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Lake Trout Assessment and Management in Michigan Waters of Lake Superior, 1993-97

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Abstract.–Lean and siscowet lake trout *Salvelinus namaycush* population data for Michigan management areas 2-7 during 1993-97 are presented and analyzed. Wild fish made up over 80% of populations in all areas. Relative abundance (number of fish per 1,000 feet of gill net) was either without trend or increasing during 1993-97 and higher than during 1988-92 in most areas. Relative abundance of commercial-sized leans (≥ 17 in, total length) was highest in MI-5 and lowest in MI-3. Abundance of lake trout 25 inches and larger increased in MI-3, MI-4, and MI-5 and was without trend in MI-6 and MI-7. Sea lamprey wounding (number of wounds per 100 fish) on commercial-sized leans fluctuated without trend during 1993-97 and was highest (6.9) in MI-3 and MI-7 and lowest (2.6) in MI-5. Wild commercial-sized leans in assessment samples ranged in age from 4 to 25 years, with age 7 being modal in most areas in most years. Total annual mortality rates estimated from catch curves of age-9 and older leans averaged less than 0.50 in all areas during 1993-97. Relative abundance of pre-recruit (< 17 in, total length) wild leans increased or was without trend in all areas except MI-4 and MI-6 during 1993-96. Pre-recruit leans ranged in age from 2 to 9 with age 5 being modal. Status of siscowets improved even more than leans during 1993-96. Relative abundance of siscowets in the pre-recruit assessment increased in all areas. Pre-recruit siscowet relative abundance was highest in MI-3 and lowest in MI-2. Ages ranged from 2 to 15 years, with age 8 being modal in the overall sample. In assessments of predator composition by depth strata in June 1996 and September 1997, siscowets were the dominant predator and outnumbered leans by 12:1 and 48:1, respectively. Siscowets were not captured at depths less than 60 feet but increased in abundance with increasing depth and outnumbered leans in depths greater than 180 feet. Siscowets ranged in age from 3 to 30 years, with modal ages of 15 in 1996 and 16 in 1997. Fish, mainly coregonines, contributed most to the diet of siscowets and leans. The number of hatchery leans stocked annually in Michigan waters decreased dramatically in 1996-97 when Michigan and other member agencies of the Great Lakes Fishery Commission Lake Superior Committee agreed to end stocking in most management areas. Fisheries harvested more leans than siscowets during 1993-97. Sport catch fluctuated without trend and annual catches (number of fish) ranged from 15,900 to 26,600 for leans and from 4,400 to 19,400 for siscowets. Tribal commercial catch (pounds dressed weight) decreased during the period and ranged from 123,000 to 244,000 for leans and from 46,000 to 142,000 for siscowets. We recommend continuation of current net and creel assessments (in cooperation with state-licensed commercial fishers and tribal agencies), location of siscowet spawning grounds, expansion of assessments of siscowet populations, and refinement of methodology for using otoliths to age lake trout. Management recommendations include completion of age-based population models for determining total allowable catches, continuance

of inter-agency cooperation in data collection and analysis and management of lake trout, supporting efforts to reduce sea lamprey abundance and contaminant input, and emphasis on stewardship of the rehabilitated self-sustaining wild lake trout populations in Lake Superior.

Lake Superior is home to at least three lake trout *Salvelinus namaycush* phenotypes, or forms, and an unknown number of genotypes (Burnham-Curtis 1993). The three forms are the shallow water-dwelling lean lake trout (leans), and the deeper-dwelling siscowet lake trout (siscowets) and humper lake trout (humpers). Some genotypes of the three forms may have been lost in the 1950s or early 1960s when populations were most severely impacted by the sea lamprey *Petromyzon marinus* and commercial fishing. Although deep-dwelling lake trout resembling siscowets and humpers may have existed in the other Great Lakes, they are now present only in Lake Superior (Burnham-Curtis 1993). Consequently, Lake Superior contains the most genetically diverse lake trout populations in the Great Lakes. Leans in Lake Superior are generally most abundant at depths less than 240 feet in inshore waters and offshore around islands and shoals such as Isle Royale and Stannard Rock. Commercial-sized leans (≥ 17 in, total length) have been assessed in Michigan waters since 1959 to monitor success of sea lamprey control and lake trout management actions, especially closure of fisheries and stocking of hatchery-reared fingerlings and yearlings (Pycha and King 1975; Peck and Schorfhaar 1991; Peck and Schorfhaar 1994; Curtis et al., unpublished report). These assessments have been expanded over the years to include spawning leans and pre-recruit segments of lean and siscowet populations. Siscowets are the most widespread lake trout in Lake Superior, occupying a greater depth range than leans or humpers (Burnham-Curtis 1993). They are generally most abundant at depths greater than 240 feet. They are called "fat trout" or "fats" because they contain a high flesh-fat content (Eschmeyer and Phillips 1965). This high fat content has affected their marketability as a food fish because the fat accumulates higher levels of contaminants. The State of Michigan currently prohibits commercial sale and advises anglers against retention of siscowets 18 inches and larger because of high chlordane levels. Humper lake trout (humpers) are small (< 25 in, total length) and in Michigan waters are found only in the vicinity of offshore reefs at Isle Royale (MI-1) and south of Caribou Island (MI-7) at depths generally ranging from 120 to 270 feet (Rahrer 1965; Patriarche and Peck 1970). Humpers have a flesh-fat content slightly higher than leans but lower than siscowets (Eschmeyer and Phillips 1965). Due to the humpers' remote location and small size, they have received little attention from commercial and sport fisheries. Siscowets have been assessed annually in the summer pre-recruit assessment in Michigan inshore waters (Peck and Schorfhaar 1991; Peck and Schorfhaar 1994). Siscowet and humper populations at Isle Royale and Caribou Island have been assessed periodically (Patriarche and Peck 1970; Curtis 1990; Bronte 1993).

In this report, we present results from lean and siscowet lake trout assessments conducted by the Michigan Department of Natural Resources (MDNR) Marquette Fisheries Research Station (MFS) during 1993-97, and make recommendations for future assessment and management of these populations. We also document stocking of hatchery-reared leans in Michigan waters and harvest of leans and siscowets in the sport and tribal commercial fisheries.

Methods

Data in this report are presented by lake trout management area (Figure 1). Management area boundaries generally follow those of statistical districts described by Hile (1962), except that MI-3 and MI-4 represent east and west portions of statistical district MS-3, and MI-5 and MI-6 represent east and west portions of MS-4. Boundaries have also been adjusted to contain whole statistical grids, except where grids are divided by state or international boundaries. Statistical grids are numbered areas bounded by 10 minutes of longitude and latitude. For the commercial-sized assessment, management areas except MI-3 and MI-7 have been subdivided into stations that represent former commercial lake trout fishing grounds. In MI-4, grids 1026, 1125, and 1126 make up the Bete Grise station, grid 1224 is the Traverse Island station, and grid 1325 is the Point Abbaye station. In MI-5, grid 1327 is the Big Bay Station and grids 1429, 1529, and 1530 make up the Marquette station. In MI-6, grids 1533 and 1632 make up the Munising-west station and grids 1534 and 1535 make up the Munising-east station.

Most data described in this report for areas MI-2 through MI-7 are those collected and analyzed by MFS personnel, but commercial-sized lake trout data for MI-7 were collected by Chippewa/Ottawa Treaty Fishery Management Authority (COTFMA) personnel, and commercial-sized lake trout data for MI-3 in 1997 were collected by the Red Cliff Fisheries Department (RCFD) of the Red Cliff Band of Lake Superior Chippewa. Collection and analysis of commercial-sized lake trout data in MI-2 was done by RCFD and in MI-8 by Bay Mills Indian Community during 1993-97. In addition, lake trout data were collected by two assessment fisheries in MI-1 (Isle Royale) during 1991-97 and were entered in standard databases by MFS personnel. These data for Isle Royale waters will be presented in a later report.

The scope of lake trout assessment has been broadened in recent years to include siscowets, because of their increased abundance and distribution that overlaps that of leans (Peck and Schorfhaar 1994). Humpers have attracted recent attention by some lake trout scientists as a source of genetic diversity for restoration of deepwater lake trout populations in Lake Huron and Lake Michigan but are not currently assessed (Eshenroder et al. 1999). All three lake trout forms are still considered by taxonomists as one species but a number of characteristics have been identified for distinguishing among them. Burnham-Curtis (1993) was able to separate hatchery-reared lean and siscowet progeny using principal component analysis of a number of morphometric characters indicating that these differences had a genetic basis. Burnham-Curtis (1993) also identified osteological character differences among the three forms. Siscowets and humpers were found to have radii on the anterior of the supraethmoid bone and a notch in the opercle bone, and leans lacked both characters. Eschmeyer and Phillips (1965) found that siscowets had a much greater flesh fat content than leans or humpers. However, none of the above studies have provided a new and efficient means of field identification. The large numbers of fish routinely encountered in commercial and agency catches do not allow time for detailed morphometric/meristic analysis or laboratory analysis for flesh fat content. The opercular notch identified by Burnham-Curtis (1993) appeared promising but has proven difficult to check for in field situations.

Characters most used for separation of leans and siscowets by agency personnel continue to be body shape and angle of the snout as depicted in Figure 2. Body shape works for large fish where siscowets are distinctly more deep-bodied than leans. Body shape does not work well for small fish (around 20 inches or less) but the angle-of-the-snout character seems to work reasonably well for all sizes with siscowets having a definite downward angle. These characters are subjective, and in each sample, a few fish are usually encountered that do not seem to fit the stereotypical pictures. Some agency personnel and commercial fishers visually check flesh fat content by slicing and inspecting muscle tissue as an additional identification character, but this is not considered by most people to be a definitive field character. Other more subjective characters for separating leans and siscowets include shape of the tail and size of the eye. The difference between width of the caudal fin and width of the caudal peduncle appears greater in siscowets than leans, and siscowet eyes appear to be larger relative to size of the head. Identification of humpers presents a greater challenge because body shape and snout angle lie between siscowets and leans. Humpers tend to have a body shape more akin to siscowets but a snout angle more like leans. Humpers are mature at a much smaller size than either siscowets or leans, and maturity has been used as an identification character (Rahrer 1965; Patriarche and Peck 1970). Identification of humpers has not posed much of a problem, because there has not been a commercial fishery for them since the early 1970s and humpers are rarely encountered in contemporary lake trout assessments.

Assessment of Commercial-sized Lake Trout

Annual assessments of commercial-sized (≥ 17 in, total length) leans were done during a 5-6 week period beginning the last week of April and extending through the first or second week of June. Assessment nets were 1,500-foot gangs of 6-foot deep (18 meshes) multifilament nylon gill net of 4.5-inch stretch-measure mesh fished on the bottom at depths of 120-240 feet for 72 hours. Permitted commercial fishers conducted the assessment fishing in MI-5 and MI-6 and were allowed to take a quota of lake trout at each station: 500 at Big Bay, 500 at Marquette, 400 at Munising-west, and 400 at Munising-east. In MI-3, MI-4, and MI-7, assessment fishing was done by MFS or COTFMA personnel until a targeted level of gill-net effort (feet) was fished: 45,000 in MI-3, 45,000 (15,000 feet each at Bete Grise, Traverse Island, and Point Abbaye stations) in MI-4, and 24,000 feet in MI-7.

Data pertaining to net sets, and data from lean and siscowet lake trout, were recorded by 1,500-foot gang and included relative abundance (CPUE = number of fish per 1,000 feet of net), total length (in), weight (lb), sex, maturity, fin clip, and number and classification of sea lamprey attack marks. Otoliths and/or scales were collected from each fish for subsequent age determination. Otoliths were collected from leans 23 inches and longer and all siscowets. Stomach contents from 100 lean and 100 siscowet lake trout from each management area were examined and recorded on board the vessel. These diet data were provided to the United States Geological Survey, Great Lakes Science Center, Ashland Biological Station in Ashland, WI for analysis and will not be described in this report. Sea lamprey attack marks were classified according to King and Edsall (1979). We designated marks A1, A2, and A3 as wounds and marks A4, B1, B2, B3, and B4 as scars. Wounds and scars were reported as number per 100 fish (Eshenroder and Koonce 1984). Wounds per 100 fish provided the basis for estimating mortality caused by sea lampreys (Pycha 1980; Ebener et al. 1989; Eshenroder and Koonce 1984). Wounding was summarized for the total sample of leans and by 4-inch size groups (17-20, 21-24, 25-28, 29+) to compare wounding among management areas and to measure the size-selective nature of sea lamprey predation. Age determinations were based on a random subsample of 20 fish per inch group per management area. An age-length key was constructed for each year in each management area and applied to total catch to determine age composition.

Assessment of Pre-recruit Lake Trout

Lake trout less than 17 inches long are not common in the sport harvest and generally not legal in the commercial harvest, and so are considered pre-recruits to these fisheries. Knowledge of the status of these pre-recruit fish would provide some ability to forecast future management to protect these fish stocks when they recruit to sport and commercial fisheries in future years. Marquette Fisheries Research Station personnel assessed the status of these pre-recruit lean and siscowet lake trout at 25 stations from Black River Harbor (MI-2) to Grand Marais (MI-7) with 1,800-foot gangs of 6-foot deep multi-filament nylon graded-mesh gill net, made up of 300-foot panels of 2.0-, 2.25-, 2.5-, 2.75-, 3.0-, and 3.5-inch stretch-measure mesh. These gangs were fished on the bottom overnight for approximately 24 h at depths of 90 to 240 feet during the last week of July through the third or fourth week of August each year. Data recorded for each fish captured in each mesh size in each 1,800-foot gang included species and total length (in). A body structure for aging was collected from each lean, siscowet, other salmonines, burbot *Lota lota*, and a sample of 10 for each coregonine species from each gang. Otoliths were collected from leans 23 inches and longer, all siscowets, and all burbot. Scales were taken from leans less than

23 inches and all other species sampled except suckers *Catostomus spp*. and rainbow smelt *Osmerus mordax*. Other data collected along with otoliths or scales included fin clip, sea lamprey marks, sex, and maturity. Stomachs were collected and weights were obtained from a sample of 50 leans and 50 siscowets in each management area, to obtain diet data for future bioenergetics modeling. The pre-recruit assessment was not done in 1997 due to lack of a boat captain to operate the assessment vessel.

Assessment of Predator Fish Composition

Preliminary bioenergetics analyses conducted in western Lake Superior in the early 1990s indicated that siscowets dominated the predator fish population in that portion of the lake (M. P. Ebener, COTFMA, personal communication). To confirm this and determine if a similar domination occurred lakewide, agency members of the Great Lakes Fishery Commission, Lake Superior Technical Committee, conducted a lakewide assessment in June 1996 and August-September 1997 to determine the species composition, relative abundance, and diet for predator fish (especially leans and siscowets) at depth strata from inshore to as deep offshore as was feasible to sample. All agencies agreed on standardized methods for conducting this assessment. Marquette Fisheries Research Station conducted its part of this assessment in MI-5 east of Marquette in grids 1430 and 1530 (Figure 1). Graded-mesh gill nets were fished overnight (some two-night sets in 1997 due to bad weather) on the bottom at 60-foot depth intervals in 1996 and at 120-foot depth intervals in 1997. The nets were 6 feet deep and 2,700 feet long and made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch extension-measure multifilament nylon mesh. Fish captured in each mesh in each set were identified and enumerated; and, except suckers and rainbow smelt, were measured, weighed, examined for sex and maturity, examined for number and stage of sea lamprey attack marks, and sampled for scales or otoliths for age analysis. Otoliths were collected from leans 23 inches and longer, all siscowets, and all burbot. Scales were collected from leans less than 23 inches and all other fishes. Fin clips were recorded for all salmonines, and stomachs were collected from all salmonines and burbot for diet analysis. Stomach contents were analyzed by COTFMA personnel.

Calculation of Population Parameters

Annual indices of relative abundance of lake trout in the assessments of commercial-sized and pre-recruit lake trout were based on the total catch-per-unit-effort (CPUE) from samples collected at multiple fixed stations within each management unit. Sampling stations were distributed within each management unit to provide spatial representation of population densities and some stations were temporally replicated within a year. Sampling stations were the same as those reported and illustrated in Peck and Schorfhaar (1994). Various indices of relative abundance presented in this report included CPUE for total catch in both assessments, CPUE of large (≥ 25 in) fish in the commercial-sized assessment that are presumed to be spawning fish, CPUE of the pre-recruit component of leans and siscowets in the pre-recruit assessment, and CPUE of leans and siscowets captured in 2- and 2.5-inch mesh in the pre-recruit assessment. This latter CPUE was presented because these two meshes were standard among agencies on Lake Superior doing pre-recruit lake trout assessments. In the predator-composition assessments, CPUE was also number per 1,000 feet of gill net and was used to compare relative abundance of fishes among depth strata at the site fished. Total annual mortality rates were estimated using the catch-curve method described by Robson and Chapman (1961) for wild leans and siscowets in age groups that were considered fully vulnerable to the gill nets. Age-9 and older leans were considered fully vulnerable to the 4.5-inch mesh and 17-inch size limit used in the commercial-sized assessment. In previous years, age-9 has sometimes been the modal age group, always on the descending limb of the catch curve, and almost all age-9 fish are 17 inches and larger (Peck and Schorfhaar 1994). Ages 7 and 8, although often modal, have sometimes been on the ascending limb of the catch curve and some fish of these ages have been less than 17 inches in most assessment samples (Peck and Schorfhaar 1994). Mortality was estimated for age-15 and older or age-16 and older siscowets in the graded-mesh nets used in the predator composition assessment because these were the modal ages. However, calculating catch-curve mortality rates from age composition in a graded-mesh net is problematic due to different vulnerabilities for each mesh size. Chi-square (χ^2) values were calculated to compare two separately estimated survival rates for the same population using the Robson and Chapman (1961) method. A chi-square value in excess of 3.84 indicated that there was a greater than 5% chance that factors other than sampling error were compromising validity of survival estimated from the age composition catch curve. Mortality rates were not estimated for hatchery leans in the commercial-sized assessment due to low numbers captured in each area. Mortality rates were not estimated for leans and siscowets in the pre-recruit assessment because it was suspected that the mesh sizes used caused an artificial truncation of age groups on the descending limb of the catch curve (Peck and Schorfhaar 1994).

Stocking history

An average of 646,000 leans was stocked annually in Michigan waters of Lake Superior during 1983-97. These stocked leans were fin clipped to distinguish them from naturally-produced lake trout. Most leans were stocked as yearlings but some were stocked as fall fingerlings. In recent years, fall fingerlings were stocked only in management area MI-8.

Assessment of Sport Fishery Harvest

The sport fishery harvest of lean and siscowet lake trout during 1993-97 was assessed with a stratified-random on-site creel survey (Ryckman 1981; Lockwood et al. 1999) in MI-2 during May-October, in MI-4 during February-October, in MI-5 during March-October, and in MI-6 during February-September. Creel survey sites and months surveyed were generally consistent during 1993-97 except for reduced survey effort at one site in MI-2 in 1994.

Assessment of Commercial Fishery Harvest

There is no commercial lean lake trout harvest by state-licensed commercial fishers except that in research-permit assessment fisheries in MI-1, MI-5, and MI-6; leans may be sold by the fishers as compensation for doing the assessment. State-licensed fishers may also fish for siscowets under research permits but this fishery is restricted to waters deeper than 360 feet and to fish less than 18 inches total length. Lean and siscowet lake trout are commercially harvested by tribal commercial fishers under 1836 and 1842 treaty fishing rights. Harvest data were obtained from unpublished lake trout extraction reports presented in minutes of the Great Lakes Fishery Commission Lake Superior Committee annual meetings, GLIFWC administrative reports, and unpublished COTFMA data (M. P. Ebener, COTFMA, personnel communication).

Results

Assessment of Commercial-sized Lake Trout

During 1993-97, relative abundance (CPUE) of commercial-sized hatchery leans increased slightly in MI-4 and fluctuated without trend in MI-3, MI-5, MI-6, and MI-7 (Table 1, Figure 3a). CPUEs of wild leans increased in MI-4 and MI-5 and were without trend in MI-3, MI-6, and MI-7 (Table 1, Figure 3b). Relative abundances of hatchery and wild leans were highest in MI-5 and MI-6, and lowest in MI-3. Relative abundance of wild leans 25 inches and larger increased in MI-3, MI-4, and MI-5, and was without trend in MI-6 and MI-7. These larger leans were most abundant in MI-5 and MI-6 (CPUE = 3.4-7.6) and least abundant in MI-3 and MI-4 (CPUE = 0.2-2.5). The percentage of wild leans was highest in MI-7 (93-97%) and lowest in MI-5 (81-91%). Sea lamprey wounding on leans fluctuated in all areas without trend during 1993-97 (Table 1). Wounding in 1993 was generally higher than in other years except in MI-6 where wounding was highest in 1997. Average wounding was highest (6.9) in MI-3 and MI-7 and lowest (2.6) in MI-5. Wounding on leans 25 inches and larger fluctuated without trend and averaged highest (22.0) in MI-4 and lowest (8.0) in MI-5.

Wild leans sampled in MI-3 through MI-7 during 1993-97 ranged in age from 4 to 25 years and modal age ranged from 6 to 8 years and averaged 7 years (Tables 2-6). Age composition in MI-4, MI-5, and MI-7 indicated a strong 1989 year class that became modal at age 6 in 1995, and remained strong in 1996 and 1997 samples (Tables 3, 4, and 6). Mean age among areas ranged between 7.5 and 8.0. Estimated total annual mortality for age-9 and older wild leans for the combined 5-year age composition in each area was less than 0.50 in all areas and was lowest in MI-3 (0.41) and highest in MI-4 (0.49). Although the highest rate was in 1993 in areas MI-3, MI-4, and MI-5, annual mortality rates otherwise fluctuated without trend in all areas sampled during 1993-97. Numbers of hatchery lake trout were too few to evaluate age composition on a management area basis, so annual catches from all areas were combined. Hatchery lake trout ranged in age from 3 to 27 years, modal age was 6 most years, and mean age was just over 7 years during 1993-97 (Table 7). The age composition of hatchery lake trout in assessment samples corresponded to numbers stocked for some but not all year classes. The 1989 year class was stocked in low numbers (Table 8) and correspondingly was nearly absent in assessment samples. Over a million 1985 year class fish were stocked and distributed among most areas and these fish were well represented in the samples. On the other hand, twice as many 1986 year class fish were stocked than 1987 year class fish, yet more 1987 year class fish were captured in the assessment.

The mean weight and total length of individual commercial-sized leans (hatchery and wild combined) fluctuated without trend in management areas during 1994-97 but averaged largest in MI-3 and smallest in MI-4 (Table 9). However, weight-length coefficients for leans in MI-3 and MI-4 were not significantly different, nor were they different among other areas.

The total allowable catches (TACs) based on the methodology described in Ebener et al. (1989) and presented in Peck and Schorfhaar (1994) were not updated during 1993-97. State, tribal, and federal biologists are currently working together to develop new methods for TAC calculation.

Assessment of Pre-recruit Lake Trout

Wild leans made up over 80% of the lean catch in most years in all management areas but the percentage wild decreased slightly in MI-2, MI-3, and MI-4 during 1993-96 (Table 10). Pre-recruit wild lean CPUE increased in MI-7, fluctuated without trend in MI-2, MI-3, and MI-5, and decreased in MI-4 and MI-6 (Table 10, Figure 3). Pre-recruit hatchery lean CPUE increased in MI-2, MI-3, and MI-4, and fluctuated without trend in the other areas. Wild lean CPUE was highest in MI-5 (CPUE = 7.3-13.6) and lowest in MI-6 (CPUE = 0.9-1.9), whereas hatchery CPUE was highest in MI-4 (CPUE = 0.7-1.7) and lowest in MI-7 (CPUE = 0.0). Siscowet CPUE, including all sizes and pre-recruits, increased in all areas. Pre-recruit siscowet CPUE was highest in MI-3 (CPUE = 10.2-17.5) and lowest in MI-6 (CPUE = 1.6-3.3) (Table 10).

Wild leans in the pre-recruit assessment ranged in age from 2 to 15 years, with the pre-recruit component ranging from 2 to 9 years (Table 11). Modal age of total lean catches by area was age 5 in MI-2, MI-3, and MI-5 and age-6 in MI-4, MI-6, and MI-7. Age 5 was the modal age for the total pre-recruit lean lake trout age composition in all areas (Table 11). Mean age of the total lean catch ranged from 5.2 in MI-2 to 6.2 in MI-7. Mean age of pre-recruit leans ranged from 4.6 in MI-2 to 5.2 in MI-4. Mean total length-at-age among years and management areas was without trend. Although length-at-age tended to be greater in MI-6 and MI-7, this difference was not significant in most cases based on overlapping 95% confidence intervals (Tables 12-17).

Siscowets in the pre-recruit assessment ranged in age from 2 to 32 years, with the pre-recruit component ranging from 2 to 15 years (Table 18). Modal age of total siscowet catches by area was age 8 in all areas except MI-3 where it was age 7. Modal age for siscowets in the pre-recruit component was age 5 in MI-2, MI-6, and MI-7, age 6 in MI-3 and MI-5, and age 8 in MI-4. Mean age of all siscowets ranged from 8.6 in MI-7 to 10.1 in MI-4 and mean age of the pre-recruit component ranged from 6.5 in MI-2 to 7.6 in MI-3. Mean total length-at-age varied among management areas and among years within areas (Table 19). Length-at-age was shorter in 1995-96 than in 1993-94 in MI-2, MI-3, and MI-4, and tended to be longer in MI-6 and MI-7 than in the other more western areas.

Mean weight (lb) of pre-recruit leans in the assessment samples ranged from 0.81 in 1994 to 0.92 in 1995, and total length (in) ranged from 14.5 in 1994 and 1996 to 14.7 in 1995 (Table 20). Mean weight of pre-recruit siscowets ranged from 0.85 in 1996 to 0.98 in 1995, and total length ranged from 14.6 in 1996 to 15.0 in 1995. Siscowets in 1995 averaged heavier than in 1994 and 1996, and longer than in 1996. Lean and siscowet weight-length coefficients were not different among years except that the slope coefficient for siscowets in 1994 was greater than for siscowets in 1995 and 1996 (Table 20).

Lake herring *Coregonus artedi* was the most abundant species other than lake trout captured in the pre-recruit assessment (Table 21). Lake herring abundance increased substantially in most areas in 1996, likely due to the influx of fish from strong 1989 and 1990 year classes. Other species that were common in the assessment were lake whitefish *Coregonus clupeaformis*, round whitefish *Prosopium cylindraceum*, bloater *Coregonus hoyi*, longnose sucker *Catostomus catostomus*, burbot, and rainbow smelt. These species were much less abundant than lake herring and no substantial changes in their relative abundance were observed. Other species occasionally caught included coho salmon *Oncorhynchus kisutch* and kiyi *Coregonus kiyi*.

Assessment of Predator Fish Composition

Siscowet abundance generally increased with increasing depth in 1996 and 1997, and siscowets greatly outnumbered leans at depths greater than 180 feet, especially in 1997 (Table 22). Siscowets were not captured at depths less than 60 feet. Abundance of siscowets peaked in the 540- to 599-foot stratum in June 1996 and in the 480- to 599-foot stratum in September 1997, and abundance decreased in depths 600 feet and greater both years. Leans were most abundant in depths less than 180 feet although a few were caught at various deeper strata (less than 600 feet). Other fish caught in these nets were bloater, burbot, lake herring, and kiyi. Overall, siscowets outnumbered leans 12 to 1 in 1996 and 48 to 1 in 1997. Sea lamprey attack marks were more numerous on siscowets than leans. In 1996, wounds and scars per 100 siscowets increased with increasing size from 3 wounds and 1 scar for the 17-20 inch group to 45 wounds and 127 scars for the 29+ inch group, with the average for all sizes being 12 wounds and 15 scars. Leans averaged 6 wounds and 3 scars per 100 fish in 1996. Wounds and scars were fewer on siscowets in the 1997 samples, averaging 6 wounds and 7 scars. For leans in 1997, the average was 0 wounds and 8 scars but the sample size was only 9 fish. Siscowet ages ranged from 3 to 30 years but most were less than 20 (Table 23). Age 15 was the modal age in 1996 and age 16 was modal in 1997, with mean age being 12.4 and 15.5 for the two years, respectively. Total mortality rates estimated for the modal ages and older were 0.59 in 1996 and 0.48 in 1997. Weight-length coefficients determined for 549 siscowets in 1996 were –9.023 (2SE=0.172) and 3.326 (2SE=0.058). No age, mortality, or weight-length data were calculated for the few leans in these samples.

Fish made up the bulk of the diet (percent of total food weight) of siscowets and leans, with coregonines (mainly deep-water ciscoes) the main contributor to siscowet diet and burbot the main contributor to lean diet in June 1996 (Table 24). Burbot made up a substantial portion of the siscowet diet, and coregonines and rainbow smelt did likewise in the lean diet. Differences in the fish diet of siscowets and leans included the absence of ninespine sticklebacks *Pungitius pungitius* in siscowets, and the much greater contribution of rainbow smelt in leans. Comparisons between siscowets and leans must be tempered by the smaller sample of leans, but differences in the overall diet included the greater terrestrial contribution to the diet of siscowets as evidenced by the presence of birds and insects and the greater contribution of the crustacean *Mysis oculata* in the lean diet. The diet of siscowets in the September 1997 assessment was also dominated by fish (90%) represented by coregonines (68%), burbot (12%), sculpins *Cottus spp*. (10%), and ninespine sticklebacks (< 1%). The invertebrate component of the diet was mainly amphipods (5%) with *Mysis* and terrestrial insects being much less important than in June 1996. Too few leans were captured in 1997 to present their diet data or to compare with siscowets.

Stocking History

The average number of yearling hatchery leans stocked annually during 1983-97 ranged from 5,000 in MI-7 to 186,000 in MI-5 (Table 8). These two areas were likewise lowest and highest in terms of number stocked per square mile of lean lake trout habitat (depth ≥ 240 feet). Number stocked in all Michigan waters has decreased in recent years as an effort has been made to eliminate stocking. Michigan and other agency representatives on the Great Lakes Fishery Commission Lake Superior Committee determined that self-sustaining populations have been established in all Michigan management areas except MI-8, and stocking should cease or be substantially reduced to protect the genetic integrity of these developing stocks and provide additional hatchery fish for restoration efforts in other Great Lakes. Since 1996, stocking has taken place only in Keweenaw Bay (MI-4) and Whitefish Bay (MI-8) due to prior agreements with Native American tribes.

Sport Fishery

The estimated sport catch of lean and siscowet lake trout in the non-charter sport fishery fluctuated without trend in surveyed areas MI-2, MI-4, MI-5, and MI-6 although fishing effort decreased during 1993-97 (Table 25). The catch of leans averaged a little over 21,000 fish annually, with a low of 15,900 fish in 1995 and a high of 26,600 fish in 1993. The sport catch of siscowets averaged about 11,000 with a low of 4,400 fish in 1995 and a high of 19,400 fish in 1994. The highest catch of leans was in MI-5 and the highest catch of siscowets in MI-4. The catch of siscowets in MI-4 fluctuated considerably due to most being caught during the winter ice fishery. Good ice conditions in 1994, reduced survey effort in 1995, and warm weather in 1997 influenced this fishery. Charter boats caught an additional 3,000-4,000 lake trout annually in areas 2-6 and an additional 1,000 in MI-1 (G. P. Rakoczy, MDNR, Charlevoix Fisheries Research Station, unpublished data).

Assessment of Commercial Fishery Harvest

The tribal commercial catch of lean and siscowet lake trout generally decreased during 1993-97 and averaged 170,000 and 88,000 pounds dressed weight, respectively (Table 26). The catch of leans and siscowets was highest in MI-4 and lowest for leans in MI-3 and lowest for siscowets in MI-8. The catch of siscowets exceeded that for leans only in MI-3, but was similar in MI-2 and MI-4.

Discussion

Despite pressures from fisheries and increasing siscowet populations, the status of lean lake trout populations generally improved in most Michigan waters during 1993-97. Relative abundance of commercial-sized wild leans, indicated by CPUEs, either increased slightly or fluctuated without trend. This signified a halt to a trend of decreasing relative abundance observed in most management areas in 1988-92 (Peck and Schorfhaar 1994). However, CPUEs in 1993-97 in MI-3, MI-4, and MI-5 were generally lower than in 1988-92, which indicates that these populations could be in better shape (Figure 3). Commercial-sized lake trout CPUEs in MI-2 have increased since 1991 and were without trend during 1993-97 (Gallinat 1998). Although sport harvest appears to be unchanged, tribal commercial harvest of leans has decreased, likely contributing to the improved status of commercial-sized populations. Relative abundance of large leans, presumably spawners, increased during 1993-97 and was higher than in 1988-92, which should bode well for reproduction in the near future. Sea lamprey wounding on large leans was lower in 1993-97 than in 1988-92 except in MI-4 (Schorfhaar and Peck 1994). Total annual mortality rates averaged above the target rate of 0.45 set by the Great Lakes Fishery Commission, Lake Superior Technical Committee (Hansen 1996), but averaged less than 0.50 which Healey (1978) believed was the maximum mortality rate that would allow natural lake trout populations to increase or remain stable. This is in contrast to 1988-92 when most rates exceeded 0.50 (Peck and Schorfhaar 1994). However, actual total annual mortality rates even during 1988-92 may have been low enough for rehabilitation, and rates for 1993-97 even lower because mortality rates derived from catch curves may overestimate by as much as 20% due to selectivity of the 114-mm mesh used in the commercial-sized assessment (Hansen et al. 1997). Pre-recruit abundance that was decreasing in MI-2 and MI-3 in 1988-92 appeared to have leveled off or increased slightly in 1993-96 (Figure 3). However, the decrease in pre-recruit lean abundance has persisted in MI-4, and abundance that had increased during 1988-92 in MI-6 decreased during 1993-96. The decreased abundance in MI-4 in 1993-96 might be reflecting the decreased abundance of larger leans in 1988-92, but the decreased abundance in MI-6 is not readily explainable because abundance of larger leans has generally been increasing since 1990.

Siscowet lake trout populations appeared to have done even better than leans during 1993-97. Abundance of pre-recruit siscowets increased in all assessed areas during 1993-96 (Figure 4). The siscowet's position as the dominant predator in Lake Superior was identified and described in an unpublished bioenergetics study of western Lake Superior in 1995 (M. P. Ebener, COTFMA, personal communication). Siscowets were estimated to make up 72% of the total predator biomass in western Lake Superior. Lean lake trout made up about 22%, with Pacific salmon and walleye *Stizostedion vitreum vitreum* contributing the remaining 6%. The dominance of siscowets there and elsewhere in the lake was confirmed by lakewide predator composition assessments in 1996 and 1997. The abundance of siscowets compared to leans reported in this study for MI-5 was typical of that reported at sites across U. S. waters of Lake Superior, and diet information indicated that siscowets foraged in all parts of the lake from top to bottom and from offshore to inshore (Lake Superior Technical Committee, unpublished reports). Despite their abundance, siscowets were exploited much less than leans by both the sport and commercial fisheries. Siscowets 18 inches and larger cannot be harvested by Michigan state-licensed commercial fishers, and anglers are advised not to eat them due to high chlordane levels. Even tribal commercial fisheries, that can harvest larger siscowets, harvested fewer siscowets than leans. Apparently, fear of contaminants has affected markets at the wholesale and retail levels.

Progress in lake trout management in Michigan waters during 1993-97 centered on cessation of stocking, maintenance of consistent survey and assessment levels, and development of improved population models to estimate stock abundance and TACs. The role of hatchery fish in restoring lean lake trout populations in Michigan waters of Lake Superior has essentially come to an end. Hatchery lake trout did contribute to restoration in most Michigan waters, but declining survival of hatchery fish and presence of restored wild fish dictated termination of stocking (Hansen et al. 1994; Hansen et al. 1995). The limited stocking that has been done since 1996 has been in MI-4, an area with restored populations but where continued stocking by federal hatcheries has been done as payment for use of a tribal hatchery as an isolation facility; and in MI-8, an area where lake trout rehabilitation has been deferred by order of the 1985 Consent Agreement (Peck and Schorfhaar 1994). There is ample evidence that lake trout move among Michigan management areas (Ebener 1990; Peck and Schorfhaar 1991), so movement of wild leans from rehabilitated areas could be sufficient to restore populations in deferred rehabilitation areas providing that fishing mortality is not excessive. Movement of leans from rehabilitated areas MI-5 and western MI-6 likely contributed in part to the restored populations in one deferred area (MI-7) because no lake trout have been stocked in this area since 1985. Lean populations have not been restored in MI-8 despite annual stocking since the 1960s. Relative abundance (CPUE = fish per 1,000 feet of gill net) of hatchery and wild leans in MI-8 in 1998 was 1.9 and 2.8, respectively, and total annual mortality exceeded 0.50 (K. Gebhardt, Bay Mills Indian Community, Bay Mills, MI, unpublished assessment report). A major advancement in lake trout population modeling began during 1993-97 in collaboration with the Department of Fisheries and Wildlife at Michigan State University and member agencies of the Lake Superior Technical Committee, Great Lakes Fishery Commission. Statistical catch-at-age analysis was applied to age-structured lake trout population models in Lakes Huron and Superior to estimate mortality, harvest, and abundance (Sitar 1996; Weeks 1997; Sitar et al. 1999). Advantages of these catch-at-age models include: 1) they provide age-specific estimates of mortality, abundance, and harvest; 2) they decompose mortality into subcomponents such as recreational fishing, commercial fishing, and sea lamprey-induced; and 3) the models are quantitatively fit to both fishery and fishery-independent data using a maximum likelihood fitting approach that accounts for the associated variances for each data source. Furthermore, these models provide mortality estimates for ages not fully recruited to the fishery and do not depend on the unrealistic assumptions of catch curves such as equal vulnerability to the sampling gear and age-independent mortality (e.g., Ricker 1975). Catch curves have been the standard technique to estimate mortality rates for lake trout in Lake Superior, but do not provide information on the relative contribution of the various mortality sources or on how these mortality rates vary by age.

Recommendations

Assessment Recommendations

Continue assessment of commercial-sized leans in all Michigan waters, in cooperation with state-licensed commercial fishers and Native American tribal biologists. Continue assessment of pre-recruit leans and siscowets in management areas 2-7, and add MI-8 if status is upgraded from deferred rehabilitation. Since the lake trout resource is shared by both commercial and recreational fisheries, short-term TACs have been used to manage the fisheries. The lake trout assessment data are critically necessary in the statistical catch-at-age models used to generate these TACs. The mortality sources that operate on lake trout can impact the populations on a short time scale such as a year, therefore temporal gaps in the assessment data can delay detection of real stock declines. Continuation of these assessments is necessary to maintain the long-term data set that has provided information on the dynamic variation of lake trout population fluctuations and progress towards complete rehabilitation.

Assess siscowet populations as necessary to assess status in all management areas and provide data for bioenergetics models.

Continue creel surveys to assess sport harvest of lean and siscowet lake trout in management areas 2, 4, 5, and 6 and seek funding to do creel surveys in areas 3, 7, and 8. Contemporary lake trout harvest in areas 3, 7, and 8 has been only crudely estimated based on relative effort in a 1970s mail survey in these areas. Standardized on-site estimates of sport harvest and biological data from harvest in areas 3, 7, and 8 are necessary to measure the amount of lake trout extracted by anglers, and to improve the statistical catch-at-age models currently under construction for these areas.

Locate siscowet spawning grounds in Michigan waters and assess spawning populations. Only a few sites have been identified, one each in MI-1, MI-3, MI-4, and MI-7. Numerous others likely exist in deep waters along the Michigan mainland shore and at offshore sites like Stannard Rock and the Caribou Island grounds.

Refine methodology for using otoliths to age lake trout. The whole-otolith oil-soak method used at this station should be compared to the transverse-section method used by some other agencies to determine the best standardized method for aging.

Management Recommendations

Complete statistical catch-at-age lake trout models so that mortality subcomponents and TACs can be estimated for each management area to measure progress towards rehabilitation and to better manage sport and commercial fisheries.

Continue interagency cooperation and negotiation in lake trout management. This cooperation allows for an exchange of ideas, opinions, data, and provides peer pressure for appropriate management. Management areas 7 and 8 should be upgraded from deferred to a classification that would promote lake trout restoration.

Support U.S. Fish and Wildlife Service efforts to further reduce sea lamprey abundance. Reducing sea lamprey-induced mortality would speed rehabilitation of lake trout populations while enhancing sport and commercial fisheries. Support efforts by all entities, especially the Binational Program, to reduce input of contaminants into Lake Superior so that contaminant advisories will be unnecessary. This could lead to removal of restrictions on harvest of siscowets that would lessen fishery exploitation on lean populations.

Emphasize stewardship of established self-sustaining populations by elimination of all stocking and controlling fishing mortality. Current stocking in MI-4 where self-sustaining populations have been established, and in MI-8 where rehabilitation has been deferred, is contributing little towards the goal of lake trout restoration and is mainly encouraging excessive fishing.

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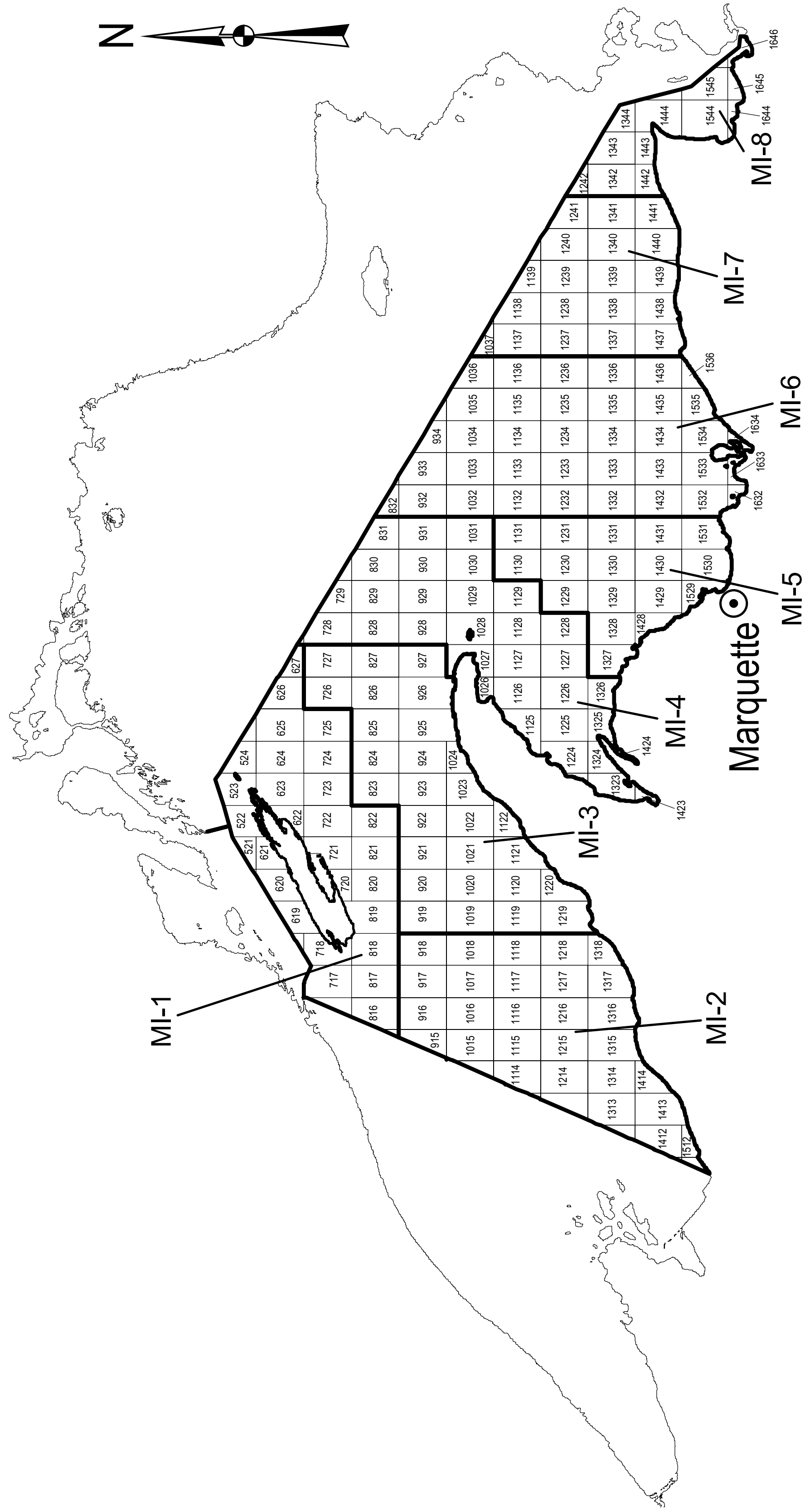

Figure 1.-Lake trout management areas and component statistical grids in Michigan waters of Lake Superior.

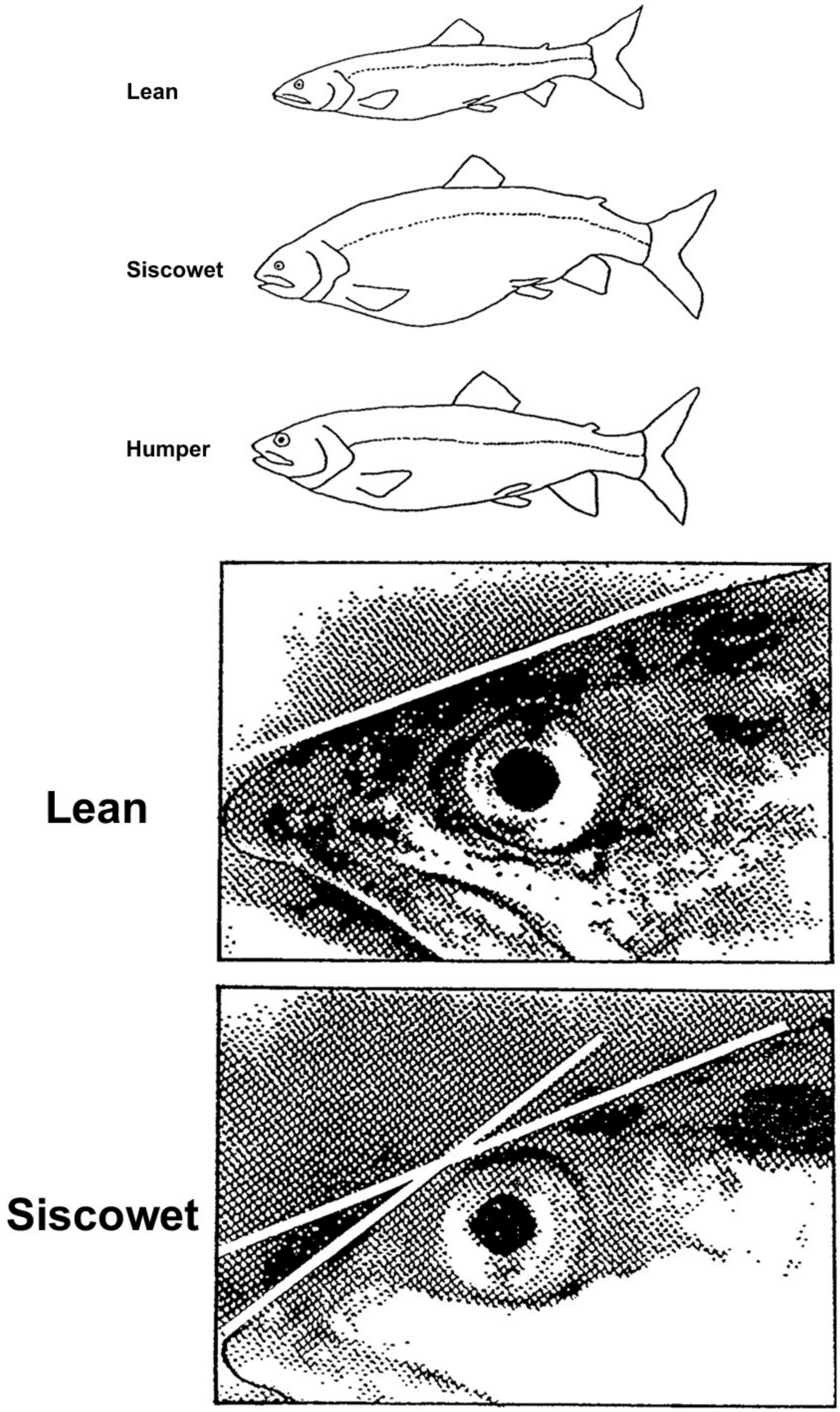

Figure 2.-Body shape and angle of snout profiles of lean, siscowet, and humper lake trout presented from Burnham-Curtis (1993) with permission of the author.

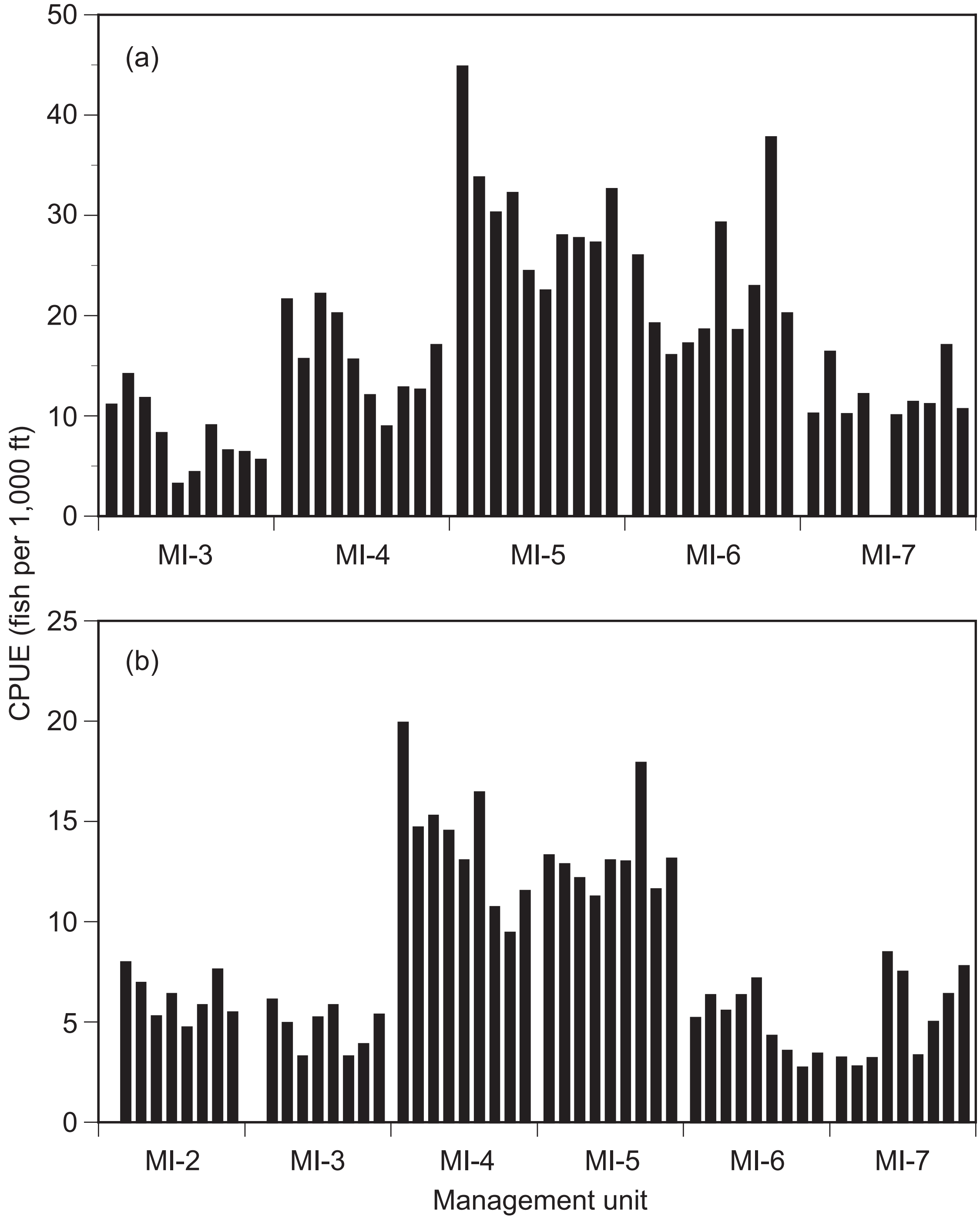

Figure 3.-Index of relative abundance of commercial-sized (³ 17 in) wild lean lake trout (a) in the commercial-sized assessment during 1988-97, and (b) of pre-recruit (< 17 in) wild lean lake trout in pre-recruit assessments during 1988-96. The graphs are presented with vertical bars in chronological order from left to right for each management unit. Relative abundance was based on catch-per-unit-effort (CPUE) expressed as fish per 1,000 feet of gill net. No sampling was done in MI-7 during the 1992 commercial-sized assessment. Pre-recruit assessments were not done in MI-2 and MI-3 during 1988 and not done in any management units during 1997.

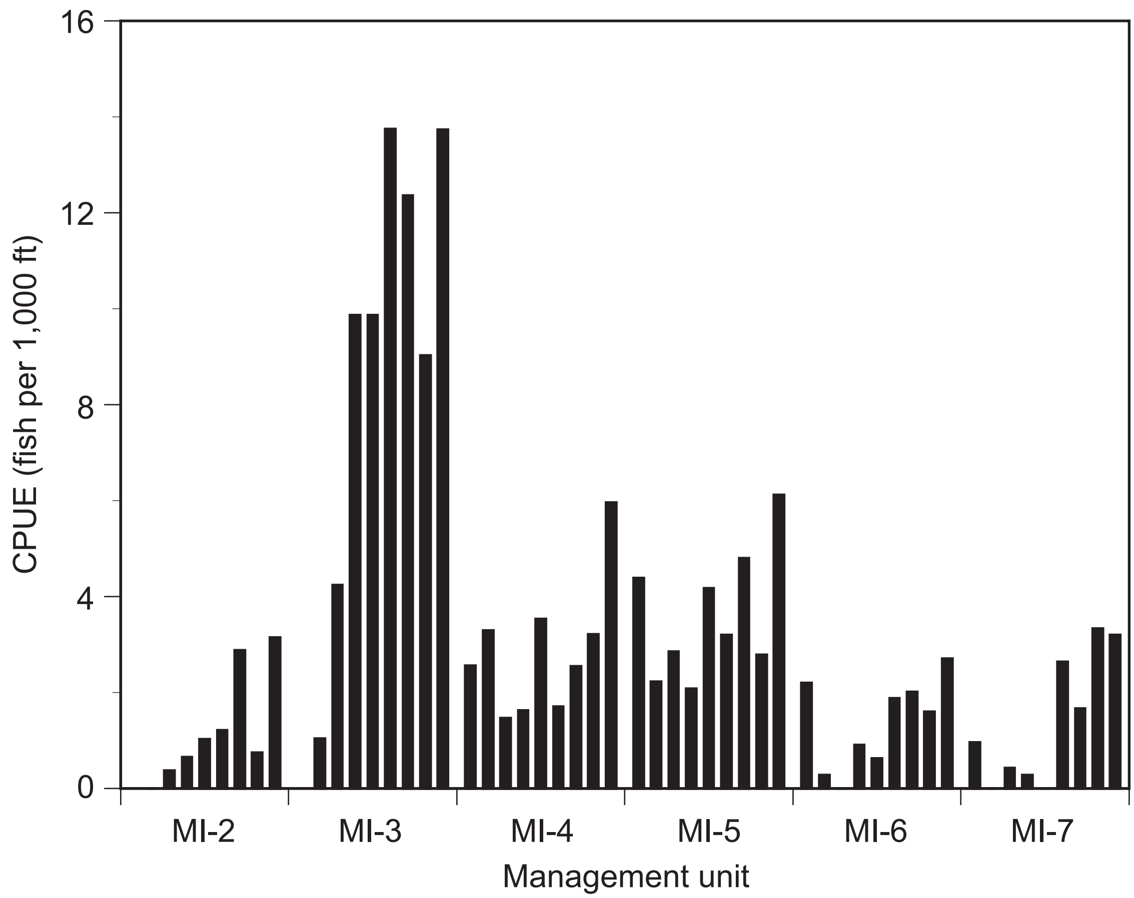

Figure 4.-Index of relative abundance of pre-recruit (< 17 in) siscowet lake trout in the pre-recruit assessment during 1988-96. The graphs are presented with vertical bars in chronological order from left to right for each management unit. Relative abundance was based on catch-per-unit-effort (CPUE) expressed as fish per 1,000 feet of gill net. Pre-recruit assessments were not done in MI-2 and MI-3 during 1988.

Table 1.–Abundance (CPUE[a]) of commercial-sized lean lake trout, mean total length of age-7 wild lake trout, and sea lamprey wounding[b] in Michigan's Lake Superior management areas MI-3, MI-4, MI-5, MI-6, and MI-7 during April-June 1993-97.

Area/ year	CPUE[a] Hatchery	CPUE[a] Wild (% wild)	CPUE[a] 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-3										
1993	0.5	4.4 (90)	0.2	20.8	14.9	2.3	16.8	40.7	50.0	41.9
1994	0.7	9.1 (93)	2.0	21.6	3.0	0.7	3.4	5.7	0.0	5.2
1995	0.8	6.6 (89)	1.2	21.9	6.4	4.7	5.7	12.2	7.1	11.1
1996	0.6	6.4 (91)	1.0	23.0	7.3	0.0	5.4	28.0	0.0	25.5
1997	0.6	5.6 (91)	2.2	22.4	2.9	0.0	2.2	6.0	0.0	4.7
MI-4										
1993	1.5	11.8 (89)	1.6	21.4	8.1	1.4	6.9	28.3	55.6	30.6
1994	1.2	9.0 (88)	1.7	21.9	5.1	1.9	1.2	20.0	33.3	21.3
1995	2.2	12.9 (85)	2.1	22.2	3.8	1.0	2.1	13.8	31.6	17.2
1996	1.6	12.6 (88)	1.8	21.1	5.9	0.0	4.2	32.5	0.0	28.1
1997	3.0	17.0 (85)	2.5	21.3	2.8	0.6	1.7	10.9	30.8	13.0
MI-5										
1993	4.7	22.5 (83)	3.7	21.9	3.1	0.4	2.3	7.9	46.2	11.4
1994	5.4	28.0 (84)	4.9	20.9	2.0	0.7	0.7	8.0	16.7	8.6
1995	6.4	27.7 (81)	3.9	21.3	1.1	0.0	1.0	3.6	0.0	3.3
1996	5.4	26.8 (83)	6.5	21.9	3.5	0.0	2.7	6.9	14.3	7.9
1997	3.3	32.6 (91)	5.9	21.4	3.2	0.0	2.6	8.7	7.1	8.6
MI-6										
1993	6.0	29.3 (83)	3.4	22.2	4.4	2.3	5.0	8.0	33.3	9.6
1994	2.5	18.6 (88)	3.5	21.7	2.4	0.3	3.9	3.0	0.0	2.7
1995	3.0	22.9 (88)	3.7	21.6	1.5	0.0	0.5	6.6	25.0	8.7
1996	4.7	39.9 (90)	7.6	21.6	2.7	0.8	2.0	6.4	16.7	8.0
1997	2.1	20.2 (91)	3.7	20.7	11.5	3.1	6.1	35.0	53.3	38.7
MI-7										
1993	0.8	10.1 (93)	1.7	21.2	9.6	1.9	11.9	17.1	37.5	20.4
1994	0.5	11.4 (96)	3.1	21.8	2.1	0.0	2.9	2.7	0.0	2.5
1995	0.4	11.2 (97)	1.4	21.1	7.6	0.8	11.7	16.7	40.0	20.0
1996	1.1	17.0 (94)	3.4	22.2	6.7	1.8	6.7	12.5	16.7	12.8
1997	0.7	10.7 (94)	2.2	21.0	8.4	0.0	8.0	17.9	25.0	18.3

[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.
[b]Number of stage A1, A2, and A3 sea lamprey attack marks per 100 lean lake trout.

Table 2.–Number at age, mean age, 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, 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
4			5			5
5		9	30	13	11	63
6	20	53	62	114	45	294
7	71	98	82	72	70	393
8	62	56	48	37	38	241
9	25	74	25	21	46	191
10	19	39	16	8	15	97
11	6	22	13	10	17	68
12	4	27	7	7	10	55
13	3	22	4	1	14	44
14	2	4		4	5	15
15		2			4	6
16				3	1	4
17			1			1
18			2			2
20		1		1		2
Total	212	407	295	291	276	1,481
Mean age	8.1	8.6	7.5	7.4	8.4	8.0
Total annual mortality (A)						
Age group	9-14	9-14	9-14	9-14	9-14	9-15
A	0.47	0.41	0.45	0.41	0.40	0.41
χ^2	0.98	0.25	1.81	0.01	0.72	0.22

[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 3.–Number at age, mean age, 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, 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
4		14	3	3	24	44
5	5	22	53	14	80	174
6	94	83	203	157	207	744
7	222	61	110	208	256	857
8	208	121	82	79	132	622
9	122	66	52	52	81	373
10	42	20	37	30	52	181
11	22	18	24	10	17	91
12	5	8	2	5	20	40
13	4	12	8	5	21	50
14	1	1	4	2	4	12
15		3	1	1	2	7
16		2		2		4
17					1	1
18						1
19					3	3
Total	725	431	579	568	900	3,203
Mean age	7.8	7.9	7.3	7.4	7.4	7.6
Total annual mortality (A)						
Age group	9-14	9-14	9-14	9-14	9-14	9-15
A	0.62	0.48	0.47	0.52	0.44	0.49
χ^2	0.11	1.96	3.27	0.35	0.65	0.15

[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 4.–Number at age, mean age, 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, 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
4	1	1		7	8	17
5	17	41	12	33	48	151
6	89	153	252	196	208	898
7	168	241	213	335	245	1,202
8	271	163	194	112	313	1,053
9	154	87	72	80	100	493
10	46	58	56	47	85	292
11	32	29	11	30	29	131
12	16	26	9	22	12	85
13	8	32	11	7	4	62
14	3	8	1	6	7	25
15	4		1	6	11	22
16					5	5
17		1				1
18				1		1
19	1			2		3
20			1	1	1	3
21	1					1
Total	811	840	833	885	1,076	4,445
Mean age	8.1	7.9	7.5	7.6	7.8	7.8
Total annual mortality (A)						
Age group	9-14	9-14	9-14	9-14	9-14	9-15
A	0.56	0.40	0.51	0.45	0.51	0.46
χ^2	3.28	2.04	4.31	1.81	13.57	1.51

[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 5.–Number at age, mean age, 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, 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
4	5	3		1		9
5	6	33	12	10	16	77
6	142	193	109	93	68	605
7	186	193	111	138	92	720
8	208	129	54	53	96	540
9	89	76	54	27	46	292
10	33	27	32	31	28	151
11	11	30	17	4	29	91
12	8	15	12	2	6	43
13	7	14	8		11	40
14	3	6	1		3	13
15	1	4	2		5	12
16			1		1	2
17	1					1
18		1				1
20					1	1
23	1					1
Total	701	724	413	359	402	2,599
Mean age	7.7	7.6	7.8	7.3	8.2	7.7
Total annual mortality (A)						
Age group	9-15	9-15	9-15	9-15	9-15	9-15
A	0.54	0.41	0.45	0.58	0.40	0.46
χ^2	2.58	0.92	0.57	15.82	1.22	0.04

[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.–Number at age, mean age, 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, 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
5	3	4	5	6	2	20
6	39	28	76	71	36	250
7	83	27	74	159	64	407
8	57	27	56	89	81	310
9	30	25	28	53	38	174
10	16	12	9	9	20	66
11	6	4	6	9	11	36
12	2	8	4	6	10	30
13	2	1	8	1	5	17
14	3	2	2	4	3	14
15					1	1
16					2	2
18				1		1
19	1					1
24	1			1		2
25		1				1
Total	243	139	268	409	273	1,332
Mean age	7.9	8.2	7.6	7.6	8.3	7.9
Total annual mortality (A)						
Age group	9-14	9-14	9-14	9-14	9-14	9-15
A	0.50	0.47	0.43	0.54	0.45	0.48
χ^2	0.01	0.06	1.58	7.87	0.05	4.00

[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.–Number at age and mean age of hatchery lean lake trout from combined-area samples in the commercial-sized assessment[a] in Michigan's Lake Superior management areas MI-3, MI-4, MI-5, MI-6, and MI-7 during 1993-97.

Age (years)	1993	1994	1995	1996	1997	Total
3			1			1
4		25	43	31	16	115
5	67	1	100	63	46	277
6	142	100		93	80	415
7	49	126	100		78	353
8	66	31	61	68		226
9	98	27	28	43	44	240
10	2	25	11	11	16	65
11	7	4	23	5	6	45
12	2	5	7	13	7	33
13	2	2	2	3	7	16
14				1	2	3
15			1		6	7
16			1	1	1	3
17						
18		1				1
19				1		1
20						
21						
22						
23			1			1
24			1			1
25	2	1				2
26						
27	1					1
Total	437	347	380	333	309	1,806
Mean age	7.2	7.1	7.0	7.0	7.3	7.1

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

Table 8.–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 1983-97.

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
1983	80	75	169	338	112	33	32	839
	(178)	(426)	(306)	(1,158)	(388)	(229)	(55)	(338)
1984	0	0	12	154	30	30	258	484
	(0)	(0)	(22)	(527)	(104)	(208)	(443)	(195)
1985	279	91	436	460	298	10	171	1,745
	(621)	(517)	790)	(1,575)	(1,031)	(69)	(294)	(702)
1986	117	26	327	303	135	0	156	1,064
	(261)	(148)	(592)	(1,038)	(467)	(0)	(268)	(428)
1987	0	0	313	286	159	0	136	894
	(0)	(0)	(567)	(979)	(550)	(0)	(234)	(360)
1988	64	0	121	146	63	0	0	394
	(143)	(0)	(219)	(500)	(218)	(0)	(0)	(159)
1989	86	0	54	280	103	0	38	561
	(192)	(0)	(98)	(959)	(356)	(0)	(65)	(226)
1990	0	0	0	0	0	0	38	38
	(0)	(0)	(0)	(0)	(0)	(0)	(65)	(15)
1991	202	0	136	160	94	0	38	607
	(449)	(0)	(246)	(548)	(325)	(0)	(65)	(244)
1992	204	0	192	185	101	0	38	719
	(454)	(0)	(348)	(634)	(348)	(0)	(65)	(289)
1993	150	0	137	120	70	0	40	517
	(334)	(0)	(484)	(411)	(242)	(0)	(70)	(208)
1994	196	0	260	150	91	0	38	735
	(436)	(0)	(916)	(514)	(313)	(0)	(65)	(296)
1995	151	0	173	151	94	0	38	607
	(337)	(0)	(313)	(517)	(324)	(0)	(65)	(244)
1996	0	0	263	53	0	0	38	354
	(0)	(0)	(476)	(182)	(0)	(0)	(65)	(143)
1997	0	0	101	0	0	0	38	139
	(0)	(0)	(184)	(0)	(0)	(0)	(65)	(56)
Average	102	13	180	186	90	5	73	646
	(227)	(45)	(325)	(636)	(311)	(34)	(126)	(260)

[a]Includes number of stocked fall fingerlings adjusted to yearling equivalents based on a 25% survival rate from an unpublished Wisconsin Department of Natural Resources study in the 1980s.
[b]No lake trout have been stocked in area MI-1.

Table 9.–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-3, MI-4, MI-5, MI-6, and MI-7 in Lake Superior during 1994-97, with 95% confidence intervals (CI) on the means for weight and length and the weight-length intercept and slope coefficients.

Year/ Area	N	Mean total weight ± 95% CI	Mean total length ± 95% CI	$\log_e$ total weight(lb) and $\log_e$ total length(in) coefficients with ± 95% CI: a	b	R^2
1994						
MI-3	108	4.22 ± 0.39	23.2 ± 0.6	-8.83 ± 0.47	3.24 ± 0.15	0.94
MI-4	103	3.50 ± 0.25	22.3 ± 0.5	-8.27 ± 0.54	3.05 ± 0.17	0.92
MI-5	118	4.03 ± 0.25	22.7 ± 0.4	-8.62 ± 0.92	3.19 ± 0.14	0.95
MI-6	101	3.58 ± 0.29	21.9 ± 0.5	-8.25 ± 0.44	3.07 ± 0.14	0.95
MI-7	143	4.51 ± 0.28	23.3 ± 0.5	-8.48 ± 0.42	3.15 ± 0.14	0.94
1995						
MI-3	107	4.38 ± 0.49	23.1 ± 0.7	-8.50 ± 0.59	3.15 ± 0.19	0.91
MI-4	116	3.71 ± 0.36	21.8 ± 0.6	-8.34 ± 0.46	3.11 ± 0.15	0.94
MI-5	100	3.86 ± 0.28	22.3 ± 0.5	-7.70 ± 0.51	2.91 ± 0.16	0.93
MI-6	Not sampled					
MI-7	277	3.74 ± 0.19	21.7 ± 0.3	-8.27 ± 0.29	3.10 ± 0.09	0.94
1996						
MI-3	Not sampled					
MI-4	Not sampled					
MI-5	Not sampled					
MI-6	100	4.12 ± 0.32	23.3 ± 0.5	-9.20 ± 0.60	3.36 ± 0.19	0.93
MI-7	432	4.30 ± 0.16	22.7 ± 0.2	-8.42 ± 0.28	3.14 ± 0.09	0.92
1997						
MI-3	99	4.67 ± 0.39	24.0 ± 0.6	-8.23 ± 0.46	3.06 ± 0.14	0.95
MI-4	102	3.36 ± 0.24	22.1 ± 0.5	-8.25 ± 0.56	3.05 ± 0.18	0.92
MI-5	109	3.78 ± 0.23	23.2 ± 0.5	-7.70 ± 0.52	2.86 ± 0.16	0.92
MI-6	109	3.52 ± 0.25	21.7 ± 0.4	-7.83 ± 0.88	2.94 ± 0.29	0.79
MI-7	273	4.02 ± 0.17	22.8 ± 0.3	-7.70 ± 0.32	2.90 ± 0.10	0.92

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

Table 10.–Relative abundance (CPUE)[a] of lean and siscowet lake trout 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 July-August 1993-96.

		CPUE (All meshes)						CPUE (2.0- and 2.5-inch mesh)		
			All sizes			Pre-recruit (<17 in)			Pre-recruit (<17 in)	
Area/ Year	Variety	Effort (ft x 1,000)	Total (% wild)	Wild	Hatchery	Wild	Hatchery	Effort (ft x 1,000)	Wild	Hatchery
MI-2										
1993	Lean	10.8	5.1(93)	4.7	0.4	3.2	0.1	3.6	4.2	0.3
	Siscowet		5.3			1.2			1.7	
1994	Lean	10.8	9.6 (82)	7.8	1.7	5.6	1.1	3.6	5.2	2.2
	Siscowet		8.5			3.9			6.0	
1995	Lean	10.8	11.1 (91)	10.1	1.0	10.1	1.0	3.6	7.0	1.8
	Siscowet		2.8			1.0			1.1	
1996	Lean	10.8	9.6 (75)	7.2	2.4	5.9	1.8	3.6	8.0	2.2
	Siscowet		10.4			4.1			5.4	
MI-3										
1993	Lean	14.4	6.2 (94)	5.8	0.4	4.1	0.1	4.8	4.8	0.2
	Siscowet		25.4			13.8			15.8	
1994	Lean	14.4	4.6 (85)	3.9	0.7	3.0	0.5	4.8	3.5	0.5
	Siscowet		28.3			14.9			15.8	
1995	Lean	14.4	5.2 (85)	4.4	0.8	3.4	0.6	4.8	3.8	1.2
	Siscowet		18.0			10.2			10.9	
1996	Lean	14.2	8.0 (84)	6.7	1.2	4.9	1.2	4.7	5.4	1.3
	Siscowet		38.6			17.5			19.1	
MI-4										
1993	Lean	25.2	17.4 (94)	16.4	1.0	11.3	0.7	8.4	11.0	0.7
	Siscowet		5.5			1.7			1.3	
1994	Lean	25.2	14.2 (91)	12.9	1.3	8.3	0.9	8.4	8.0	1.0
	Siscowet		7.0			3.0			2.9	
1995	Lean	25.2	12.2 (89)	10.9	1.3	6.9	0.9	8.4	5.5	1.2
	Siscowet		9.8			3.7			4.1	
1996	Lean	25.2	16.6 (86)	14.3	2.2	8.3	1.7	8.4	7.8	1.8
	Siscowet		18.6			7.5			8.4	
MI-5										
1993	Lean	14.4	11.8 (88)	10.4	1.4	7.3	0.6	4.8	6.7	0.3
	Siscowet		8.1			2.6			1.2	
1994	Lean	14.4	22.0 (90)	19.8	2.2	13.6	0.8	4.8	11.7	1.2
	Siscowet		11.6			5.3			5.5	
1995	Lean	14.4	14.4 (91)	13.1	1.2	9.4	0.9	4.8	9.4	1.2
	Siscowet		10.0			3.2			2.4	
1996	Lean	14.4	16.6 (88)	14.6	1.9	9.6	1.3	4.8	11.2	1.6
	Siscowet		16.8			6.8			7.0	
MI-6										
1993	Lean	14.4	3.9 (95)	3.8	0.2	1.4	0.1	4.8	1.2	0.0
	Siscowet		4.7			1.6			0.9	
1994	Lean	14.4	5.0 (88)	4.4	0.6	1.9	0.3	4.8	2.6	0.8
	Siscowet		9.0			2.5			2.0	
1995	Lean	14.4	4.0 (91)	3.6	0.4	0.9	0.4	4.8	1.1	0.8
	Siscowet		8.6			2.1			1.4	
1996	Lean	14.4	4.9 (86)	4.2	0.7	1.0	0.3	4.8	1.5	0.3
	Siscowet		12.2			3.3			2.0	
MI-7										
1993	Lean	7.2	3.3 (100)	3.3	0.0	1.4	0.0	2.4	1.7	0.0
	Siscowet		8.6			2.6			1.7	
1994	Lean	7.2	5.5 (97)	5.3	0.2	2.5	0.0	2.4	3.1	0.0
	Siscowet		5.5			1.8			3.6	
1995	Lean	7.2	7.1 (100)	7.1	0.0	3.2	0.0	2.4	1.4	0.0
	Siscowet		9.2			3.6			1.4	
1996	Lean	7.2	9.3 (98)	9.1	0.2	2.3	0.0	2.4	1.0	0.0
	Siscowet		14.0			3.7			4.9	

[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 11.–Age composition and mean age of all, and pre-recruit (PreR[a]), wild lean lake trout captured in the pre-recruit assessment[b] in Michigan's Lake Superior management areas MI-2 – MI-7 during July-August 1993-96.

	MI-2		MI-3		MI-4		MI-5		MI-6		MI-7		Total	
Age	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR
2					1	1							1	1
3	12	12	10	10	18	18	51	51	7	5	1	1	99	97
4	55	54	41	40	79	79	120	118	13	10	14	13	322	314
5	78	71	56	53	198	181	182	166	36	20	31	22	581	513
6	28	12	34	24	232	135	147	70	39	9	40	10	520	260
7	10	3	19	5	119	26	53	14	28		34	4	263	52
8	5	2	8		42	7	28		13		7		103	9
9	1		1		14		14	1	3		4		37	1
10	2		2		4		8		1		1		18	
11			1		2		4		1		2		10	
12			1				2		1		2		6	
13	1		2		1		1						5	
14	2												2	
15	1						1						2	
Total	195	154	175	132	710	447	611	420	142	44	136	50	1,969	1,247
Mean	5.2	4.6	5.4	4.8	5.8	5.2	5.4	4.7	6.0	4.8	6.2	5.1	5.6	4.9

[a]Lake trout less than 17 inches total length.
[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.

Table 12.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-2, July-August 1993-96.

Year and parameters	Age (years) 3	4	5	6	7	8	9
1993							
Number	3	16	12	8	2	1	2
Length (CI)	12.8 (3.3)	13.7 (0.8)	15.8 (0.7)	16.5 (1.1)	17.6 (10.8)	18.5	13.1 (20.7)
Length range	11.5-14.6	11.4-17.7	14.2-18.4	14.7-19.1	16.4-18.8		20.8-25.4
1994							
Number	6	12	26	11	3		
Length (CI)	11.7 (1.5)	14.4 (0.9)	15.3 (0.7)	17.8 (1.1)	23.5 (6.9)		
Length range	9.6-13.5	11.4-16.5	13.4-22.2	15.6-20.7	20.0-26.8		
1995							
Number	4	29	24	4	7	3	1
Length (CI)	12.8 (2.1)	14.0 (0.5)	15.4 (0.8)	16.5 (2.2)	18.6 (1.3)	20.2 (7.7)	26.7
Length range	10.8-14.2	11.0-17.4	12.4-19.6	14.3-17.8	16.6-20.7	16.9-24.3	
1996							
Number	2	14	28	13		2	
Length (CI)	12.2 (3.6)	13.6 (0.8)	15.3 (0.5)	16.6 (0.9)		25.5 (18.0)	
Length range	11.8-12.6	11.0-16.4	13.3-18.2	14.3-19.5		23.5-27.5	

[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 13.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-3, July-August 1993-96.

Year and	Age (years)						
parameters	3	4	5	6	7	8	9
1993							
Number	7	17	18	24	8	3	3
Length (CI)	12.4 (1.0)	14.1 (0.6)	15.3 (0.3)	17.1 (0.8)	20.0 (2.4)	20.7 (3.2)	23.9 (5.9)
Length range	11.1-14.5	12.3-16.8	13.7-16.6	13.1-20.8	14.8-23.3	19.2-22.3	21.8-27.2
1994							
Number	1	14	15	10	4	2	
Length (CI)	12.5	13.7 (0.9)	14.3 (0.6)	15.8 (1.1)	19.0 (2.9)	19.0 (12.6)	
Length range		11.4-17.3	13.2-17.2	13.1-17.9	16.8-21.2	17.6-20.4	
1995							
Number	5	12	15	12	7	1	
Length (CI)	12.8 (1.1)	13.7 (0.5)	15.3 (0.8)	16.4 (0.8)	18.4 (1.3)	19.9	
Length range	11.6-13.8	12.2-15.3	12.2-17.8	14.1-18.8	16.1-20.2		
1996							
Number	4	15	26	12	8	5	1
Length (CI)	11.2 (1.0)	13.0 (0.5)	14.8 (0.5)	16.4 (1.4)	17.7 (2.5)	20.5 (2.7)	26.2
Length range	10.6-12.2	11.8-15.0	12.2-18.5	12.3-21.1	13.3-23.8	17.2-23.8	

[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 14.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-4, July-August 1993-96.

Year and	Age (years)						
parameters	3	4	5	6	7	8	9
1993							
Number	16	65	168	112	28	9	5
Length (CI)	11.9 (0.9)	13.9 (0.4)	15.5 (0.3)	16.9 (0.3)	18.2 (0.8)	20.6 (1.4)	21.8 (4.6)
Length range	7.6-14.7	11.2-17.8	10.7-21.0	13.0-21.8	14.3-22.7	16.7-24.1	16.2-26.7
1994							
Number	4	38	89	84	38	12	3
Length (CI)	11.8 (2.2)	13.9 (0.4)	15.2 (0.2)	17.2 (0.4)	18.4 (0.6)	19.0 (1.1)	24.4 (8.8)
Length range	9.5-12.9	11.2-16.2	12.6-19.0	14.0-26.6	15.1-23.2	14.9-22.3	19.8-26.8
1995							
Number	4	14	65	93	38	9	4
Length (CI)	11.2 (1.0)	13.9 (0.6)	15.6 (0.3)	16.6 (0.3)	17.5 (0.4)	18.8 (1.1)	19.1 (1.6)
Length range	10.2-12.0	12.6-15.7	13.0-17.7	13.6-20.5	14.5-20.7	16.6-20.3	17.4-20.0
1996							
Number	10	27	44	55	43	21	7
Length (CI)	11.3 (0.6)	13.3 (0.7)	15.6 (0.3)	16.8 (0.5)	18.7 (0.7)	19.3 (1.2)	20.4 (3.4)
Length range	10.1-12.5	9.7-16.9	13.1-18.1	13.3-24.0	14.8-25.1	15.5-28.0	17.5-29.1

[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 15.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-5, July-August 1993-96.

Year and parameters	Age (years)						
	3	4	5	6	7	8	9
1993							
Number	6	48	51	47	20	8	1
Length (CI)	11.8 (1.2)	14.1 (0.3)	15.8 (0.4)	16.6 (0.5)	18.5 (0.8)	20.5 (1.5)	23.7
Length range	10.4-13.9	11.5-16.7	12.6-21.8	13.2-21.0	16.0-21.0	18.6-23.1	
1994							
Number	27	38	90	57	18	16	6
Length (CI)	11.8 (0.4)	13.6 (0.6)	15.2 (0.2)	17.0 (0.4)	18.1 (0.7)	21.1 (1.4)	24.7 (3.8)
Length range	9.7-13.7	11.3-18.4	12.7-18.5	13.1-21.3	15.5-21.3	18.4-27.0	19.0-28.6
1995							
Number	11	39	45	56	7	4	0
Length (CI)	12.4 (0.7)	13.8 (0.4)	15.3 (0.4)	17.2 (0.4)	17.2 (1.0)	18.9 (1.8)	
Length range	10.7-14.2	11.2-17.5	12.8-18.1	14.0-21.3	15.7-19.0	17.4-20.3	
1996							
Number	13	43	47	34	28	8	8
Length (CI)	11.8 (0.9)	13.5 (0.4)	15.2 (0.4)	16.8 (0.4)	18.7 (1.0)	22.2 (2.9)	22.1 (3.7)
Length range	10.0-15.0	11.0-16.8	12.8-20.8	13.0-19.2	15.4-25.8	17.5-26.6	16.9-29.5

[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 16.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-6, July-August 1993-96.

Year and parameters	Age (years)						
	3	4	5	6	7	8	9
1993							
Number	4	5	16	11	12	8	4
Length (CI)	14.4 (2.8)	15.6 (3.6)	16.7 (0.9)	18.8 (0.9)	19.4 (1.4)	19.8 (1.1)	19.3 (2.7)
Length range	11.8-16.3	12.9-21.2	13.5-20.1	16.6-20.8	15.1-22.5	17.5-22.4	16.5-21.1
1994							
Number	2	7	19	12	7	3	1
Length (CI)	13.4 (1.4)	15.6 (1.5)	16.8 (0.6)	17.5 (0.7)	19.9 (1.2)	19.7 (3.6)	24.1
Length range	13.3-13.6	12.7-18.3	14.7-19.1	15.6-19.5	18.3-22.0	18.5-21.8	
1995							
Number	2	2	9	14	10	0	1
Length (CI)	13.2 (20.2)	14.2 (0.0)	16.5 (0.9)	18.5 (0.9)	19.0 (1.1)		24.0
Length range	11.0-15.5	14.2-14.2	14.1-18.2	16.6-21.9	17.0-22.6		
1996							
Number	1	3	7	13	11	10	1
Length (CI)	11.3	15.1 (4.7)	15.6 (0.7)	17.6 (0.6)	19.5 (1.2)	21.6 (2.7)	22.0
Length range		12.6-17.2	14.7-17.0	15.1-19.0	17.3-24.1	17.2-28.8	

[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 17.–Mean total length (in) ± 95% confidence intervals (CI) for the principal ages of wild lean lake trout in the pre-recruit assessment[a] in Michigan's Lake Superior management area MI-7, July-August 1993-96.

Year and	Age (years)						
parameters	3	4	5	6	7	8	9
1993							
Number		3	7	6	7		
Length (CI)		14.5 (2.6)	16.1 (2.0)	18.7 (1.6)	19.5 (1.7)		
Length range		13.5-16.0	13.2-19.1	16.2-20.5	16.9-22.4		
1994							
Number		5	8	9	6	3	2
Length (CI)		13.3 (0.4)	15.8 (0.4)	17.5 (0.9)	19.2 (1.4)	20.2 (1.1)	21.9 (10.8)
Length range		12.8-13.7	15.1-16.6	15.8-19.1	18.0-21.5	19.8-20.8	21.9-24.3
1995							
Number	1	6	14	13	7	2	
Length (CI)	12.0	14.8 (0.8)	16.7 (0.9)	18.4 (0.9)	17.4 (0.9)	21.2 (15.7)	
Length range		13.8-15.9	14.7-20.1	15.7-21.5	15.5-18.8	19.4-22.9	
1996							
Number		3	9	18	21	2	2
Length (CI)		16.4 (0.9)	16.4 (1.0)	17.4 (0.4)	18.9 (0.9)	22.0 (2.7)	21.5 (0.9)
Length range		15.4-18.2	14.2-18.5	15.2-18.7	14.9-23.6	21.7-22.3	21.4-21.6

[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 18.–Age composition and mean age of all and pre-recruit (PreR) siscowets captured 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, July-August 1993-96.

	MI-2		MI-3		MI-4		MI-5		MI-6		MI-7		Total	
Age	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR	All	PreR
2					2	2							2	2
3	9	9	4	4	8	8	8	8	5	5	1	1	35	35
4	7	7	39	39	19	19	16	16	8	6	12	12	101	99
5	19	18	103	95	47	40	37	35	36	29	30	26	272	243
6	17	11	173	136	60	51	60	55	25	19	26	14	361	286
7	19	9	180	128	65	42	56	32	51	22	30	7	401	240
8	28	14	173	117	137	94	83	50	64	19	45	8	530	302
9	16	5	147	95	82	41	71	22	50	6	25	3	391	172
10	19	4	115	48	71	19	53	9	30	1	14		302	81
11	19	4	63	9	60	11	54	3	37	1	18	1	251	29
12	17	1	71	10	68	3	56	6	31	1	9	1	252	22
13	17		60	2	66		53	1	28	1	8	1	232	5
14	15		46	1	69		31		20		5		186	1
15	11		39		43		32		12		7		144	1
16	5	1	27		34		8		4		2		80	
17	6		18		13		5		1				43	
18	1		3		2		2		1				9	
19	1		6		3								10	
20					2				1				3	
21			1		1								2	
22	2				1								3	
23														
24			1		1				1		1		4	
25							1				1		2	
26											1		1	
27														
28			1								1		2	
29														
30											1		1	
31														
32							1						1	
Total	228	83	1,270	641	854	320	627	229	405	99	237	61	3,621	1,518
Mean age	9.7	6.5	9.0	7.6	10.1	7.4	9.2	7.1	9.2	7.1	8.6	7.2	9.4	7.0

[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. Pre-recruits were fish less than 17 inches, total length.

Table 19.–Mean total length (in) ± 95% confidence intervals (CI) for principal ages of siscowet lake trout sampled in the pre-recruit lake trout assessment[a] in Michigan's Lake Superior management areas during July-August 1993-96.

Area, year, and parameters	Age (Years) 5	6	7	8	9	10	11	12	13	14	15
MI-2											
1993											
Number			1	4	5	5	7	10	5	5	
Mean length			17.5	18.7	17.5	18.6	19.7	20.5	21.1	22.2	
CI				1.4	0.6	1.2	1.5	1.0	3.9	2.4	
1994											
Number	13	10	10	8	5	3				2	3
Mean length	14.3	17.1	18.2	20.6	22.4	22.6				24.0	24.8
CI	1.0	1.8	1.5	2.6	2.1	0.8				4.0	2.3
1995											
Number			3		2	2	3	2	4	2	
Mean length			15.6		15.8	19.6	19.5	19.8	20.4	21.9	
CI			3.9		9.4	0.4	1.8	22.9	1.6	4.5	
1996											
Number	4	6	4	11	3	8	8	4	8	6	8
Mean length	13.3	11.8	13.7	15.8	15.2	17.8	18.5	20.6	19.8	21.8	21.9
CI	2.5	1.6	1.0	1.0	5.2	1.8	1.7	1.1	1.9	1.7	1.8
MI-3											
1993											
Number			2	10	14	18	16	15	9	8	2
Mean length			19.8	18.3	18.2	19.1	20.3	21.0	19.7	23.3	23.5
CI			10.8	0.6	0.6	0.7	1.0	1.4	0.8	1.6	16.2
1994											
Number	70	104	55	36	22	9			1	2	4
Mean length	14.3	16.1	18.5	19.7	20.7	21.2			23.5	27.6	24.2
CI	0.4	0.4	0.5	0.6	0.8	0.9				9.9	1.1
1995											
Number	7	6	61	14	18	27	24	20	15	11	2
Mean length	12.1	14.5	14.5	14.9	16.5	17.2	18.6	19.1	20.8	21.1	23.8
CI	0.4	1.5	0.3	0.6	0.7	0.8	0.8	1.1	1.4	1.5	2.2
1996											
Number	7	30	34	68	38	47	23	32	35	25	31
Mean length	13.2	14.0	14.4	15.6	16.4	17.6	19.1	20.2	20.7	21.7	22.8
CI	1.1	0.6	0.5	0.4	0.4	0.8	1.0	0.8	0.8	1.1	0.8
MI-4											
1993											
Number			2	6	9	10	19	18	18	8	2
Mean length			18.0	17.8	18.1	18.9	20.1	21.0	21.5	24.0	23.8
CI			4.0	0.8	0.5	1.1	1.2	1.4	1.3	1.4	0.9
1994											
Number	26	28	23	20	12	3	1	7	10	8	5
Mean length	15.4	16.0	17.2	17.8	19.0	21.0	19.2	23.9	24.4	25.2	25.8
CI	1.0	0.8	1.0	1.0	1.1	2.8		1.9	0.7	1.3	2.9
1995											
Number	1	2	24	43	22	26	17	14	10	19	10
Mean length	12.7	13.2	15.9	15.9	16.8	18.0	19.0	21.7	21.9	22.8	23.4
CI		8.1	0.6	0.4	0.9	0.6	1.1	1.5	1.4	0.9	1.8
1996											
Number	16	19	9	59	35	28	21	28	28	34	26
Mean length	12.5	14.4	14.7	16.0	16.8	17.8	18.5	20.8	22.0	22.2	23.4
CI	0.9	1.3	1.8	0.5	0.6	0.7	1.0	1.0	1.0	1.0	1.0

Table 19.–Continued.

Area, year, and parameters	Age (Years) 5	6	7	8	9	10	11	12	13	14	15
MI-5											
1993											
Number				2	11	12	25	19	15	8	3
Mean length				18.2	17.9	19.0	19.3	20.5	22.2	22.3	24.3
CI				10.8	0.5	0.8	0.5	1.0	1.3	1.9	8.5
1994											
Number	17	27	35	25	15	7	3	2	3	3	5
Mean length	15.2	15.6	17.6	18.7	20.2	21.6	22.1	22.8	23.7	26.0	24.9
CI	0.7	0.6	0.7	0.9	1.3	1.2	4.2	28.8	2.0	5.9	1.3
1995											
Number	2	1	5	22	15	20	12	12	16	8	3
Mean length	11.2	13.4	15.2	15.7	17.4	17.6	19.2	21.6	21.9	21.8	23.9
CI	10.8		1.2	0.6	0.6	0.5	0.7	1.4	1.3	1.6	8.4
1996											
Number	11	19	10	25	24	13	12	23	18	12	21
Mean length	12.6	14.2	15.3	15.9	17.1	17.8	18.5	19.0	21.3	21.9	22.7
CI	0.9	0.6	1.6	0.9	0.9	1.1	0.8	1.2	1.3	1.3	1.3
MI-6											
1993											
Number	5	6	4	10	8	6	8	10	9	4	2
Mean length	14.1	15.2	17.4	17.5	17.5	19.0	20.1	20.6	20.5	23.2	21.6
CI	0.8	2.7	4.2	1.7	0.9	1.5	2.3	1.4	2.0	1.2	13.0
1994											
Number	14	9	27	22	14	3	1	2	3	1	1
Mean length	15.4	15.7	18.5	19.6	20.5	22.5	25.6	24.0	23.8	23.2	23.7
CI	0.7	1.3	0.7	0.9	1.2	2.4		1.4	1.1		
1995											
Number	1	3	7	14	12	7	13	12	9	5	2
Mean length	15.0	16.6	17.1	16.8	18.4	19.5	20.8	21.3	22.1	25.5	23.0
CI		3.5	1.3	1.0	1.2	1.8	1.2	1.7	1.6	1.6	14.4
1996											
Number	16	7	13	18	16	14	15	7	7	10	7
Mean length	16.1	16.0	15.9	17.6	19.0	19.9	20.6	20.3	21.7	21.2	24.0
CI	0.6	2.3	1.2	0.9	0.8	1.3	1.2	0.5	2.2	1.7	2.0
MI-7											
1993											
Number	6	4	6	15	11	3	5	3	2		1
Mean length	14.8	15.8	16.8	18.2	18.4	21.3	20.5	19.3	20.2		22.8
CI	1.7	1.9	1.5	0.7	0.8	3.0	1.8	7.1	9.0		
1994											
Number	5	7	12	7	2	1		1			
Mean length	16.5	16.8	18.8	18.9	19.2	20.4		23.6			
CI	2.7	1.3	1.0	1.7	26.5						
1995											
Number	7	6	6	9	3	3	6	1	4	1	2
Mean length	15.7	16.4	16.6	17.9	19.6	18.4	18.8	22.8	21.9	23.2	22.9
CI	1.0	2.2	1.2	1.1	3.3	2.4	2.0		5.0		23.4
1996											
Number	12	9	6	14	9	7	7	4	2	4	4
Mean length	15.7	16.7	19.0	18.8	19.9	20.8	21.5	22.2	20.1	21.3	22.8
CI	0.8	1.2	2.5	0.9	1.3	1.4	2.3	3.5	1.8	1.1	7.2

[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), mean total length (in), and the weight-length coefficients for pre-recruit lean and siscowet lake trout (< 17 inches, total length) 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 1994-96, 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) and log_e total length(in) coefficients with ± 95% CI		R^2
					a	b	
1994	Lean	96	0.81 ± 0.06	14.5 ± 0.3	-8.97 ± 0.52	3.26 ± 0.19	0.92
	Siscowet	66	0.86 ± 0.07	14.8 ± 0.4	-9.94 ± 0.92	3.62 ± 0.34	0.87
1995	Lean	297	0.92 ± 0.05	14.7 ± 0.2	-8.89 ± 0.35	3.26 ± 0.13	0.89
	Siscowet	200	0.98 ± 0.04	15.0 ± 0.2	-8.35 ± 0.46	3.07 ± 0.17	0.87
1996	Lean	307	0.85 ± 0.04	14.5 ± 0.2	-8.52 ± 0.26	3.11 ± 0.10	0.92
	Siscowet	322	0.85 ± 0.03	14.6 ± 0.2	-8.47 ± 0.27	3.08 ± 0.10	0.92

[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 fished during July-August.

Table 21.–Abundance (CPUE)[a] of principal species other than lake trout captured in the pre-recruit lake trout assessment[b] in Michigan's Lake Superior management areas 2-7, July-August 1993-96.

		Management area and (annual fishing effort in thousands of feet of gill net)						
Species	Year	MI-2 (10.8)	MI-3 (14.4)	MI-4 (25.2)	MI-5 (14.4)	MI-6 (14.4)	MI-7 (7.2)	Mean (86.4)
Lake herring	1993	8.1	7.2	13.8	5.0	6.5	1.8	8.3
	1994	8.9	16.9	12.2	7.6	9.9	2.8	10.6
	1995	6.3	22.1	15.7	5.7	7.9	0.8	10.1
	1996	59.5	33.5	29.6	6.9	10.7	2.9	19.6
Lake whitefish	1993	4.5	31.5	0.3	0.7	1.6		6.3
	1994	4.0	17.4	0.3		2.5		3.9
	1995	3.0	36.1			1.8		5.8
	1996	3.5	13.8	0.1	0.2	5.2		2.9
Round whitefish	1993		0.4	2.8	7.8	3.7	0.6	2.9
	1994	0.2	0.3	2.2	7.2	0.6	0.3	2.0
	1995	0.1	1.0	3.7	5.6	5.6	0.4	2.7
	1996	2.3	6.6	3.7	13.9	2.6	0.5	4.4
Bloater	1993	3.4	3.1	3.1	4.6	0.5	0.1	2.7
	1994	3.3	11.2	4.1	5.3	0.8		4.5
	1995	0.1	0.6	3.6	1.2	0.6		1.3
	1996	2.6	1.0	1.2	0.3	1.1	0.2	0.9
Longnose sucker	1993	1.0	3.4	3.5	2.8	5.8		3.2
	1994	0.7	0.3	0.6	1.0	3.6		1.1
	1995	1.0	2.0	2.0	1.3	4.3		1.6
	1996	0.8	1.8	2.2	0.8	7.4		1.9
Burbot	1993	0.3	0.3	1.4	3.1	1.0		1.2
	1994	0.4	0.6	1.3	0.2	0.6		0.6
	1995	0.1	1.3	0.7	4.2	2.0		1.2
	1996	0.1	0.7	1.7	0.7	0.3	0.2	0.6
Rainbow smelt	1993	0.5	0.6	1.0			0.1	0.4
	1994	0.6	0.3	2.1				0.8
	1995	0.4	0.2	0.3	0.2			0.2
	1996	1.3	0.6	2.8				0.9

[a]Number of fish per 1,000 feet of gill net.
[b]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 22.–Number and CPUE[a] (in parentheses) of lean and siscowet lake trout by 60-foot depth strata in June 1996 and by 120-foot depth strata in September 1997 in the predator composition assessment[b] in Michigan's Lake Superior management area MI-5.

	1996		1997	
Depth strata (feet)	Lean	Siscowet	Lean	Siscowet
0-59	8 (3.0)	0		
60-119	5 (1.9)	2 (0.7)	5 (1.9)	2 (0.7)
120-179	14 (5.2)	7 (2.6)		
180-239	2 (0.7)	19 (7.0)	3 (1.1)	80 (29.6)
240-299	1 (0.4)	34 (12.6)		
300-359	0	18 (6.7)	2 (0.7)	98 (36.3)
360-419	1 (0.4)	29 (10.7)		
420-479	0	67 (24.8)	2 (0.7)	139 (51.5)
480-539	0	45 (16.7)		
540-599	2 (0.7)	96 (35.6)	0	170 (63.0)
600-659	0	89 (33.0)		
660-719	Not fished		0	60 (22.2)
Total	34 (1.1)	406 (13.7)	12 (0.7)	549 (33.9)

[a]Number caught per 1,000 feet of gill net.
[b]Assessment effort in each strata were 2,700-foot gill nets made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, 6.0-inch multifilament nylon mesh.

Table 23.–Siscowet lake trout age composition in the predator composition assessment[a], June 1996 and September 1997.

Age (years)	1996	1997
3		2
4	2	6
5	3	14
6	7	14
7	14	14
8	29	6
9	17	18
10	21	29
11	34	23
12	48	26
13	51	51
14	55	64
15	60	75
16	34	76
17	7	55
18	2	26
19	1	9
20		4
21		
22	1	1
23	1	1
24		
25		1
26		
27		
28		
29		
30		1
Total	387	364
Mean age	12.4	15.5

[a]Assessment gill nets were 2,700 feet long and made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch multifilament nylon mesh.

Table 24.–Diet of siscowet and lean lake trout captured in the predator composition assessment[a] in Michigan's Lake Superior management area MI-5 in June 1996 expressed as percent frequency of occurrence for each food item, total weight (g) of each food item, and percent of total food weight for each food item.

	Siscowets (n = 208)			Leans (n = 21)		
Food item	% freq.	Weight	% weight	% freq.	Weight	% weight
Coregonines[b]	22	1,149	39.6	10	92	24.4
Rainbow smelt	2	25	0.9	24	69	18.3
Burbot	5	843	29.1	10	161	42.7
Sculpins	28	413	14.2	33	32	8.5
Ninespine stickleback				14	4	1.1
Unident fish	27	337	11.6	19	11	2.9
Total fish		2,767	95.4		369	97.9
Birds	2	22	0.8			
Mysis	9	13	0.4	10	8	2.1
Diptera larvae	2	4	0.1			
Terrestrial insects	27	93	3.2	10	< 1	
Total invertebrates		110	3.8		8	2.1

[a]Assessment gill nets were 2,700 feet long and made up of 300-foot panels of 2.0-, 2.5-, 3.0-, 3.5-, 4.0-, 4.5-, 5.0-, 5.5-, and 6.0-inch multifilament nylon mesh.

[b]Coregonines were mainly deepwater ciscoes that were not identified to species and some lake herring.

Table 25.–Lake Superior sport fishing effort (E = thousands of angler-hours), lake trout sport catch[a] (C = thousands of fish), and lake trout catch per unit of effort (CPUE = number of fish per angler-hour) in creel-surveyed management areas[b] in Michigan waters of Lake Superior, 1993-97.

Year		MI-2	MI-4	MI-5	MI-6	Total
1993	E	55.8	93.3	80.9	77.8	307.8
Lean	C	2.9	4.2	14.2	5.2	26.6
	CPUE	0.05	0.05	0.18	0.07	0.09
Siscowet	C	2.3	6.9	0.1	<0.1	9.3
	CPUE	0.04	0.07	<0.01	-	0.03
1994	E	23.9	125.0	59.4	70.6	278.9
Lean	C	1.0	3.4	8.1	4.8	17.4
	CPUE	0.04	0.03	0.14	0.07	0.06
Siscowet	C	0.5	18.7	0.1	0.1	19.4
	CPUE	0.02	0.15	<0.01	<0.01	0.07
1995	E	47.5	63.5	52.7	45.3	208.9
Lean	C	2.5	1.4	8.8	3.3	15.9
	CPUE	0.05	0.02	0.17	0.07	0.08
Siscowet	C	1.5	2.9	0.1	<0.1	4.4
	CPUE	0.03	0.05	<0.01	-	0.02
1996	E	47.3	86.2	59.1	54.7	247.4
Lean	C	3.9	1.9	11.7	4.4	21.9
	CPUE	0.08	0.02	0.20	0.08	0.09
Siscowet	C	1.1	14.1	0.3	0.1	15.6
	CPUE	0.02	0.16	0.01	<0.01	0.06
1997	E	30.9	42.2	72.3	57.8	203.2
Lean	C	1.9	1.5	15.4	5.0	23.8
	CPUE	0.06	0.04	0.21	0.09	0.12
Siscowet	C	0.7	3.9	0.2	0.2	5.0
	CPUE	0.02	0.09	<0.01	<0.01	0.02

[a]Does not include charter boat catch.
[b]No creel surveys conducted in MI-1, MI-3, MI-7, and MI-8 during 1993-1997.

Table 26.–Lake trout catch (thousands of pounds dressed weight) by tribal commercial fisheries[a] in Michigan's Lake Superior management areas during 1993-97.

		Management areas							
Year	Variety	MI-2	MI-3	MI-4	MI-5	MI-6	MI-7	MI-8	Total
1993	Lean	13	13	77	25	13	74	29	244
	Siscowet	22	18	93	3	1	5	0	142
1994	Lean	11	10	67	3	10	23	68	192
	Siscowet	7	17	60	3	3	0	0	90
1995	Lean	12	6	62	8	5	17	13	123
	Siscowet	9	8	52	2	0	2	<1	73
1996	Lean	15	4	52	8	16	14	47	156
	Siscowet	3	4	38	1	0	<1	0	46
1997	Lean	19	9	56	6	10	17	19	136
	Siscowet	9	6	66	2	0	4	<1	87
Mean	Lean	14	8	63	10	11	29	35	170
	Siscowet	10	11	62	2	1	2	<1	88

[a]Lake trout catch from Great Lakes Fishery Commission, Lake Superior Committee Meeting annual extraction reports; and unpublished data from the Chippewa/Ottawa Treaty Fisheries Management Authority Inter-tribal Fisheries Assessment.

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