks in Lake Superior. Assessment recommendations are (1) continue the commercial-size assessment with elimination of one fishing ground in MI-4 and addition of one fishing ground in MI-6, (2) do pre-recruit assessment in all management zones at least every 2 years, (3) assess spawning lake trout populations every 5 years, (4) determine the conversion factors necessary to switch from multifilament to monofilament nylon mesh in assessment gill nets, and (5) use otoliths to age lake trout age-8 and older. Management recommendations are (1) maintain current restrictions on lake trout catch and effort in Michigan-licensed fisheries, (2) continue to participate in interagency management of lake trout, (3) maintain an assessment of the lake trout sport fishery at major ports, (4) plant yearling lake trout only on spawning reefs where spawner abundance is low, and (5) evaluate survival of hatchery lake trout cohorts from different hatcheries and in other Great Lakes.

Lake trout (*Salvelinus namaycush*) populations in the Great Lakes have been severely affected by commercial fishing and predation by sea lamprey (*Petromyzon marinus*) during this century. By the early 1960s, lake trout were extinct in Lake Michigan and the main basin of Lake Huron, and nearly so in Lake Superior. The destruction of lake trout stocks in the Great Lakes resulted in an international restoration effort. The Great Lakes Fishery Commission was established by treaty between Canada and the United States in 1955 to implement sea lamprey control and coordinate research on fish stocks of common concern throughout the Great Lakes. Individual states and the Province of Ontario also became more involved in the management of Great Lakes fishes. In Lake Superior during the 1960s, Michigan closed the commercial fishery for lake trout, limited the number of fishers, and initiated efforts to eliminate the use of gill nets at depths shallower than 50 fathoms. These regulations, reduced sea lamprey abundance, and annual plants of millions of hatchery yearlings resulted in restoration of adult stocks to record levels by the late 1960s (Pycha and King 1975).

Since 1970 lake trout stocks have still been affected by predation and exploitation. Sea lamprey populations were not eliminated and continued to prey on lake trout. The abundant lake trout resulted in reestablishment of the lake trout sport fishery, and treaty fishing rights of Native American tribes were confirmed, which resulted in commercial fishing with gill nets in most of Michigan's Lake Superior waters.

Lake trout assessment in Michigan waters of Lake Superior prior to 1959 was restricted to commercial catch data (Baldwin et al. 1979) for the statistical districts described by Hile (1962). Abundance and biological assessment of commercial-size (≥17 inches 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 during 1970-87 and has been complemented with periodic assessments of spawning stocks and pre-recruit (mostly juveniles <17 inches long) stocks starting in 1973 and 1975. Michigan began an annual assessment of the sport fishery in 1967.

The lean, siscowet, and humper varieties of lake trout in Lake Superior are sufficiently distinct to be recognized by some anglers, commercial fishers, and biologists (Eschmeyer and Phillips 1965, Rahrer 1965, Khan and Qadri 1970), and are routinely kept separate in assessment catches from Michigan waters. Although distributions may overlap, lean lake trout usually predominate in water less than 40 fathoms deep contiguous with the Upper Peninsula shoreline and around offshore reefs and islands, siscowets are most abundant deeper than 50 fathoms, and humper lake trout are generally found only on offshore reefs around Isle Royale and Caribou Island.

This report describes assessment methods, assessment results, and management during 1970-87 for stocks of hatchery and wild lean lake trout (henceforth referred to as lake trout) in waters 40 fathoms and shallower that are contiguous with Michigan's Upper Peninsula shoreline. The report also presents recommendations for future assessment and management. Most data described in this report are those collected by the Michigan Department of Natural Resources (MDNR), but some data collection and tabulation were performed by personnel from the U. S. Fish and Wildlife Service (USFWS) Biological Station at Ashland, Wisconsin.

Methods

Assessment data were obtained from lake trout stocks in management zones MI-2, MI-3, MI-4, MI-5, MI-6, MI-7, and MI-8 (Figure 1). A similar assessment has been conducted for lake trout stocks in waters contiguous with Isle Royale (MI-1); these data will be presented in a separate report (MDNR and USFWS, unpublished data). Individual management zones with location of assessment netting sites are presented in Figures 2-8. The area of each zone 40 fathoms and shallower is depicted in these figures and presented in Table 1. The management zones presented in this report generally follow the boundaries of statistical districts described by Hile (1962), except that districts 3 and 4 have been each divided into two zones and zone 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 and are used to further subdivide management zones and statistical districts.

The interpretation of parameters was similar in the commercial-size, pre-recruit, and spawner assessments. CPE (number of lake trout per 1,000 feet of gill net) was used to assess relative abundance among years within management zones. Comparisons between or among zones were made on the assumption that the amount of sampling in each zone offset differences among individual netting sites, therefore, zone CPEs would be indicative of lake trout relative abundance. Netting sites in all zones except MI-3 were widely distributed within the lake trout habitat (≤40 fathoms). The assessments were conducted during the same 1- to 2-month period each year at specified depths with the same gear. CPE was calculated by fin clip to assess origin (clipped hatchery or non-clipped wild) and to assess the contribution of specially marked plants to spawning stocks, and by size to assess abundance of large (≥25 inches, total length) mostly mature fish.

Lake trout origin (hatchery or wild) was based on the presence or absence of a fin clip, with all having a clip designated as hatchery and those with no clip designated as wild. Thousands of hatchery lake trout have been planted annually in Michigan waters of Lake Superior (Table 1). Practically all of these lake trout have been fin clipped. The percentage of planted lake trout that were accidentally or intentionally not clipped has been low. Only 1-4% of the lake trout in assessment samples from Michigan waters of Lake Superior during 1967-70 were not clipped (Pycha and King 1975) and some of these could have been wild. Most hatchery lake trout were planted as yearlings, but some were planted 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 planted fish. Recent survival-to-yearling values for fall fingerling plants have ranged from 63% for the largest fingerlings to 45% for the smallest. Numbers of fall fingerlings were converted to yearlings in Table 1 based on a mean survival rate of 55%, except that only 20% of the fingerlings planted in 1984 were assumed to have survived to yearling age because they were disease stressed (USFWS, Ashland, Wisconsin, unpublished analyses).

Sea lamprey wounding was determined for the total commercial-sized sample (≥17 inches) and for the best represented large lake trout size group (25.0-28.9 inches) to illustrate the size-selective nature of sea lamprey predation. Sea lamprey 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 only means of estimating lake trout mortality due to sea lamprey in Lake Superior.

Lake trout age was mainly determined from the length-frequency distribution of each fin clip during the 1960s and into the 1970s because practically all of the lake trout were of hatchery origin, each hatchery year class was given a distinctive fin clip, and there was little overlap of year-class length distributions because there was a 3- to 5-year interval between year classes using the same clip. However, lake trout growth slowed during the 1970s and early 1980s (Busiahn 1985) as lake trout stocks increased in age and abundance, and as forage fish abundance decreased (Selgeby 1985). Length distributions of hatchery year classes even 3-5 years apart began to overlap substantially and more non-clipped (presumed wild) lake trout were caught. In addition, some clips were used at intervals less than 3-5 years to accommodate special studies, further complicating use of length-frequency by fin clip to separate age groups. By the late

1970s, scale samples were collected from most lake trout in the assessment catches. Scale analysis has been the primary method of determining age of lake trout during 1970-87, with fin clip used to verify scale age of hatchery fish.

Commercial-size lake trout (17 inches and longer, total length) were assessed annually at 10 fishing grounds in management zones 3-8 during April-May (Figures 3-8). The assessment data were derived from the catch (number) in 72-hour sets of 1,500-foot or 3,000-foot gangs of 4.5-inch stretched-mesh multifilament-nylon mesh gill nets fished at depths of 20-40 fathoms at two to five sites on each ground until a quota of fish was captured on each ground. This quota was as high as 1,000 fish per ground during part of the 1970s but has been 500 fish at all grounds since 1980. Contracted commercial fishers conducted the assessment fishing using the marketable lake trout as contract payment. MDNR personnel monitored and collected data from some catches during the 1970s and most catches during the 1980s, with the assessment fishers responsible for data collection from the remainder. MDNR personnel assumed responsibility for assessment at two grounds (Whitefish Bay and Grand Marais) when lake trout abundance became too low to interest commercial fishers. CPE of hatchery and wild lake trout and CPE of all lake trout 25 inches and larger were determined for the assessment catches. Data collected for individual fish were total length, fin clip, number and classification of sea lamprey marks, and age (years) determined from fin clip and/or scale samples. Scale samples were sent to the USFWS Biological Station at Ashland, Wisconsin, for age analysis. Some mean-age and age-range data for 1970-85 were derived from age distribution data provided by the USFWS, Ashland, Wisconsin, and are presented in the text. Otoliths were collected from some lake trout in 1986 and 1987 because the validity of scales for aging older lake trout was suspect. Otolith samples were sent to the Ontario Ministry of Natural Resources, Thunder Bay, Ontario, for subsequent analysis. Some of the CPE and individual fish data collected during 1970-78 were lost or could not be verified for certain management zones and are not presented in this report. Sex and some maturity data were collected but were not used in this report. Assessment of maturity was attempted during the 1970s but discontinued during the 1980s because it could not be done with certainty during this spring-sampling period. Dressed and round weight data are not presented in this report. Dressed weight of the entire catch in each net was recorded and used by the commercial fishers for their monthly reports, and occasionally used by biologists in reports of total lake trout harvest (Great Lakes Fishery Commission and Technical Fisheries Review Committee reports, unpublished) or to roughly estimate weight of individual lake trout. Round weight was obtained for some individual lake trout sampled at Marquette (MI-5) in 1986 to reevaluate the length-weight relationship for future quota calculations. CPE, fish length, and fish age from this assessment were not normally distributed which precluded calculation of parametric comparative statistics, at least without transformation. These non-transformed CPE, length, and age data are presented as population indices rather than direct measures of population parameters.

The assessment of pre-recruit lake trout was done with 1,800-foot gangs of multifilament-nylon graded-mesh gill net (300-foot panels of 2.00-, 2.25-, 2.50-, 2.75-, 3.00-, and 3.50-inch stretched mesh) fished 24 hours at depths of 15-50 fathoms at eight sites in the area encompassed by management zones MI-2 and MI-3 in 1983 and 1986; at 18 sites in the area encompassed by zones MI-4, MI-5, and MI-6 in 1975, 1978, 1981, and 1984-87; and at two sites in MI-7 during 1986-87 (Figures 2-7). The assessment was conducted during August but occasionally started the last week in July and extended into the first week of September. All lake trout captured in these graded-mesh nets, regardless of size, were included in the pre-recruit data. Most lake trout in these nets were less than 17 inches long, and lake trout of this size were infrequently taken in the sport fishery or in 4.5-inch and larger mesh gill nets used in state-licensed and tribal commercial gill-net fisheries. Lake trout captured in this assessment were recorded as number per 1,000 feet of net (CPE); with total length, sex, maturity, fin clip, number and classification of sea lamprey marks, and age from scale analysis determined for individual fish. USFWS personnel conducted the assessment and data analysis at these sites in zones MI-4, MI-5, and MI-6 in 1975, 1978, 1981, and 1984; and in MI-2 and MI-3 in 1983 and 1986. All data collection and analysis since then has been done by Marquette Fisheries Station personnel.

Spawning lake trout were assessed on selected reefs in MI-4 and MI-5 during October-November 1982-86 (Figures 4-5). Assessment collections were made with 24-hour sets of 4.5-inch stretched-mesh multifilament-nylon gill nets fished on the reefs. Data obtained included CPE of hatchery and wild lake trout in each set, and fin clip, total length, sex, maturity, and age for individual fish. Live fish were tagged with a numbered anchor tag (Floy FD-67C) and released to determine movements. To determine if yearling lake trout planted on spawning reefs would make a significant contribution to subsequent spawning populations, some plants of yearlings made on reefs in 1976 and 1977 were given special fin clips to identify them from cohorts planted at mainly shoreline planting sites. The contribution of these reef-planted lake trout to the respective reef spawning populations was evaluated during the 1982-86 spawning lake trout assessment.

The lake trout sport fishery was assessed lake-wide with a mail survey during 1967-82 (G. C. Jamsen, Fisheries Division, Michigan Department of Natural Resources, Lansing, personal communication), and with on-site creel surveys in MI-5 during 1984-87 (Marquette Fisheries Station, unpublished) and in MI-2, MI-4, and MI-6 in 1987 (Rakoczy and Rogers 1988). These data are presented in Table 2. The mail-survey method involved mailing periodic questionnaires to a 2-4% random sample of licensed anglers at intervals of 3 months or more and analyzing the returns (Jamsen 1985). The on-site creel surveys were based on stratified-random angler counts and direct-contact interviews (Ryckman 1981) at major fishing ports.

The commercial catches of lake trout by Native American tribal fishers operating under 1836 and 1842 treaties during 1976-87 are reported in Table 3. Michigan waters of Lake Superior included in the 1836 treaty were those east of a line running north from the mouth of the Chocolay River in MI-5 (Figure 1). All Michigan waters west of this line were included in the 1842 treaty. The catch data presented for 1836 treaty waters were provided by the Chippewa/Ottawa Treaty Fisheries Management Authority (COTFMA) in unpublished reports by the Tripartite Technical Working Group (TTWG) and the Technical Fisheries Review Committee (TFRC). In 1842 treaty waters, catch data for 1976-83 from MI-4 were obtained from fish wholesale records because tribal fishers were not required to report their catch during that period. The catches in management zones 2-5 since 1983 have been monitored and presented in unpublished reports by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

Assessment Results

Commercial-size Lake Trout

MI-2.—No assessment of commercial-size lake trout was done in MI-2 (Figure 2) during 1970-87 because there was no state-licensed commercial fishery available for contract, and the MDNR was either not equipped or committed to conduct assessments in other zones. The number of hatchery lake trout planted in this zone ranked third among the seven zones, but the mean planting density ranked only fifth because of the large area of water 40 fathoms and shallower (Table 1). MI-2 was one of the more intensively sport-fished zones. Sportfishing catch and effort increased during the mid- to late-1970s then declined after 1979 (Table 2). The 1987 on-site estimates of catch and effort were lower than those from the 1978-82 mail survey by a factor of about five. Wild lake trout have contributed more than 50% to the sport catch at least since 1983. Tribal fishing began in this zone in 1984 (Table 3). The percentage of wild lake trout in the tribal catch increased from 61% in 1985 to 70% in 1987.

MI-3.—Michigan has conducted an assessment of commercial-size lake trout at one fishing ground (Upper Entry) with two netting sites in MI-3 during 1970-87 (Figure 3). Plants of hatchery lake trout averaged over 100,000 yearlings for year classes through 1968, were discontinued for 4 years, then resumed but at a much lower level (Table 1). The mean number planted in MI-3 was the lowest among the seven zones. Hatchery lake trout CPE increased dramatically in 1972, was highest during the late 1970s and early 1980s, then dropped to pre-1972 levels after 1985 (Table 4). Wild lake trout CPE increased irregularly during 1970-84, but has since been less than the 1984 peak value of 14.5. Wild lake trout made up most (68%) of the commercial-size assessment for the first time in 1987. The CPE of large lake trout increased during the 1970s, leveled off, then declined sharply in 1986. Lake trout mean total length increased during the early 1970s then decreased in 1987. Mean age of lake trout in the assessment samples was 6.5 years in 1970 and 8.2 years in 1985. Ages ranged from 3 to 15 years for hatchery lake trout and from 4 to 13 years for wild lake trout. Sea lamprey wounding rates on all commercial-size lake trout have been relatively constant during the period except for higher rates during 1975-78 and lower rates since 1984. Sport fish catch and effort were generally higher during 1971-76 than during 1977-82, but the highest catch was in 1981. No on-site creel survey has been done in MI-3. Tribal commercial fishing began in this zone in 1984. The annual catch of lake trout in this fishery increased to 64,000 pounds by 1987 (Table 3).

MI-4.—Michigan conducted assessments of commercial-size lake trout stocks at four fishing grounds (Bete Grise, Traverse Island, Lower Entry, and Point Abbaye) in this management zone during 1970-87. These four grounds included nine netting sites (Figure 4), making MI-4 the most heavily fished zone. MI-4 has been the most heavily planted zone in terms of total number planted annually, with recent plants (1984-85 year classes) comparable in number to the 20-year mean (Table 1). MI-4 ranked second to MI-5 in terms of planting density. CPE of hatchery lake trout in the commercial-size assessment catch increased during the early 1970s, leveled off for the remainder of the decade, then declined during the 1980s (Table 5). Wild lake trout CPE increased during 1970-80, decreased sharply in 1982, but has increased in 1986-87. Wild lake trout have made up most of the assessment catch since 1985 and contributed 86% in 1987. CPE of large lake trout peaked in 1977 then declined steadily. The 1987 CPE of 1.0 was the lowest recorded during 1970-87. Mean length of lake trout in the assessment sample likewise peaked in 1977 then declined. Mean age was 6.8 years in 1970 and 7.6 years in 1985. Ages ranged from 3 to 16 years for hatchery lake trout and from 4 to 14 years for wild lake trout. Sea lamprey wounding on all size groups of lake trout was higher during the 1970s than during the 1980s. The sport catch of lake trout in MI-4 increased during the early 1970s then decreased somewhat thereafter. This zone and MI-5 were the most heavily sport fished zones. The on-site estimates of catch and effort in 1987 were the lowest recorded for MI-4 and differed from the 1978-82 mail-survey estimates by factors of 8.4 and 8.3, respectively. Tribal commercial fishing began in this zone in 1971, but catch data were not available for 1971-75. The reported catch averaged over 100,000 pounds during 1976-78, declined to 15,900 pounds in 1983, then increased and averaged about 104,000 pounds during 1986-87 (Table 3).

MI-5.—Commercial-size lake trout have been assessed at two fishing grounds (Big Bay and Marquette), each with two netting sites, annually during 1970-87 (Figure 5). MI-5 has been planted almost as heavily as MI-4 in terms of total number, and recent plants have fluctuated near the 20-year mean of 268,000 yearlings (Table 1). MI-5 was the most heavily planted in terms of density because it had the third-lowest water area 40 fathoms and shallower. Hatchery lake trout CPE peaked at 89.6 in 1975, remained relatively high until 1980, decreased sharply in 1980, fluctuated without trend through 1986, then dropped to a record low of 5.1 in 1987 (Table 6). Wild lake trout CPE has increased irregularly with a peak of 58.9 in 1986. Wild lake trout contributed 88% of the assessment catch in 1987. Large lake trout CPE increased to a peak of 39.0 in 1979, but has since declined irregularly with a low of 4.0 in 1987. Lake trout mean total length in the annual assessment catches was largest in 1979 and smallest in 1987. Mean age was 7.1 years in 1970 and 7.7 years in 1985. Ages ranged from 3 to 15 years for hatchery lake trout and from 4 to 12 years for wild lake trout. Sea lamprey wounding rates on lake trout in MI-5 were some of the lowest among management zones. Sea lamprey wounding fluctuated without trend during 1970-87. Lake trout catch and effort in the sport fishery in MI-5 rivaled that in MI-4 (Table 2). The increase in lake trout catch and sportfishing effort during the early 1970s and decrease during the late 1970s in Michigan waters of Lake Superior was most evident in this zone. Annual catch in the 1984-87 on-site estimates averaged 10,000 lake trout. On-site estimates of catch and effort were lower than the 1978-82 mail-survey estimates by factors of 2.6 and 1.7, respectively. Tribal commercial fishing began in 1986, but at a relatively low level (Table 3).

MI-6.—Assessment of commercial-size lake trout stocks has been done at one fishing ground (Munising) in MI-6 annually during 1970-87. Five netting sites span the full width of this zone (Figure 6). The number of lake trout planted annually in MI-6 has been much less than in MI-4 and MI-5, although the magnitude of the difference was less on a density basis (Table 1). Hatchery lake trout CPEs have decreased irregularly during 1970-87, with peaks of 89.1 in 1972 and 50.7 in 1981 (Table 7). Hatchery lake trout CPEs in the 1980s have averaged about half of those in the 1970s. Wild lake trout CPEs have increased irregularly during 1970-87. Employment of different commercial fishers and inconsistent sampling effort among netting sites are suspected to be the major factors contributing to the extreme CPE fluctuations observed in MI-6. The high CPEs for both hatchery and wild lake trout in 1981 are believed to be the result of unequal sampling effort among netting sites. Most effort that year was at the western sites where CPEs have traditionally been highest. Wild lake trout have outnumbered hatchery lake trout in annual assessment catches since 1983 and contributed 88% to the 1987 catch. Large lake trout CPE peaked at 18.5 in 1972 then declined steadily for the remainder of the period. Lake trout mean total length was greatest in 1971, was relatively uniform during the 1970s, then decreased after 1980. Lake trout mean age was 7.1 years in 1970 and 7.2 years in 1985. Lake trout age ranged from 3 to 15 years for hatchery lake trout and from 4 to 14 years for wild lake trout. Sea lamprey wounding in MI-6 fluctuated without trend for all sizes of lake trout over the 14 years of available data, and was the highest among all zones. The sport catch of lake trout in MI-6 fluctuated without trend during 1971-82 (Table 2). The 1987 on-site estimates of catch and effort were lower than those from the mail survey by factors of 12.2 and 2.0, respectively. Tribal fishing began in this zone in 1974, with lake trout catches highest during 1977-79 then dropping about 50% and leveling off through 1987 (Table 3).

MI-7.—Assessment of commercial-size lake trout stocks has been done annually at one fishing ground (Grand Marais) in MI-7 during 1970-87. The four netting sites were distributed across four of the five-grid width of this zone (Figure 7). Plants of hatchery lake trout have been reduced considerably in this zone during the past 20 years (Table 1), with none being planted in recent years because MI-7 was declared a deferred rehabilitation zone by the 1985 Negotiated Settlement. MI-7 has the least amount of water 40 fathoms and shallower, resulting in a relatively high mean planting density. Hatchery lake trout CPE decreased from 67.3 in 1970 to 1.4 in 1987 (Table 8). Wild lake trout CPE increased irregularly during the 1970s, was highest during 1980-84, but more recent values have been lower. Wild lake trout have made up most of the assessment catches since as early as 1979 and consistently since 1983. Wild lake trout made up 88% of the catch in 1987. Large lake trout CPE has oscillated with peaks at 11.6 in 1975 and 11.3 in 1984, but those for 1985-87 were the lowest recorded. Mean length fluctuations corresponded to CPE trends for large lake trout. Lake trout mean age was 6.9 years in 1970 and 7.7 years in 1985. Lake trout ages ranged from 3 to 15 years for hatchery lake trout and from 4 to 14 years for wild lake trout. Sea lamprey wounding has fluctuated without trend during 1970-87. The lake trout sport catch was highest in 1973 and 1975, but the mail-survey estimates for other years have been less than 3,000 annually (Table 2). No on-site creel survey has been done in this zone. Tribal commercial fishing has taken place in this zone since 1974. The tribal lake trout catch was low during 1976-84 then increased substantially because tribal fishers displaced by the 1985 Negotiated Settlement moved their operations into this zone (Table 3).

MI-8.—Assessment of commercial-size lake trout has been conducted in MI-8 at one fishing ground (Whitefish Bay) with four netting sites annually through 1982, but only once (1985) since then (Figure 8). The numbers of hatchery lake trout planted in this zone were reduced significantly in 1974 (1973 year class) but annual plants of at least 150,000 fingerlings were reinstated in 1985 as part of the Negotiated Settlement (Table 1). Planting density was the least of all zones because of the low number planted and the greatest area of water 40 fathoms and shallower. Hatchery lake trout CPEs increased and peaked at 54.4 in 1974, dropped precipitously to 8.3 in 1975, declined further to 1.1 in 1981, then increased to 6.0 in 1985 (Table 9). Wild lake trout CPE was low throughout the period, reaching a high of 2.1 in 1979 and 1985. Wild lake trout outnumbered hatchery lake trout only in 1979. Mean length was relatively uniform throughout the sampling period with the exception of a 23.3-in mean in 1975. Lake trout mean age was 6.2 years in 1970 and 6.6 years in 1985. Hatchery and wild lake trout age ranged from 3 to 12 years and from 4 to 11 years, respectively. Sea lamprey wounding rates were variable and without trend. Wounding rates for large lake trout varied between 0.0 and 31.1 in the last five assessment years, but sample size was small. Sportfishing catch and effort in MI-8 was the lowest among zones, with most occurring during the early 1970s (Table 2). No on-site creel survey has been done in this zone. A tribal commercial fishery employing gill nets began in MI-8 in 1971 and intensified during the early 1970s. The tribal commercial catch was high during 1976-78, decreased during the early 1980s, but recovered by 1987 (Table 3).

Pre-recruit Lake Trout

The abundance of hatchery lake trout decreased and the abundance of wild lake trout increased several-fold in the pre-recruit assessment catches from all management zones sampled during 1975-87 (Figures 2-7 and Table 10). Hatchery lake trout CPEs decreased abruptly between 1978 and 1981 in MI-4 and MI-5, and between 1983 and 1986 in MI-2 and MI-3. The decrease was much more gradual in MI-6. CPE of wild lake trout in zones 2-6 generally increased during this assessment period, but appears to have leveled off in zones 4-6 in recent years. Pre-recruit lake trout have been assessed in MI-7 only since 1986, so the decrease in wild lake trout CPE in 1987 may be due in part to extremes of sampling variation. The percentage of wild lake trout in pre-recruit assessment samples increased substantially in all zones and ranged from 76% in MI-5 to 93% in MI-6 in 1987.

Pre-recruit wild lake trout age composition and mean total length at each age was similar in management zones 4-7 during 1986-87 (Table 11). Ages 5 and 6 were the most abundant age groups in the assessment catches from all four zones, except that ages 4 and 5 were most abundant in MI-5 in 1986. Lake trout older than age 8 were rarely captured and were not included in Table 11. No age data were available for MI-2 and MI-3 assessment samples. Hatchery lake trout samples obtained in zones 4-7 during 1985-87 were too meager and variable for analysis of age composition and growth. They contributed 20% or less to the graded-mesh catch in all but MI-5 during 1985-87. Hatchery lake trout did provide some information on movements in that most hatchery lake trout captured in MI-6 and MI-7 were of the 1982 year class that was planted only in MI-4, MI-5, and MI-8.

Lake Trout Spawning Populations

The abundance of mature lake trout on traditional spawning reefs in MI-4 and MI-5 (Figures 4-5) assessed on the basis of CPE during October-November 1982-86 was generally lower than that reported for some of these same reefs by Peck (1979) during the mid-1970s (Table 12). Exceptions were Manitou Island, where CPE increased, and Garlic Island, where CPE remained the same. The percentage of wild lake trout increased on all reefs except at Huron Islands, where wild lake trout were most abundant even in the mid-1970s. Ages determined for spawning lake trout are not presented because the scale method was suspected to be invalid for large lake trout.

Yearling lake trout planted on off-shore spawning reefs made a substantial contribution to subsequent spawning populations on the reef where spawners were mainly hatchery and abundance was low, but not on those reefs where spawners were mostly wild and abundance was either high or low (Table 13). On Manitou Island, where abundance was low and most of the spawners were of hatchery origin, reef-planted yearlings contributed a mature trout CPE nearly seven times greater than cohort strays from shoreline planting sites. This CPE was almost 13 times greater when adjusted to equate number of reef- planted yearlings to those planted at shoreline sites in MI-4. This contribution was either 21% (unadjusted) or 41% (adjusted) of the total spawning population during those years. On Huron Island Reef, where abundance was also low but most of the spawners were wild, reef-planted yearlings contributed more than cohort strays but they made up only slightly more than 5% (unadjusted) or 10% (adjusted) of the total population. On Partridge Island Reef, where spawner abundance was high and most were wild, yearlings planted on the reef in 1976 contributed more than the cohort strays, while those planted in 1977 contributed less. However, the contribution to the total spawning population on Partridge Island Reef was 4% or less for both plants even for adjusted CPEs. This analysis was complicated by the unknown contribution of cohort strays from outside the management zone, by the difference in numbers of reef-planted and cohort fish, and by using the special clip for plants on more than one reef and a shoreline site in MI-5. Despite complications, these data indicate that reef planting was unnecessary in most of Michigan waters during 1970-87. Off-shore reefs in Michigan waters had abundant spawning populations made up predominantly of strays from shoreline planting sites during the 1970s (Peck 1979) and of wild lake trout during the 1980s.

Movements of adult lake trout were assessed from tag returns for 1,732 lake trout tagged during the spawning period (October-November) in management zones MI-4 and MI-5 during 1973-87. Tag returns were obtained mainly from the sport fishery and tribal commercial fishery, but some came from MDNR assessment and special project fisheries. This effort was without design, most of the returns were voluntary, and we did not attempt to adjust percentage return for relative fishing effort among zones, so little can be said about different rates of return. Most of the tag returns were from the 1,191 hatchery lake trout tagged in MI-5 (Presque Isle Harbor) in 1973. Lake trout tagged in 1973 were recaptured as late as 1985, but most (88%) were recaptured during the first 5 years (1973-77). Recapture of tagged lake trout in all management zones was mainly from the zone where they were tagged (74%), but some (6%) were recaptured two zones away at distances approaching or exceeding 100 miles. Of those recaptured outside the management zone where tagged, more were from zones east (23) than west (13). That most tagged lake trout moved east is probably a valid conclusion even without adjustment for fishing effort because, in the case of MI-5, there was more fishing (Tables 2 and 3) west (MI-4) than east (MI-6).

Population Abundance

Lake trout populations in all management zones in Michigan waters of Lake Superior during 1970-87 were characterized by a decrease to near insignificance of hatchery trout, an increase to predominance of wild trout, but a decrease in total lake trout abundance. Hatchery lake trout continued to increase through the mid-1970s from the already high abundance achieved in the late 1960s. This was due to high planting rates and apparent good survival of the planted fish. Wild lake trout, which were practically non-existent in 1970, had increased many-fold in abundance by 1980. However, any feelings of euphoria these events may have generated among lake trout biologists faded during the 1980s as hatchery lake trout abundance decreased in all zones, wild lake trout abundance either decreased in some zones or the increase slowed or leveled off in others, and abundance of both hatchery and wild large lake trout decreased in all zones. Factors that have been considered as affecting the above changes in lake trout abundance include planting, competition, predation, and fishing. Disease has been suggested as a factor leading to the decrease in hatchery lake trout abundance. However, disease was not known in hatchery year classes prior to 1984, and therefore not considered to have influenced lake trout abundance in the 1970-87 assessments.

The initial reduction in hatchery lake trout abundance was attributed to a reduction in the number planted after 1970. The number planted in Michigan waters was reduced from 2 million annually to about 1 million annually starting with the 1970 year class planted in 1971 (Table 1). Following this initial 50% reduction, planting leveled off around a mean of 0.9 million for year classes through 1985. This planting trend occurred in all zones with only some variation in the initial percentage reduction. If abundance of hatchery lake trout was mainly related to number planted, then CPE trends in the commercial-size assessment should follow trends in the number planted, allowing 7-8 years for lake trout planted as yearlings to become fully vulnerable to the 4.5-inch gill nets. Under this scenario, CPEs would drop rather abruptly after 1979 then level off. This CPE trend was evident in MI-5, where CPEs dropped from 60-70 and leveled off around a mean of 30 between 1979 and 1986 (Table 6); and possibly in MI-6, where (excluding 1981 and 1982) CPEs have leveled off around a mean of 8 during 1978-87 (Table 7). Hatchery lake trout abundance trends in MI-3, MI-4, MI-7 and MI-8 did not correspond to planting trends. CPEs in MI-3 did not show a decrease until about 6 years after reduced plants would have entered the fishery (Table 4), CPEs in MI-4 decreased steadily after 1980 despite uniform planting rates (Table 5), CPEs in MI-7 decreased irregularly throughout 1970-87 (Table 8), and CPEs in MI-8 dropped sharply between 1974 and 1975, then decreased steadily for the remainder of the decade (Table 9).

The effects of wild lake trout on hatchery lake trout and the effects of other fishes on all lake trout have not been directly measured. CPEs of wild lake trout have increased in all zones (Tables 4-9) and increased competition can be inferred from this increased abundance. However, for commercial-size fish, abundance of hatchery lake trout remained at the highest level in the zone with the highest abundance of wild trout (MI-5), but decreased to the lowest level in the zone with lowest abundance of wild lake trout (MI-8). This indicates that wild lake trout abundance may not be the dominant factor affecting abundance of hatchery lake trout. Although siscowet abundance may have increased in recent years, significant competition was not suspected because they were absent or much less abundant than lake trout in the commercial-size and pre-recruit assessment samples from lean lake trout habitat (water depths of 40 fathoms or less). Coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tshawytscha*) have been suspected of competing with lake trout, but the only available abundance data for these species (mail-survey sport catch) indicated no change in abundance since 1975. Sport catch of both increased during the early 1970s then fluctuated without trend into the early 1980s. Annual catches from the MDNR mail survey during 1975-81 were 28-95 thousand for coho and 7-28 thousand for chinook. The 1987 on-site estimates were less (10,194 coho and 1,472 chinook) but may be comparable given the reported inflationary bias of the mail survey. Sea lamprey abundance definitely affects lake trout, but this abundance, as indicated by wounding rate, has decreased or remained unchanged during 1970-87.

The decreases in lake trout abundance coincided more with increased tribal commercial fishing activity than any other factor, but the coincidence was not complete. Sportfishing catch and effort (Table 2) either decreased or was unchanged as lake trout abundance decreased. In MI-3, CPEs of hatchery and wild lake trout decreased sharply after 2 years of tribal fishing (Table 3). In MI-4, the hatchery and wild lake trout CPE decreases coincided not with the initiation of tribal fishing but with the shift of that fishing effort to off-reservation waters in the vicinity of assessment stations in the early 1980s. In MI-5, hatchery lake trout CPE decreased sharply in 1987, 1 year after the initiation of tribal fishing in this zone. However, it is hard to imagine that the relatively small harvest by tribal fishers in this zone in 1986 could be responsible for the drastic decline in hatchery lake trout CPE in 1987. Tribal fishing did not appear to have affected commercial-size lake trout abundance in MI-6. This may be because the harvest was low relative to the lake trout population, or the effect of tribal harvest could have been obscured if most of the tribal fishing was done in the eastern part of MI-6, because most of the assessment catch has come from the western part. In MI-7, little tribal fishing occurred prior to 1980. This fishing increased gradually through 1984, then increased substantially during 1985-87. It seems unlikely that the low level of tribal fishing in MI-7 prior to 1980 was responsible for the observed decrease in hatchery lake trout, but abundance in this zone may have been affected by the substantial harvests in eastern MI-6 and in MI-8. However, the most drastic CPE decrease for both hatchery and wild lake trout occurred after 1984, which corresponded to substantially higher tribal harvest in MI-7. In MI-8, the sharp drop in hatchery lake trout CPEs in 1975 occurred after just 4 years of intensifying tribal fishing.

The decrease in abundance of large lake trout (≥25 inches total length) paralleled that for hatchery trout, perhaps demonstrating the importance of the hatchery component to this size group, and implicating fishing as a causative factor. The decrease in abundance was likely accelerated by the decrease in growth rate for both hatchery and wild lake trout as it reduced the rate of recruitment into the large size group. The decrease in growth rate could increase lake trout mortality because it would prolong vulnerability to gill-net mesh sizes used by the tribal commercial fishery and extend the period of exposure to lethal sea lamprey attacks. The reduced abundance of large lake trout could also result in greater lamprey-induced mortality of lake trout. Sea lamprey prefer larger prey (Farmer and Beamish 1973), so as abundance of large lake trout decreases, large individuals may be subjected to more frequent attacks or sea lamprey may shift predation to smaller lake trout, which are less likely to survive an attack.

The loss of large hatchery or wild lake trout, whether by fishing, sea lamprey, or growth, will likely impact subsequent recruitment. Since contemporary lake trout populations in Lake Superior produce numbers of eggs in direct proportion to their body size (Peck 1988), the reduced abundance of large lake trout and reduced lake trout growth rate must also result in lower fecundity of the over-all lake trout population. This may have already occurred, because abundance of mature lake trout has decreased on spawning reefs and wild lake trout abundance in the pre-recruit assessment appeared to have leveled off in MI-4, MI-5, and MI-6, and may have declined in MI-7.

Lake Trout Management and Fisheries

Michigan's lake trout management efforts during 1970-87 included increased monitoring and further restrictions on the commercial and sport fisheries, shifting some yearling lake trout plants from shoreline sites to reefs, and participation in lake-wide interagency lake trout management. In 1974, Michigan-licensed commercial fishers were prohibited from using gill nets in water shallower than 60 fathoms (Figures 2-8) to reduce the incidental catch of lake trout in the chub (*Coregonus* spp.) fishery. The previous minimum depth was 50 fathoms, but as lake trout abundance increased so did the incidental catch in these fisheries. Lake trout CPE in chub nets in 50-59 fathoms was four times that in nets from water 60 fathoms and deeper (Marquette Fisheries Station, unpublished). Michigan decided that this incidental catch would impede lake trout rehabilitation and so elected to change the minimum depth to 60 fathoms. This regulation also applied to the siscowet fishery which developed in the 1980s. Retention of lake trout was permitted in the chub and siscowet fisheries, but at 60 fathoms the incidental catch of lake trout in the siscowet fishery has been less than 5% of the total catch (Marquette Fisheries Station, unpublished data). The lake herring (*Coregonus artedii*) fishery, which employed floating gill nets, was terminated in 1974, but this was out of concern for herring stocks; the incidental catch of lake trout in these floated nets was low. The only Michigan-licensed commercial fishery allowed in waters shallower than 60 fathoms after 1974 in zones 2-8 was the trap-net fishery for lake whitefish (*Coregonus clupeaformis*), and no retention of lake trout was allowed in this fishery. Although many lake trout were captured in the trap nets, most (>97%) were released alive (Marquette Fisheries Station, unpublished). Michigan restricted the sport fishery by reducing the lake trout creel limit from five to three fish in 1979. Michigan initiated on-site creel surveys at major Lake Superior ports during 1984-87 to better estimate the sport fish harvest. The previously used mail-survey estimates had been found to be much greater than those obtained from on-site surveys and to have wide confidence limits for individual ports. Patriarche (1980) compared mail-survey estimates of coho salmon catch to those from his on-site creel census in Lake Michigan and found that mail-survey estimates averaged 5.5 times higher. Rybicki and Keller (1978) believed that the mail survey overestimated the 1975 Lake Michigan lake trout catch by a factor of five. This was also the case in Lake Superior, where mail-survey catch-and-effort estimates for the most recent years (1978-82) were greater than on-site catch-and-effort estimates in MI-2, MI-4, MI-5, and MI-6 by factors which ranged from 2.6 to 12.2 for catch and from 1.7 to 8.3 for effort (Table 2). The small mail-survey sample size, incomplete returns, and biases associated with voluntary recall for a 1- to 3-month period may be responsible for the overestimates. The on-site surveys would also provide data on fish in the catch, thus facilitating analysis of such parameters as percentage of total catch and percentage of number planted for hatchery fish, and size and age composition of both hatchery and wild fish.

Tribal fishing in Michigan waters of Lake Superior under the 1836 treaty began in MI-8 in 1971 as a result of *State of Michigan versus A. B. LeBlanc*. No substantiated catch data were available for the 1836 treaty area during 1971-75, but visual observations by Marquette Fisheries Station personnel confirmed the development of fisheries in MI-8 and MI-6 during this period. To coordinate assessment and management of fish stocks of common concern to state, federal, and tribal agencies, the Tripartite Technical Working Group (TTWG) was formed in 1979. The TTWG existed during 1979-84. It was recreated as the Technical Fisheries Review Committee (TFRC) in 1985 as part of the Negotiated Settlement between the Chippewa-Ottawa tribes covered under the Treaty of 1836, the MDNR, and the U. S. Department of Interior. The TTWG and the TFRC were made up of representatives of the USFWS, the MDNR, and the Chippewa-Ottawa tribes. The Negotiated Settlement was an important event in the management of lake trout stocks in the 1836 treaty-ceded waters of the Great Lakes because it provided for establishment of lake trout refuges, where no retention of lake trout is allowed by any fishery, lake trout rehabilitation zones, where lake trout mortality and fishing gear is restricted, and zones where lake trout rehabilitation would be deferred until some unspecified later date and lake trout could be included in the tribal commercial catch. No refuges were established in Lake Superior, but the 1836-treaty portion of MI-5 and that portion of MI-6 from Munising west to the MI-5 boundary were designated as primary rehabilitation zones in 1985. MI-6 east of Munising was to be designated as a primary rehabilitation zone in 1990. MI-7 and MI-8 were designated as deferred zones in 1985. Chippewa commercial fishing under the 1842 treaty began in 1971 in Michigan waters of Lake Superior as a result of *People versus Jondreau*. This fishing was largely confined to waters in the southern portion of Keweenaw Bay adjacent to the Keweenaw Band Reservation (Figure 4, grid 1423 and southern end of grid 1323) during the 1970s. Tribal commercial fishing expanded in the 1842 treaty area during the 1980s, when Keweenaw Band fishers extended their efforts into the northern portion of Keweenaw Bay, and tribal commercial fishers from Wisconsin began fishing zones 2, 3, 4, and 5. Biologists from the GLIFWC, the MDNR, and the USFWS have been working together on the Lake Superior Technical Committee (see below) to coordinate assessment and management of lake trout stocks in the 1942 treaty-ceded Michigan waters.

Slow progress toward lake trout rehabilitation and the advent of commercial fishing by Native American tribal fishers under the 1836 and 1842 treaties prompted the need for coordinated lake-wide lake trout management on Lake Superior. In the early 1980s, The Lake Superior Lake Trout Technical Committee (subsequently renamed The Lake Superior Technical Committee) was formed by The Lake Superior Committee of the Great Lakes Fishery Commission. The committee was made up of one representative from Michigan, Wisconsin, Minnesota, the Province of Ontario, the Chippewa-Ottawa Treaty Fisheries Management Authority, the Great Lakes Indian Fish and Wildlife Commission, and the U. S. Fish and Wildlife Service. The committee and its invited scientific advisors met 2-3 times per year, with an initial charge from The Lake Superior Committee to develop an inter-agency lake trout management plan for Lake Superior. The plan was completed in March 1986 and included a goal for sustainable harvest (2 million pounds dressed weight in Michigan waters), guidelines for broodstock development, prioritized planting locations and rates, control of exploitation (set target mortality rates), a recommended level of sea lamprey control, a policy on exotic and forage species, lake trout assessment, research needs, and reporting requirements. The lake trout management zones referred to in this report were established by this committee and were presented in the management plan.

Recommendations

Assessment Recommendations

Continue the commercial-size assessment with the following modifications: (1) Establish an assessment on a fishing ground in MI-2 or obtain comparable data from the GLIFWC. (2) Reduce the number of fishing grounds assessed in MI-4 from four to three, thereby reducing the assessment extraction from 2,000 to 1,500 fish in this zone. (3) Subdivide the fishing ground in MI-6 into two fishing grounds, with one west of Munising in the primary lake trout rehabilitation portion of the zone, and one east of Munising where a tribal fishery with gill nets has been operating. This will increase the assessment extraction by 500 fish in this zone.

The pre-recruit assessment should be done at least every 2 years in all management zones, although MI-8 would be low priority because of deferred rehabilitation status, intensive tribal fishery, and limited amount of lake trout spawning habitat (Lake Superior Technical Committee, unpublished).

Spawning lake trout populations on important spawning reefs should be assessed at least every 5 years. The assessment should be conducted in a manner that minimizes mortality of the spawning fish. Assessment should be coordinated with those of tribal biologists to prevent overlapping effort.

The multifilament nylon gill nets that have been used for assessment during 1970-87 may have to be replaced by monofilament nylon gill nets in the future. The monofilament nets are believed to be more efficient and manufacturer's efforts to meet the demand for this mesh has resulted in limited production of multifilament. To prepare for the day that multifilament will no longer be available, we recommend that studies be undertaken to quantify the difference in efficiency between the appropriate multi- and monofilament mesh sizes.

Recent analyses have clearly demonstrated that scales are inadequate for determining the age of many lake trout in Lake Superior (Lake Superior Technical Committee, unpublished). Scales from lake trout older than age 8 (23 inches and longer) did not grow sufficiently to form detectable annuli. Otoliths (sagittae) have been determined to be the best calcified structure for aging lake trout (Casselman, personal communication; Sharp and Bernard 1988). However, some difficulties associated with using otoliths include preparation for aging, location of the first annulus, and the incidence of crystalline otoliths. Perhaps the best method of preparing otoliths for age analysis is the acetate-replicate method. This method produces an acetate impression of an etched transverse section, which provides the best product for age analysis; the impressions can be stored for re-analysis. However, this procedure is complicated and time consuming. The crack-and-burn procedure, which involves breaking the otolith transversely and charring the face of the resulting sections, is simpler and quicker. The problems with this procedure are that practice is required to make the break transversely and to achieve the proper degree of charring, only two surfaces per otolith are available for analysis, and the analysis must be done immediately after charring because the charred surfaces become unreadable after a short period of time. Back-calculation of length-at-age is difficult from otoliths prepared in this manner. Much of the problem with location of the first annulus can be overcome with good otolith preparation. Crystalline otoliths are often irregular in shape with a nodule of apparently normal growth superimposed on a translucent crystalline otolithic mass (J. M. Casselman, Ontario Ministry of Natural Resources, unpublished). Johnson and MacCallum (1987) found that these otoliths produced featureless replicates that were impossible to age. Johnson and MacCallum (1987) reported that the incidence of crystalline otoliths in a sample from Lake Superior lake trout was 35% for hatchery lake trout and 10% for wild lake trout. Sharp and Bernard (1988) found that operculum bones provided an attractive alternative to otoliths for aging lake trout in Alaska. We recommend the continued use of otoliths for aging lake trout 23 inches and longer, further sampling to establish the incidence of crystalline otoliths, and evaluation of operculum bones for aging lake trout in Lake Superior.

Management Recommendations

The overlap of jurisdictions that occurred with the granting of treaty fishing rights in Michigan waters and the likely movement of lake trout across jurisdictional boundaries are ample reasons for continued interagency cooperation for management of lake trout stocks. We must continue to work with the Lake Superior Technical Committee to manage lake trout stocks through regulation of fisheries and support of sea lamprey control, to prioritize stocking of hatchery lake trout, and to study other factors that may positively or negatively impact lake trout.

Current sport and commercial regulations affecting lake trout should not be relaxed. The decline in abundance of large lake trout, lack of progress in sea lamprey control, apparent decreasing survival of hatchery lake trout, and increased exploitation require that lake trout stocks be given more protection, not less. Michigan will continue to restrict state-licensed fisheries employing gill nets to waters 60 fathoms and deeper, prohibit retention of lake trout by fisheries using trap nets, consider further restrictions on the lake trout sport fishery, and continue to work toward controlling lake trout extractions by tribal fisheries through negotiation and support of regulations.

The sport fishery should be assessed annually by creel survey to estimate total catch and monitor trends in catch and effort for lake trout and potential competing species. These data will enable us to better regulate this fishery. Total lake trout catch is a necessary parameter for calculation of total allowable catch, which we are obligated to do for lake trout rehabilitation zones established by the 1985 Negotiated Settlement. Planting hatchery yearlings on offshore reefs is recommended only for reefs where abundance of spawning lake trout is low. A quantitative guideline might be CPE less than 25 if the population is mainly hatchery, or less than 10 if the population is mainly wild. These CPE values correspond to "fair" and "poor" spawning populations, respectively, described by Peck (1979).

We must determine if there has been a decrease in survival of hatchery lake trout, and if so, whether it is due to competition from rehabilitated wild lake trout or other fishes, disease, or a decline in genetic fitness. The analysis that has been done on lake trout in Lake Superior (GLIFWC, unpublished), although restricted to not-fully recruited age groups, did include age groups routinely harvested by the sport and commercial fisheries. Future analyses should focus on pre-recruit lake trout data to look at survival of younger age groups that are much less impacted by fishing. Survival of lake trout from various hatcheries where disease occurrence and fitness differ should be determined. Survival should be determined for cohorts planted in lakes Michigan and Huron, where competition from native lake trout does not exist. Hatchery lake trout have previously demonstrated the ability to survive and reproduce in the Great Lakes (Peck 1986, Nester and Poe 1984, Jude et al. 1981, Wagner 1981, Marsden et al. 1988). Hatchery lake trout will be required to maintain stocks in the lower Great Lakes and may be needed again in Lake Superior if the decrease in lake trout abundance observed in the 1980s continues.

Acknowledgments

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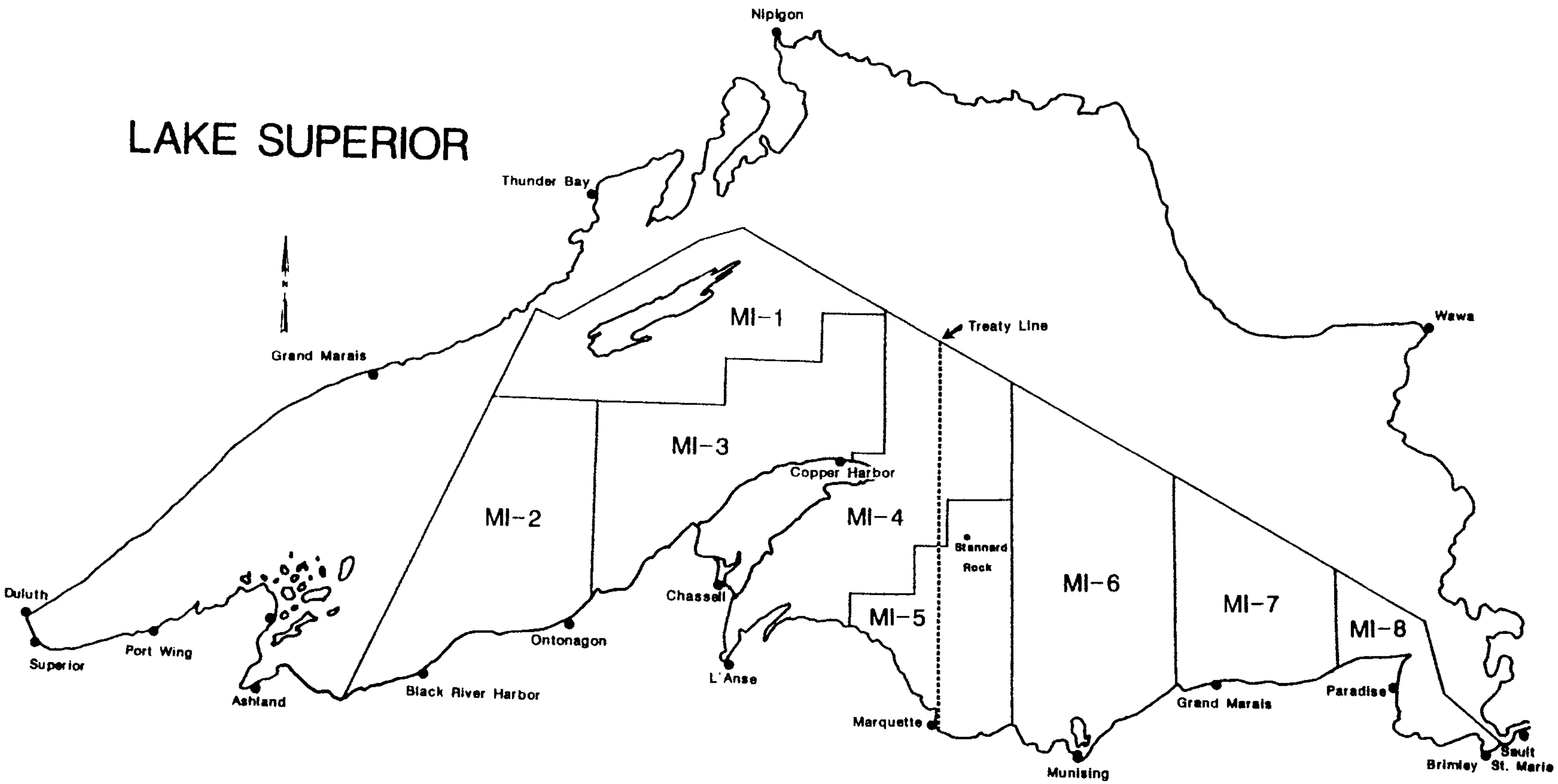

Figure 1.—Lake trout management zones in Michigan waters of Lake Superior.

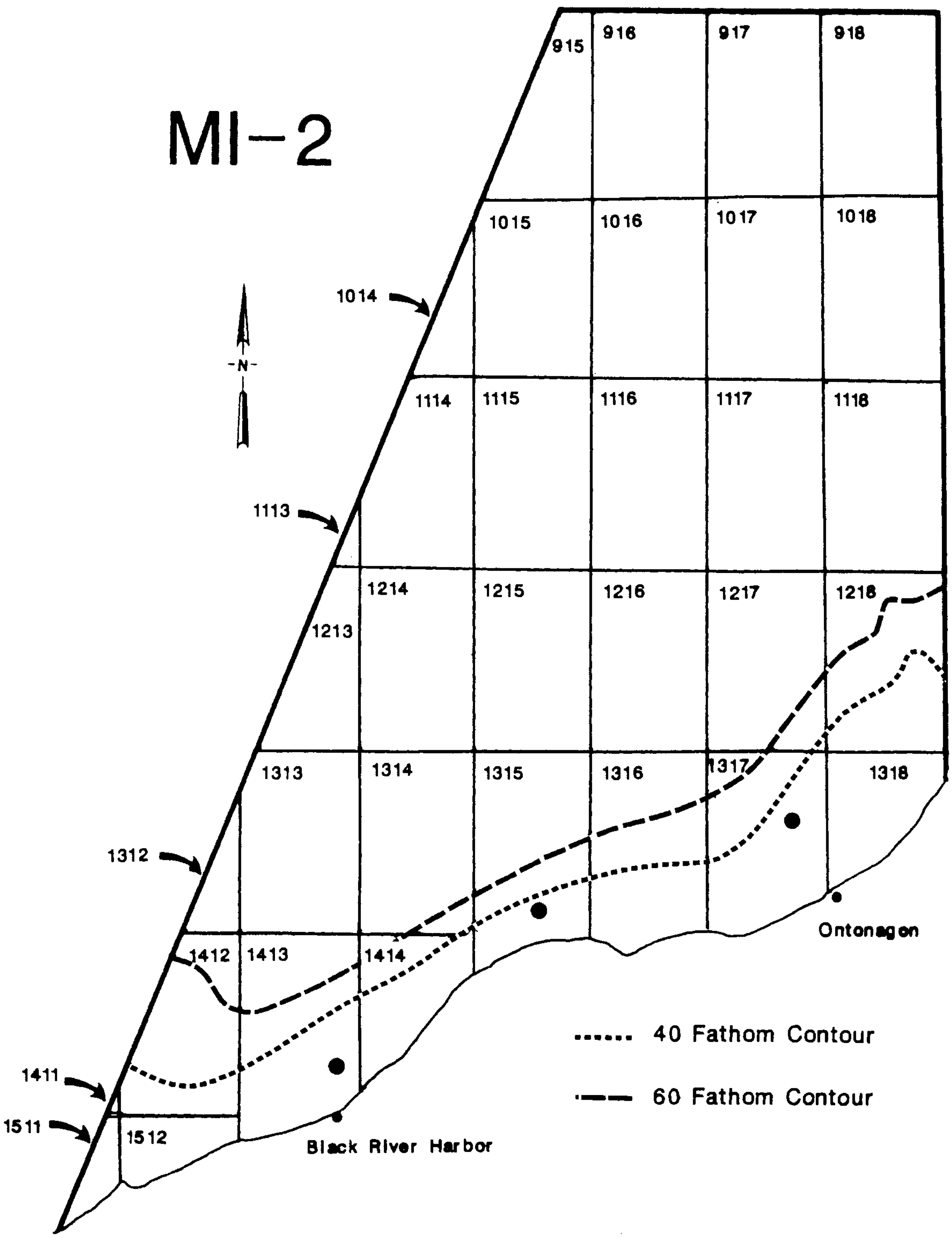

Figure 2.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-2, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

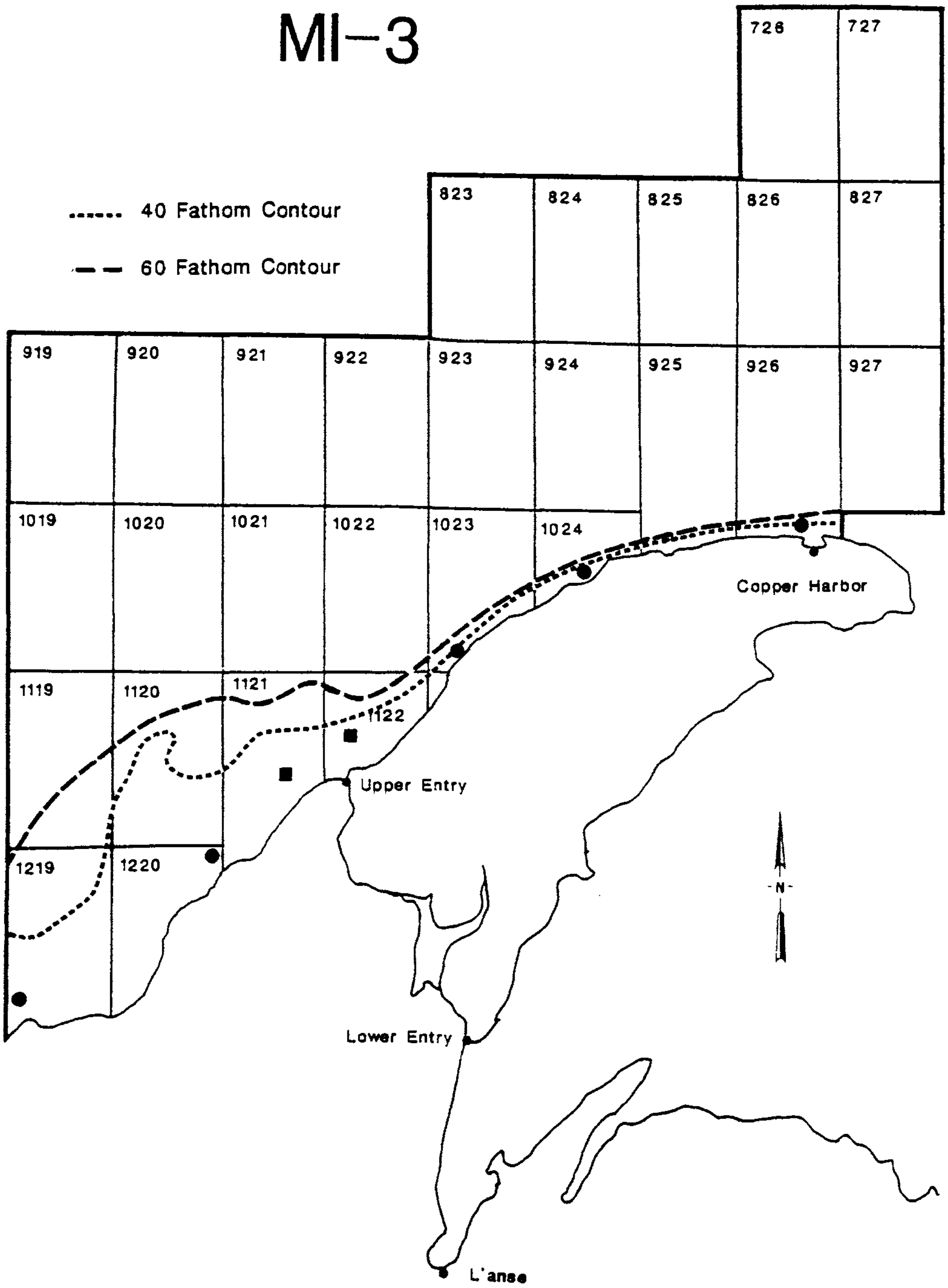

Figure 3.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-3, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

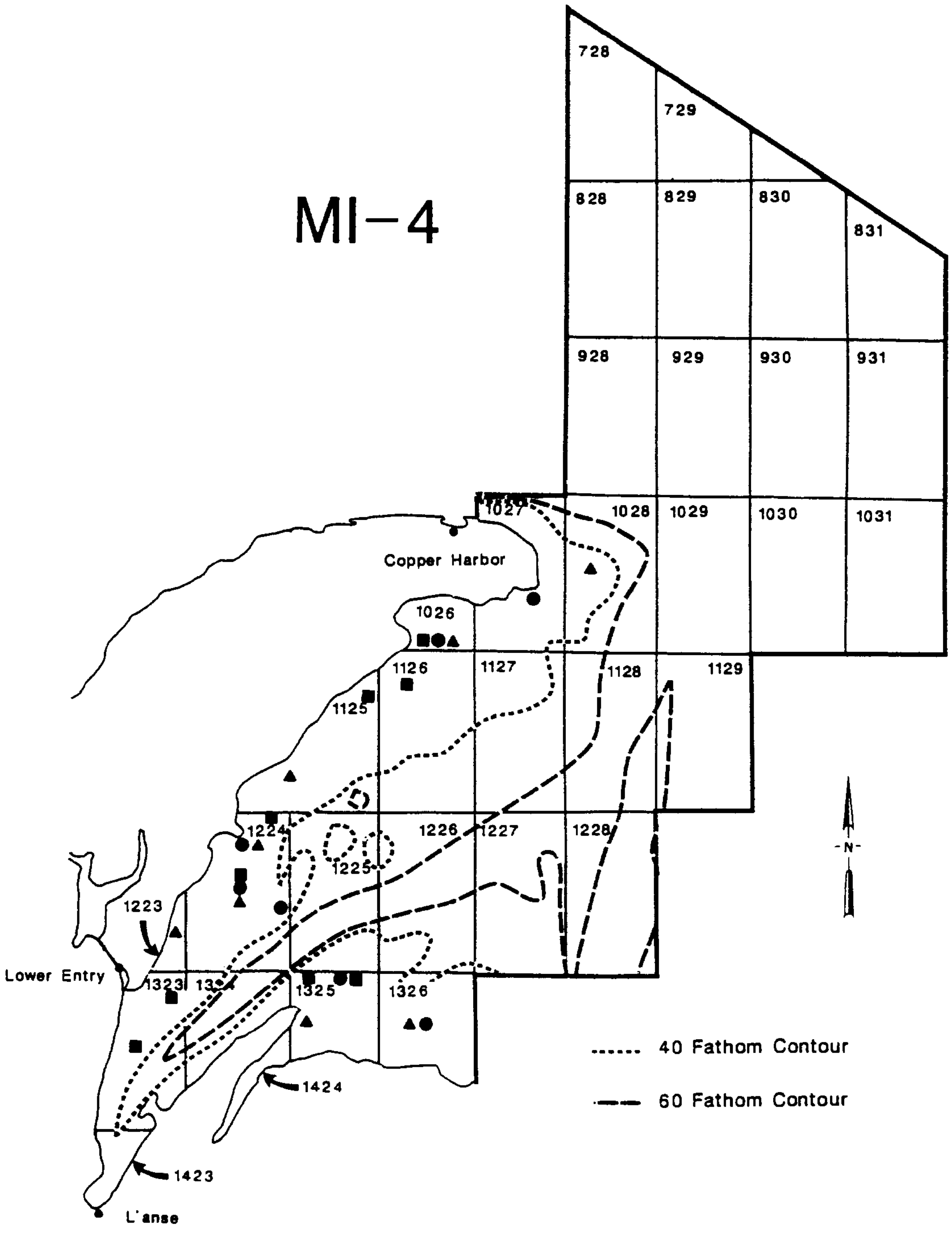

Figure 4.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-4, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

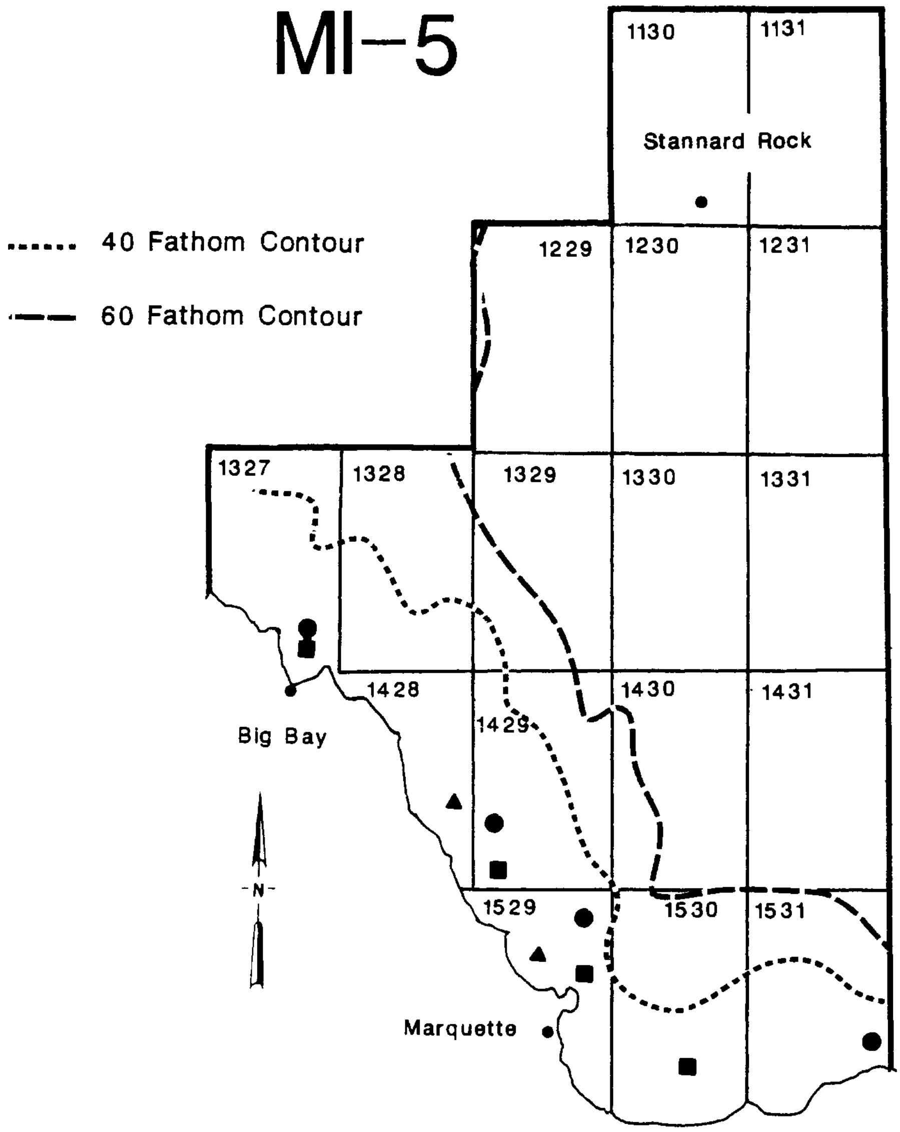

Figure 5.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-5, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

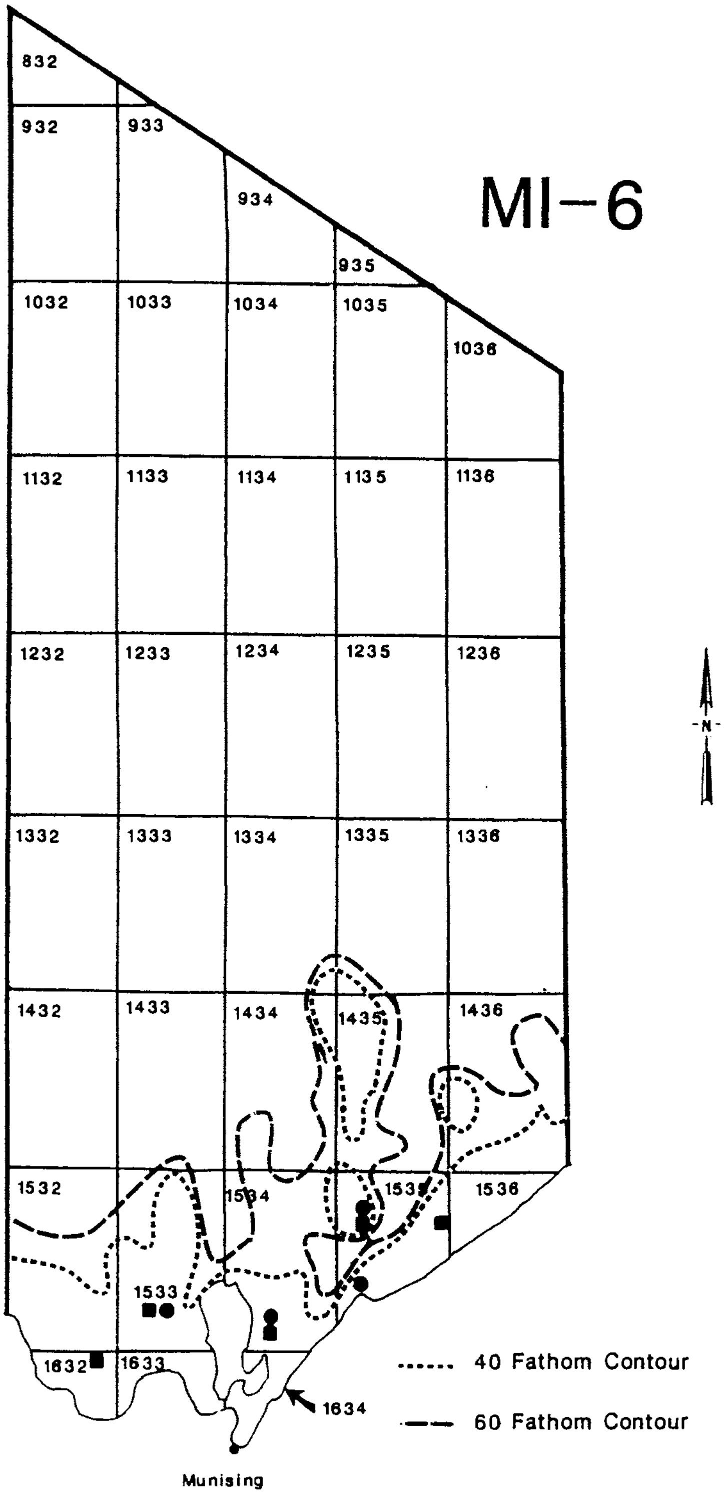

Figure 6.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-6, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

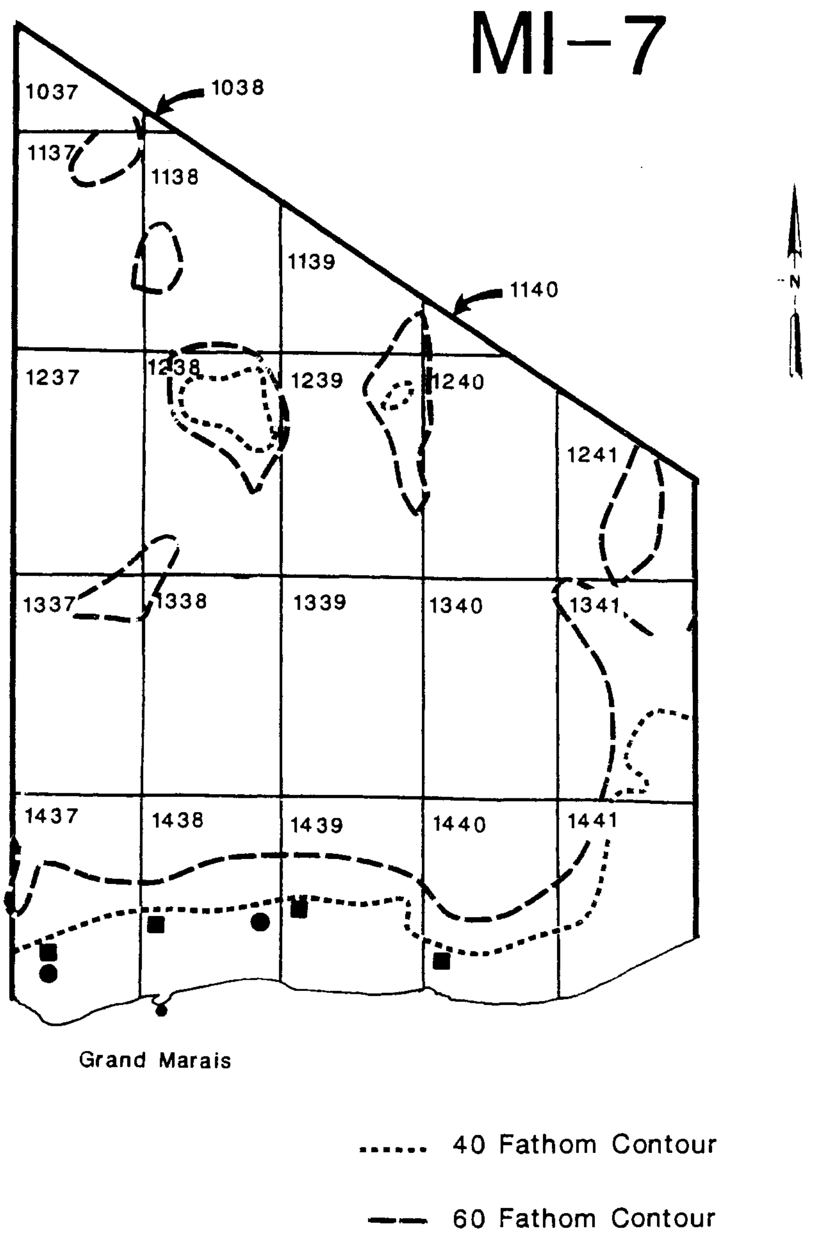

Figure 7.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-7, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

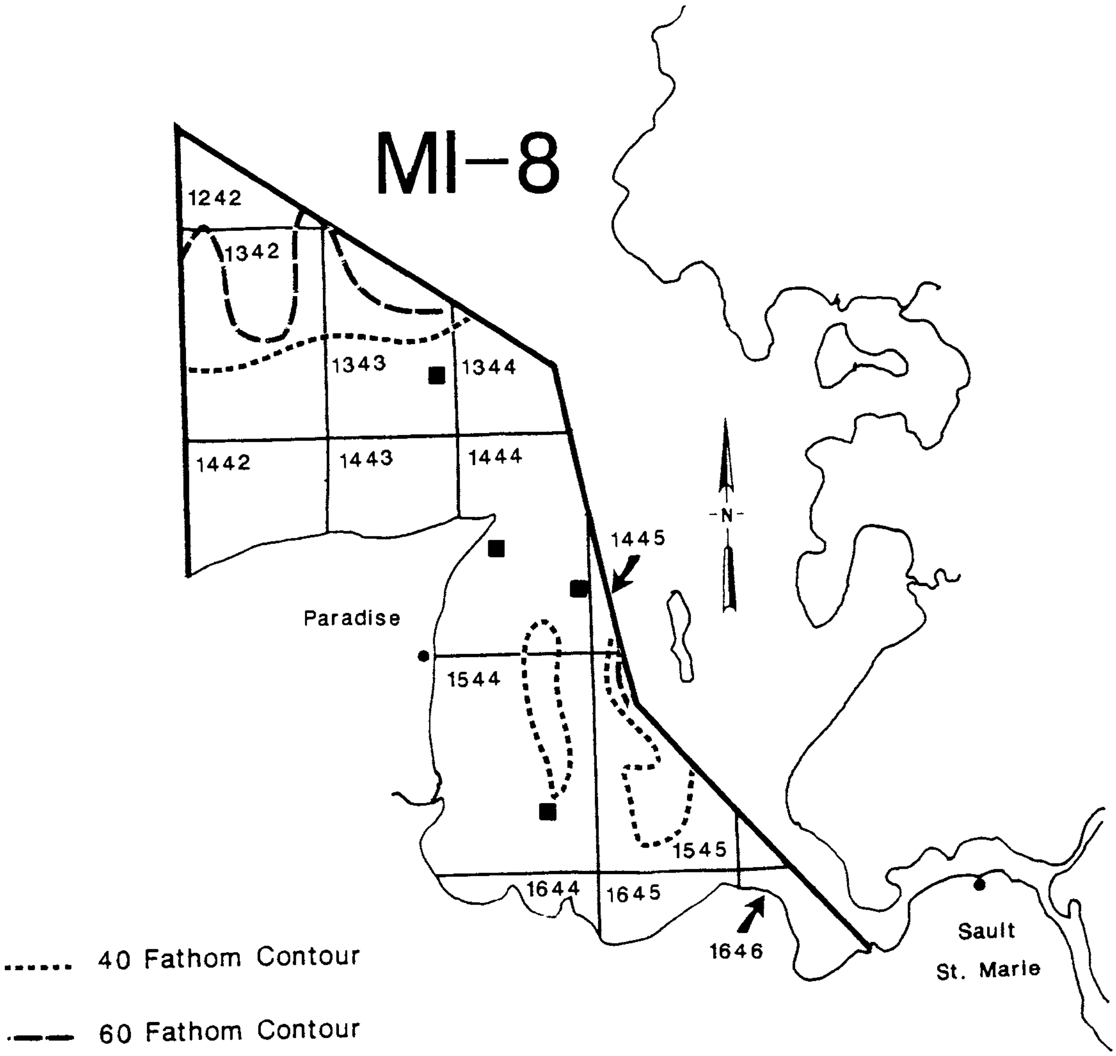

Figure 8.—Lake trout assessment netting sites in Michigan's Lake Superior management zone MI-8, 1970-87. [Commercial-size (■), pre-recruit (•), spawning-population (▲).]

Table 1.—Number (thousands) and number planted per square mile of water 40 fathoms and shallower (in parentheses) of 1966-85 lake trout year classes planted as yearlings in Lake Superior lake trout management zones 2-8 during 1967-86. (Fall fingerling plants adjusted to yearlings based on a 55% survival rate.)

	Management zone and square miles ≤40 fathoms							
Year	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	MI-8	Total
class	449	176	552	292	289	144	582	2,484
1966	260	90	623	252	329	253	252	1,829
	(579)	(513)	(1,128)	(863)	(1,138)	(1,762)	(433)	(736)
1967	254	108	630	457	294	252	256	2,251
	(566)	(615)	(1,141)	(1,566)	(1,017)	(1,755)	(440)	(906)
1968	361	140	482	380	190	94	213	1,860
	(805)	(798)	(873)	(1,302)	(657)	(655)	(538)	(749)
1969	279	0	650	743	0	107	165	1,944
	(622)	(0)	(1,177)	(2,545)	(0)	(745)	(283)	(783)
1970	205	0	310	260	0	60	220	1,055
	(457)	(0)	(561)	(890)	(0)	(418)	(378)	(425)
1971	164	0	261	259	111	55	192	1,042
	(366)	(0)	(473)	(887)	(384)	(383)	(330)	(419)
1972	175	0	230	207	125	50	107	894
	(390)	(0)	(417)	(709)	(433)	(348)	(184)	(360)
1973	218	25	165	220	176	54	28	886
	(486)	(142)	(299)	(754)	(609)	(376)	(48)	(357)
1974	148	25	225	150	154	50	25	777
	(330)	(142)	(407)	(514)	(553)	(348)	(43)	(313)
1975	165	53	168	174	116	81	28	785
	(368)	(302)	(304)	(596)	(401)	(564)	(48)	(316)
1976	110	28	168	250	112	28	0	696
	(245)	(160)	(304)	(856)	(388)	(195)	(0)	(280)
1977	149	27	267	128	106	25	28	730
	(332)	(154)	(484)	(439)	(367)	(174)	(48)	(294)
1978	179	0	273	272	120	50	20	914
	(399)	(0)	(494)	(932)	(415)	(348)	(34)	(368)
1979	88	26	149	206	117	28	28	642
	(196)	(148)	(270)	(706)	(405)	(195)	(48)	(258)
1980	75	25	203	196	138	25	25	687
	(167)	(142)	(368)	(671)	(478)	(174)	(43)	(277)
1981	75	50	247	190	125	25	26	738
	(167)	(285)	(447)	(651)	(433)	(174)	(45)	(297)
1982	80	75	197	326	150	33	69	930
	(178)	(427)	(357)	(1,117)	(519)	(230)	(119)	(374)
1983	0	0	0	154	30	30	258	472
	(0)	(0)	(0)	(528)	(104)	(209)	(443)	(190)
1984	338	91	496	354[a]	244[a]	0	14	1,537
	(753)	(519)	(898)	(1,213)	(844)	(0)	(24)	(619)
1985	117	78	255	180	90	0	156	876
	(261)	(444)	(462)	(617)	(311)	(0)	(268)	(353)
1966-1985	172	42	300	268	136	65	106	1,077
Mean	(383)	(239)	(543)	(918)	(471)	(453)	(182)	(434)

[a]Plant of fingerlings stressed by disease adjusted to yearling based on 20% survival.

Table 2.—Lake trout sport catch (thousands of fish) and effort (thousands of angler days in parentheses) in Michigan's Lake Superior management zones 2-8 estimated by mail survey (1971-82) and on-site survey (1984-87).

Year	Management zone							Total
	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	MI-8	
1971	6.1	2.5	28.2	9.7	12.6	0.8	13.0	72.9
	(6)	(5)	(36)	(36)	(25)	(5)	(13)	(126)
1972	10.1	10.5	50.4	15.6	12.7	2.0	10.0	111.3
	(12)	(6)	(42)	(27)	(25)	(18)	(20)	(150)
1973	10.6	15.5	74.4	29.6	9.0	14.6	1.2	154.9
	(18)	(10)	(50)	(51)	(10)	(11)	(2)	(152)
1974	35.2	12.0	60.7	23.9	7.3	2.3	2.5	143.9
	(49)	(13)	(86)	(60)	(31)	(17)	(25)	(281)
1975	29.8	11.5	71.6	41.3	18.1	18.2	0.9	190.5
	(43)	(20)	(113)	(96)	(30)	(15)	(4)	(321)
1976	27.2	11.1	67.2	86.1	12.2	1.9	0.3	206.0
	(37)	(12)	(74)	(108)	(32)	(28)	(8)	(299)
1977	18.7	5.2	50.0	65.0	0.3	0.5	—[a]	139.7
	(41)	(7)	(47)	(67)	(8)	(10)	(5)	(185)
1978	72.7	8.5	48.5	28.0	17.5	2.7	0.2	178.1
	(68)	(11)	(78)	(100)	(19)	(17)	(4)	(297)
1979	70.2	7.3	36.8	17.4	3.2	1.0	0.5	136.4
	(86)	(8)	(58)	(53)	(22)	(12)	(4)	(243)
1980	32.2	3.9	32.1	39.7	16.5	0.1	0.2	124.7
	(35)	(7)	(58)	(71)	(34)	(3)	(6)	(214)
1981	27.2	17.4	85.0	23.7	17.4	2.0	0.3	173.0
	(24)	(13)	(74)	(40)	(29)	(18)	(10)	(208)
1982	40.5	7.6	37.3	30.8	22.4	2.8	0.1	141.5
	(42)	(7)	(46)	(53)	(24)	(7)	(3)	(182)
1983	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—
1984	—	—	—	9.7	—	—	—	—
	—	—	—	(31)	—	—	—	—
1985	—	—	—	8.7	—	—	—	—
	—	—	—	(36)	—	—	—	—
1986	—	—	—	14.0	—	—	—	—
	—	—	—	(47)	—	—	—	—
1987	8.5	—	5.7	10.2	1.1	—	—	—
	(10)	—	(8)	(36)	(13)	—	—	—

[a]Less than 100.

Table 3.—Lake trout catch[a] (thousands of pounds) by tribal commercial fisheries in Michigan's Lake Superior management zones during 1976-87[b].

	Management zone						
Year	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	MI-8
1976	0.0	0.0	98.4	0.0	39.1	5.8	41.9
1977	0.0	0.0	121.6	0.0	77.7	0.0	33.1
1978	0.0	0.0	126.2	0.0	53.2	0.0	43.2
1979	0.0	0.0	43.4	0.0	56.0	1.5	19.2
1980	0.0	0.0	20.4	0.0	16.1	7.4	8.9
1981	0.0	0.0	22.2	0.0	28.1	9.9	21.8
1982	0.0	0.0	22.4	0.0	26.1	7.7	11.5
1983	0.0	0.0	15.9	0.0	28.1	15.5	25.1
1984	12.5	16.6	39.2	0.0	27.4	17.1	24.3
1985	9.5	38.3	42.1	0.0	20.5	85.1	22.5
1986	15.3	32.0	133.2	4.3	29.5	123.7	30.0
1987	36.6	64.0	75.3	11.0	17.3	97.6	40.1

[a]Catch reported as dressed weight in zones 2-5, and round weight in zones 6-8.

[b]Catches in Zone 4 during 1976-83 estimated from wholesale records by the Michigan Department of Natural Resources. Catches in zones 2-5 during 1984-87 reported by the Great Lakes Indian Fish and Wildlife Commission. Catches in zones 6-8 during 1976-87 provided by the Chippewa-Ottawa Treaty Fisheries Management Authority in Technical Fisheries Review Committee Reports.

Table 4.—Commercial-size (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-3 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	7.3	0.1	0.5	20.4	7.0	1.7
1971	4.7	1.9	0.2	20.1	5.8	1.6
1972	28.5	1.9	3.9	19.9	5.9	2.8
1973	25.5	1.5	3.0	22.3	7.6	4.8
1974	17.1	1.5	5.4	23.6	6.0	5.1
1975	18.8	2.3	10.8	23.6	13.0	7.2
1976	27.8	4.3	14.0	24.0	11.8	11.6
1977	48.2	6.5	27.0	24.3	8.1	7.6
1978	20.4	2.7	10.9	24.3	13.0	7.1
1979	28.5	5.7	15.7	24.6	7.4	5.6
1980	35.8	6.8	19.9	24.7	8.6	5.5
1981	34.0	6.8	16.3	23.9	8.7	3.6
1982	35.1	6.0	18.1	24.4	6.6	5.2
1983	19.8	6.1	7.0	23.6	6.6	5.5
1984	31.3	14.5	17.8	24.4	5.2	6.5
1985	26.0	12.4	11.3	23.6	2.7	2.1
1986	7.7	5.0	4.3	24.2	5.2	3.6
1987	4.0	8.4	3.3	22.5	4.3	2.3

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 5.—Commercial (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-4 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	26.4	0.2	5.7	22.8	10.3	7.1
1971	46.6	1.0	11.6	23.0	21.9	14.6
1972	52.2	1.9	8.0	21.8	25.0	15.4
1973	79.6	3.9	13.7	22.1	—	—
1974	49.6	2.7	10.6	22.7	9.3	5.8
1975	63.1	3.1	14.0	22.7	13.8	7.1
1976	79.0	4.3	13.0	22.7	10.5	5.7
1977	77.3	6.2	26.1	23.4	10.3	6.4
1978	64.4	8.0	24.7	23.4	12.4	7.6
1979	61.9	18.9	24.2	23.0	7.5	4.5
1980	67.6	33.7	22.8	22.8	10.2	5.9
1981	43.0	30.5	17.0	23.0	8.7	5.6
1982	26.2	12.7	11.8	22.7	12.3	7.8
1983	25.0	14.2	6.0	22.1	9.3	2.8
1984	17.4	10.5	6.0	22.3	8.2	4.3
1985	13.0	13.7	6.1	22.1	5.1	2.9
1986	9.5	22.7	3.8	21.0	8.7	3.9
1987	3.0	18.3	1.0	20.3	10.5	4.8

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 6.—Commercial-size (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-5 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	45.9	0.5	10.4	23.4	4.1	4.4
1971	58.8	0.8	19.6	23.3	11.9	9.6
1972	51.4	1.9	14.5	22.8	13.5	8.3
1973	75.9	4.8	15.9	22.5	—	—
1974	38.5	2.1	9.0	22.5	5.2	2.5
1975	89.6	6.3	24.4	22.9	4.8	2.9
1976	63.7	7.5	20.3	22.8	5.0	4.0
1977	72.4	9.3	24.3	22.9	4.3	2.6
1978	59.7	15.6	25.6	23.1	11.1	5.6
1979	59.1	20.9	39.0	24.5	5.7	4.1
1980	20.1	10.3	17.1	22.8	1.3	1.2
1981	39.9	14.7	11.0	22.0	7.4	2.3
1982	44.3	31.3	10.3	22.2	9.7	2.4
1983	26.6	25.1	9.4	22.4	6.2	1.4
1984	25.5	21.2	7.5	22.2	8.8	5.5
1985	32.9	41.8	12.0	22.2	8.6	4.9
1986	24.1	58.9	14.6	21.8	17.8	5.6
1987	5.1	37.6	4.0	21.4	2.3	1.3

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 7.—Commercial-size (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-6 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	39.4	0.2	13.1	23.3	7.4	5.1
1971	47.9	1.0	17.8	23.8	19.6	13.5
1972	89.1	6.2	18.5	23.1	9.0	11.7
1973	14.5	1.9	—	—	—	—
1974	22.0	3.0	6.7	23.0	—	—
1975	18.3	4.2	7.8	23.0	—	—
1976	20.0	5.4	7.2	22.8	—	—
1977	16.1	6.3	5.7	22.7	12.6	6.8
1978	12.5	7.8	5.0	22.3	19.8	12.5
1979	7.7	5.5	4.0	23.0	17.9	12.3
1980	9.5	6.0	3.3	22.0	22.7	19.6
1981	50.7	44.7	4.0	20.9	20.1	5.2
1982	20.5	11.5	5.1	21.6	9.3	7.9
1983	5.6	5.9	1.1	20.9	26.8	8.3
1984	8.2	11.8	3.1	21.8	6.5	6.4
1985	7.1	15.0	2.4	20.7	37.7	12.5
1986	12.7	35.6	2.6	20.7	16.0	2.6
1987	2.4	17.7	1.1	20.5	4.6	5.6

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 8.—Commercial-size (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-7 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	67.3	1.6	—	—	6.6	7.8
1971	55.1	1.5	7.2	23.6	13.5	11.2
1972	39.2	2.3	7.2	23.5	15.0	21.7
1973	34.8	5.3	—	—	—	—
1974	26.8	4.0	10.8	23.6	—	—
1975	37.9	11.4	11.6	23.0	—	—
1976	19.9	9.8	10.2	23.1	—	—
1977	24.3	13.5	9.2	22.8	8.9	5.8
1978	10.9	8.5	4.7	22.6	21.9	10.3
1979	6.6	7.1	3.8	22.9	4.3	3.4
1980	15.1	16.1	7.9	22.9	16.5	10.4
1981	20.5	13.4	9.2	23.2	10.0	5.7
1982	11.3	8.4	7.6	23.8	9.2	6.0
1983	10.4	14.1	6.3	22.9	10.1	5.6
1984	12.2	16.5	11.3	24.1	13.4	8.4
1985	3.8	7.6	2.6	22.4	17.2	12.6
1986	1.6	8.3	1.7	21.5	16.8	8.5
1987	1.4	10.6	2.2	22.0	26.7	11.3

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 9.—Commercial-size (≥17 inches, total length) lake trout assessment CPE[a], mean total length, and sea lamprey wounding[b] in Michigan's Lake Superior management zone MI-8 during 1970-87.

Year	CPE			Total length (inches)	Sea lamprey wounding	
	Hatchery	Wild	Large (all ≥25 inches)		25.0-28.9 inch group	All ≥17 inches long
1970	19.7	0.2	1.6	20.6	20.1	7.0
1971	22.0	0.4	1.0	20.5	11.8	19.6
1972	11.3	0.2	0.9	21.4	9.2	4.8
1973	32.7	0.1	—	—	—	—
1974	54.4	0.1	5.9	21.7	—	—
1975	8.3	0.5	3.3	23.3	—	—
1976	3.6	0.7	—	—	—	—
1977	2.8	0.8	—	—	—	—
1978	—	—	—	—	—	—
1979	1.4	2.1	0.1	20.0	0.0	0.0
1980	1.2	1.1	0.3	20.9	0.0	2.0
1981	1.1	0.5	0.2	21.1	18.3	5.6
1982	3.5	1.1	0.3	20.2	31.1	8.4
1983	—	—	—	—	—	—
1984	—	—	—	—	—	—
1985	6.0	2.1	0.3	20.1	24.1	7.4
1986	—	—	—	—	—	—
1987	—	—	—	—	—	—

[a]Number per 1,000 feet of 4.5-inch nylon-multifilament-mesh gill net.

[b]Mean total number of stage A1, A2, and A3 wounds per 100 lake trout.

Table 10.—Number of hatchery and wild lake trout captured per 1,000 feet of graded-mesh[a] gill net and percent wild in Michigan's Lake Superior management zones during August, 1975-87.

Management zone and year	Origin			Percent wild
	Hatchery	Wild	Total	
MI-2				
1983[b]	6.9	4.5	11.4	40
1986[b]	2.2	11.8	14.0	84
MI-3				
1983[b]	6.9	4.2	11.1	38
1986[b]	1.5	9.8	11.3	87
MI-4				
1975[b]	18.5	2.9	21.4	14
1978[b]	26.4	10.2	36.6	28
1981[b]	9.6	6.2	15.8	39
1984[b]	7.1	14.4	21.5	67
1985	3.5	16.5	20.0	82
1986	3.3	31.3	34.6	91
1987	1.8	17.4	19.2	91
MI-5				
1975[b]	16.9	1.8	18.7	10
1978[b]	11.3	6.3	17.6	36
1981[b]	4.0	2.3	6.3	37
1984[b]	4.7	7.2	11.9	60
1985	2.5	5.2	7.7	67
1986	1.8	7.3	9.1	80
1987	2.1	6.5	8.6	76
MI-6				
1975[b]	7.2	3.5	10.7	33
1978[b]	3.5	4.9	8.4	58
1981[b]	3.6	5.6	9.2	61
1984[b]	2.0	12.8	14.8	86
1985	0.6	7.1	7.7	92
1986	1.8	15.6	17.4	90
1987	0.8	10.2	11.0	93
MI-7				
1986	2.2	18.5	20.7	90
1987	0.5	4.6	5.1	90

[a]2.00-, 2.25-, 2.50-, 2.75-, 3.00-, and 3.50-inch multifilament nylon mesh.

[b]Unpublished data from the United States Fish and Wildlife Service, Ashland, Wisconsin.

Table 11.—Age composition, mean total length (inches), and 95% confidence interval for wild (unclipped) lake trout in graded-mesh[a] gill nets fished in Lake Superior lake trout management zones MI-4, MI-5, MI-6, and MI-7 during July-September, 1986-87.

Management zone,	Age						
parameter	2	3	4	5	6	7	8
MI-4							
1986							
Number and (%)	0	27(3)	154(19)	343(43)	209(26)	57(7)	17(2)
Mean length	—	10.5	12.9	14.5	16.3	18.6	21.5
Confidence interval	—	±0.6	±0.2	±0.1	±0.2	±0.5	±0.9
1987							
Number and (%)	7(2)	23(5)	68(15)	152(34)	151(33)	43(9)	7(2)
Mean length	8.8	11.6	13.3	14.8	16.5	18.5	20.8
Confidence interval	±0.7	±0.8	±0.3	±0.2	±0.2	±0.7	±1.8
MI-5							
1986							
Number and (%)	4(3)	3(2)	39(29)	58(43)	21(16)	7(5)	3(2)
Mean length	7.6	10.8	13.1	14.9	17.5	18.3	21.2
Confidence interval	±0.2	±3.6	±0.4	±0.3	±0.8	±1.1	±8.8
1987							
Number and (%)	1(1)	4(4)	23(20)	45(40)	25(22)	11(9)	4(4)
Mean length	8.2	13.0	14.8	15.4	16.7	22.3	26.5
Confidence interval	—	±3.0	±1.1	±1.1	±0.7	±1.7	±8.0
MI-6							
1986							
Number and (%)	1	8(3)	31(13)	94(39)	71(30)	25(11)	9(4)
Mean length	7.0	10.7	13.7	14.9	16.9	19.4	21.3
Confidence interval	—	±1.8	±1.8	±0.3	±0.4	±0.8	±1.5
1987							
Number and (%)	1(1)	2(1)	20(13)	55(36)	50(33)	21(14)	3(2)
Mean length	8.1	12.3	14.3	16.6	17.2	19.2	20.6
Confidence interval	—	±2.5	±0.5	±0.9	±1.2	±1.2	±0.9
MI-7							
1986							
Number and (%)	2(4)	1(2)	3(5)	26(49)	13(24)	4(7)	5(9)
Mean length	8.4	10.7	13.7	15.5	16.6	19.8	21.1
Confidence interval	±13.3	—	±1.4	±0.5	±0.9	±1.4	±0.8
1987							
Number and (%)	0	1(3)	3(9)	10(28)	14(40)	6(17)	1(3)
Mean length	—	10.7	13.6	16.1	17.5	18.2	17.9
Confidence interval	—	—	±2.0	±1.1	±1.1	±2.3	—

[a]2.00-, 2.25-, 2.50-, 2.75-, 3.00-, and 3.50-inch multifilament nylon mesh.

Table 12.—CPE[a] and composition (% wild) of lake trout captured on spawning reefs in Michigan's Lake Superior lake trout management zones during October-November, 1982-86.

Management zone, reef, and parameters	Year					
	1982	1983	1984	1985	1986	1973-76[b]
MI-4						
Manitou Island						
CPE	8	10	15	—	15	<1
% wild	10	7	11	—	18	0
Point Isabelle						
CPE	11	4	4	—	—	57
% wild	25	50	27	—	—	2
Buffalo Reef						
CPE	—	—	—	—	55	130
% wild	—	—	—	—	55	0
Traverse Island						
CPE	—	—	—	—	21	83
% wild	—	—	—	—	52	35
Red Rocks						
CPE	—	—	—	—	5	12
% wild	—	—	—	—	17	7
Point Abbaye						
CPE	5	1	2	—	—	47
% wild	18	0	29	—	—	0
Huron Islands						
CPE	20	12	13	—	—	17
% wild	60	55	73	—	—	70
MI-5						
Garlic Island						
CPE	70	42	79	—	—	60
% wild	69	65	63	—	—	52
Partridge Island						
CPE	117	49	61	49	—	122
% wild	63	82	62	79	—	27

[a]Number per 1,000 feet of 4.5-inch multifilament-nylon-mesh gill net.

[b]Data from Peck (1979).

Table 13.—Contribution of reef-planted yearling lake trout (reef) and shoreline-planted yearlings (shoreline) to spawning populations on some reefs in Michigan waters of Lake Superior, based on October-November CPEs[a], with reef-planted CPEs adjusted for numerical difference between reef and shoreline plants (in parentheses).

Management zone, reef, year planted, and number planted[b]	Year					Total CPE	Percent of all spawners
	1982	1983	1984	1985	1986		
MI-4							
Manitou Island							
1976							
Reef	1.7	0.7	3.0	—	1.6	7.0	21
56,000	(3.3)	(1.4)	(5.8)	—	(3.1)	(13.6)	(41)
Shoreline	0.8	0.0	0.0	—	0.3	1.1	3
109,000							
Huron Islands							
1976							
Reef	1.4	0.7	0.3	—	—	2.4	5
56,000	(2.7)	(1.4)	(0.6)	—	—	(4.7)	(10)
Shoreline	0.5	1.1	0.3	—	—	1.9	4
109,000							
MI-5							
Partridge Island							
1976							
Reef	5.0	0.0	0.0	0.0	—	5.0	2
56,000	(10.5)	—	—	—	—	(10.5)	(4)
Shoreline	2.7	0.4	0.3	1.7	—	4.9	2
118,000							
1977							
Reef	0.9	0.7	0.7	0.8	—	3.1	1
87,500	(1.1)	(0.8)	(0.8)	(1.0)	—	(3.7)	(1)
Shoreline	3.6	1.8	1.7	2.5	—	8.6	3
104,000							

[a]CPE-number caught per 1,000 feet of 4.5-inch multifilament-nylon-mesh gill net.

[b]The number of cohorts is the number planted within the same management zone, except that Manitou Island (MI-4) cohorts included 53,000 planted at Copper Harbor (MI-3) due to proximity (within 10 miles).

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