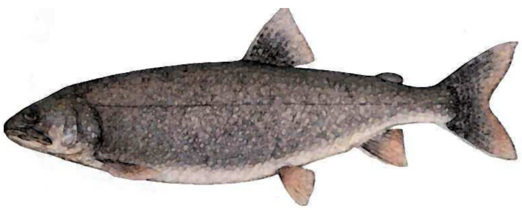
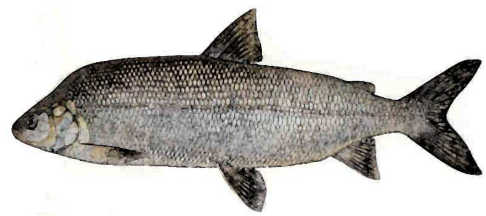
Technical Fisheries Committee Administrative Report 2012: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron, and Michigan, with Recommended Yield and Effort Levels for 2012





A Report Submitted by the
Modeling Subcommittee
to the
Technical Fisheries Committee

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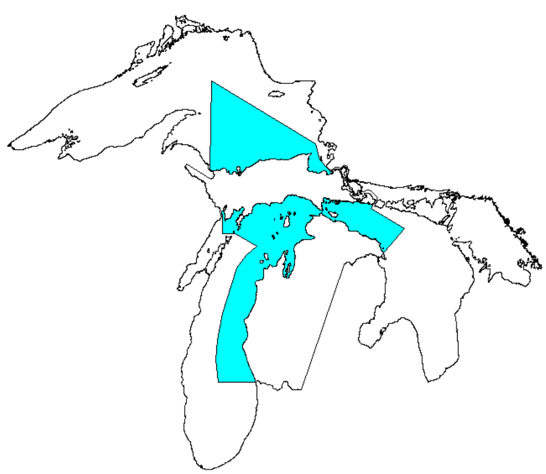
Editors



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EXECUTIVE SUMMARY

Prepared by David C. Caroffino and Stephen J. Lenart

In August 2000, Bay Mills Indian Community, Sault Ste. Marie Tribe of Chippewa Indians, Grand Traverse Band of Ottawa and Chippewa Indians, Little Traverse Bay Bands of Odawa Indians, Little River Band of Ottawa Indians, the United States of America, and the State of Michigan settled upon a negotiated agreement (Consent Decree) to resolve issues of allocation, management, and regulation of fishing in 1836 Treaty-ceded waters of lakes Superior, Michigan, and Huron (U.S. v. Michigan 2000). The provisions of the Consent Decree were to be implemented by the five tribes of the Chippewa/Ottawa Resource Authority (CORA), the United States Department of Interior's U.S. Fish and Wildlife Service (USFWS), and the State of Michigan's Department of Natural Resources (MDNR). The Consent Decree outlines a specific lake trout management regime that regulates the fishery though yield and effort limits established through maximum lake trout mortality rates, which differ by management unit. A similar management structure is described for whitefish, regulating harvest through yield limits established based upon a maximum allowed mortality rate that is consistent across 1836 Treaty waters. In management units where the state and tribes share the commercial whitefish harvest, specific yield limits apply for each party. In non-shared units where the tribes exclusively have the commercial fishing opportunities, harvest regulation guidelines (HRGs) are set based upon a number of factors, including characteristics of the fishery and the population. A Modeling Subcommittee (MSC) of the Technical Fisheries Committee (TFC) was established and charged with developing the annual yield and effort limits required by the Consent Decree.

For 2012, the MSC assessed population status and mortality rates of 13 different stocks of lake whitefish and nine stocks of lake trout that are within 1836 Treaty-ceded waters. The MSC developed and fit statistical catch-at-age (SCAA) models using a nonlinear modeling and statistics program (AD Model Builder, Otter Research Ltd.) to estimate age- and year-specific population abundance and mortality rates. Insufficient data prevented development of reliable SCAA models in three lake whitefish units, so an alternative approach was used for setting harvest limits. The estimates of abundance and mortality were combined with growth and maturity data for whitefish and lake trout in each stock or management unit to project recommended yield levels for the 2012 fishing season. Recommended yield limits were obtained by either limiting mortality to a maximum rate or achieving a minimum spawning potential reduction. The maximum allowable mortality rate (*A*) on whitefish was 65%, while the maximum mortality rate on lake trout was either 40 or 45%, depending on the management unit. The target spawning potential reduction for whitefish was 20%. Harvest limits were allocated to State and CORA fisheries for each stock following the percentages for 2012 specified in the Consent Decree.

The 2012 model-generated harvest limits for whitefish and lake trout are provided in the table below, as are the actual harvest and effort limits that were imposed based on the terms of the Consent Decree or HRGs. This report provides details when recommended and actual harvest limits differ in management units.

Species	Lake	Management unit	Model-generated yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	142,689	142,689	NA
		MI-6	176,116	136,128	3,740,000
		MI-7	71,407	71,407	3,105,000
	Huron	MH-1	517,791	410,000	11,676,000
		MH-2	177,335	177,335	NA
	Michigan	MM-123*	0	503,000	14,950,000
		MM-4*	93,044	177,177	1,130,000
		MM-5*	101,794	101,794	297,000
		MM-67	438,715	438,715	NA
Lake whitefish	Superior	WFS-04	96,000	96,000	NA
		WFS-05	528,000	528,000	NA
		WFS-06	No model estimate	210,000	NA
		WFS-07	420,200	420,200	NA
		WFS-08	242,000	242,000	NA
	Huron	Northern Combined	431,600	539,700	NA
		WFH-05	787,800	787,800	NA
	Michigan	WFM-01	4,074,600	4,074,600	NA
		WFM-02	800,900	558,000	NA
		WFM-03	2,219,400	2,219,400	NA
		WFM-04	678,000	678,000	NA
		WFM-05	396,000	396,000	NA
		WFM-06	540,600	250,000	NA
		WFM-07	No model estimate	500,000	NA
		WFM-08	1,628,400	1,628,400	NA

*Units with stipulated harvest limits

In 2012, full stock assessments were completed for the lake trout models that had been in the rotation plan (MI-7, MH-2, and MM-67). Harvest limits for these units were calculated using the same methods as all other lake trout management units. The performance of these models was evaluated according to the pre-determined MSC criteria to assess whether or not they could be put back into a rotation plan for 2013 and 2014. Each of the models was deemed acceptable for continued rotation. The output from this assessment will be used when TACs are projected for 2013 and 2014, with a full assessment next scheduled for 2015.

Lean lake trout in Lake Superior are self-sustaining, and the SCAA models and target mortality rates apply to these wild fish in three management areas (MI-5, MI-6, and MI-7). Declines in population abundance and biomass have occurred since the late 1990s, likely as a result of density dependent mechanisms affecting both growth and recruitment. Sea lamprey-induced mortality declined to 0.055 y^{-1} in MI-5 but is double that value (0.11 y^{-1}) in MI-6 and MI-7. Aside from natural mortality, sea lamprey are the greatest individual source of mortality. Commercial harvest in Lake Superior generally remains low, making biological sampling of the fishery difficult. This paucity of data has the potential to cause future convergence problems in the Lake Superior models. Direct harvest of spawning lake trout has had local implications for the MI-5 stock; however, total mortality remains below target levels both here and in MI-6. In MI-7, commercial harvest had more than doubled from 2008 to 2009, but it declined by 40% in 2010 and dropped by another 13% in 2011. Recreational yield in this unit increased by more than 150% from 2010 to 2011. Mortality and harvest of lean lake trout remain below targets throughout Lake Superior, thus our projections suggest yield could be increased in all modeled Lake Superior stocks in 1836 waters. There have been no efforts to fit a stock assessment model for lake trout in MI-8 of Lake Superior because this is a deferred area.

Evidence for widespread natural reproduction in Lake Huron continues to be found in all data sources. In 2011, unclipped fish represented 19% of the commercial fishery in the U.S. waters of northern Lake Huron and 51% of the recreational lake trout fishery. In the Canadian commercial fishery the proportion of unclipped fish reached 60%. The continued presence of unclipped fish in the population warranted their inclusion into the TAC projection for management unit MH-1. Total yield of hatchery lake trout from MH-1 has been markedly stable since 2008 (226,000 – 246,000 lb). The SCAA estimates of abundance at age were based solely on data derived from hatchery fish. These estimates were then adjusted by the proportion of unclipped fish observed in all data sources for the harvest limit calculation. An alternative model that used all fish in the data file was also constructed. Although the number of recruits was still based solely on stocked fish, this model performed well and provided realistic estimates. After three years during which stipulated harvest limits were imposed, the assessment model output was used in recommending a harvest limit for this unit. The parties agreed to a harvest limit lower than that projected from the SCAA model output, citing concerns about the magnitude of the increase and the method used for extrapolating wild fish.

The SCAA model for MH-2 was updated in 2012 and now structurally mirrors MH-1. The result was a substantially higher TAC for 2012. Lake trout mortality remains well below target in this unit. The commercial harvest in this unit is from Canadian waters, and the recreational fishery has taken, on average, only 25% of its allowed harvest in recent years.

Lamprey mortality is again becoming a concern in Lake Huron, particularly in the northern treaty waters. The estimated lamprey-induced mortality on lake trout in MH-1 increased to 0.15 y^{-1} but remained near 0.09 y^{-1} in MH-2. Increases in lamprey-induced mortality in Lake Huron may reduce the number of lake trout available for harvest and inhibit restoration progress. These rates will be carefully monitored in the years to come.

In Lake Michigan management areas wild lake trout are scarce, and the assessment models and target mortality rates apply only to stocked fish. For 2012, full assessments were run in all units. Models were updated by allowing catchability to vary through time. This change was applied to all models except MM-67, which exhibited convergence problems when the change was made. In unit MM-123 lake trout mortality is above target. Substantial sea lamprey-induced mortality (0.27 y^{-1}) continues to contribute to excessive total mortality rates, though commercial harvest is estimated to be the largest source of mortality in the unit. Biomass of young fish is growing due to increases in stocking; however, few survive past age 7. A Consent Decree Amendment dated 4 April 2007 set the harvest limit in MM-123 at 453,000 lb for CORA and 50,000 lb for the State. These limits have been imposed because the current rates of sea lamprey mortality prevent any harvest under the original terms of the Consent Decree. This unit will remain in a state of excessive mortality until sea lamprey are better controlled or until increased stocking dampens the lamprey's effects on the population.

Total mortality rates in MM-4 were below target in 2011. Total harvest declined by 12% from 2010 to 2011; however, lamprey mortality increased to 0.11 y^{-1}. Estimated spawning biomass remained stable after three consecutive years of decline. There is a Consent Decree stipulation for MM-4, which set the 2012 harvest limit at 177,177 lb, nearly double the model recommended value.

Mortality rates in MM-5 and MM-67 are below target. In 2011 commercial yield in MM-5 increased to 34,268 lb, the highest level observed under the current Consent Decree. Recreational fishery yield doubled to 47,000 lb in 2011, the result of a regulation change from a 23" maximum size limit to a 20" minimum size limit. Lamprey mortality is a growing concern in MM-5, as it has tripled over the past three years. With the increase in fishing mortality and sea lamprey mortality, this unit will warrant close attention in the years to come.

The 2011 commercial harvest of lake trout in MM-67 only slightly increased to 7,600 lb. This represented only 20% of the commercial TAC available. Overall mortality in this unit remains well below target, as the recreational fishery only harvested 19% of its allowed TAC and lamprey mortality is near baseline.

In most management units, lake whitefish harvest has been well below established harvest limits, and total mortality rates are below target in all units with functioning stock assessment models. After substantial declines in the 1980s and 1990s, size-at-age for lake whitefish has recently stabilized and even increased in some units. Recruitment continues to drive whitefish populations. Recruitment has been variable, with some stocks experiencing stable recruitment, near historic levels, and others experiencing either low or stochastic recruitment. Nonetheless, lakewide or regional patterns remain evident when estimates are compared across stocks.

In Lake Superior, commercial harvest of lake whitefish has generally declined over time in the western units as a result of declining effort. Yield has declined less dramatically in the eastern units (WFS-07 and WFS-08), but is still generally below peak yield from the late 1980s and early 1990s. Biomass is stable or declining in most units over the past decade.

In northern Lake Huron treaty waters, whitefish biomass peaked in the mid to late 1990s, as did commercial yield, which has declined by more than 50% in the last decade. Although similar patterns in biomass are evident in unit WFH-05, commercial yield peaked there in 2007, following substantial increases in effort since the late 1990s. Sea lamprey-induced mortality on lake whitefish has increased over the past decade and is a significant mortality source in the Lake Huron management areas, particularly on the older age classes. The MSC continued to model Northern Lake Huron as a single whitefish management unit by combining data from WFH-01 through WFH-04. 2011 was the first year that the Biological Services Division of CORA set a single HRG the Northern Lake Huron management unit. This practice was continued in 2012 and is expected be the practice in future years.

Most whitefish stocks in Lake Michigan exhibited a marked increase in biomass through the middle part of the 2000s, a result of strong recruitment events in the late 1990s and early 2000s and a general decline in fishing mortality. In Lake Michigan units, commercial effort and yield under the 2000 Consent Decree have been lower than prior to its implementation. However, recent years have seen some of the highest yields since 2000, and lakewide effort has steadily increased since 2006.

Modeling efforts to describe the lake whitefish stocks in WFS-06 and WFM-07 have little utility for estimating allowable harvest due to a lack of data. However, descriptions of these units are still included in this document. In 2012, the HRGs for both of these units remained consistent with their recent levels. A full assessment was completed for WFM-06, but a lack of data made the model unstable. In 2011 the TFC adopted an alternate harvest limit due to this situation, and it was continued for 2012. The limit was developed based on historic harvest patterns, knowledge of the population and habitat available, and sought to not create unrealistic expectations for the fishers.

In addition to providing assessments for each stock, the MSC also provides recommendations to improve both data collection and the SCAA models. These recommendations include gathering accurate data on all forms of fishery extractions, continuing to explore uses for and implementation of fishery-independent surveys to index abundance of lake whitefish, improving natural mortality estimates, refining estimates of hooking mortality on lake trout, improving the estimation of selectivity, implementing methods of estimating time-varying catchability, and evaluating alternate harvest policies. While the MSC is making progress on some of these recommendations, complete implementation is not currently feasible given limitations of staff and time. Although the list of improvements may appear daunting, the MSC has made progress both in the technical details of the assessments and the administrative implementation the Consent Decree, and we expect to do likewise in the years to come.

STOCK ASSESSMENT MODELS

Text adapted from Sitar et al. (2005)

We used age-structured population models in two ways. The first was as a means to generate estimates of lake trout and lake whitefish abundance and mortality rates and describe how these have changed over time. The second was to project yield, harvest amounts, and associated effort that met criteria established as part of the 2000 Consent Decree. The first of these tasks was accomplished through applying statistical catch-at-age analysis (SCAA) as a means of estimating parameters determining fish abundance and mortality. These catch-age models operated with annual time steps and age-specific abundances. Mortality rates were estimated for each year through the last year for which data were available. Models were developed for stocks in each defined management area where data were sufficient.

The second task built from the first, by projecting the estimated fish population forward through the 2012 fishing season, accounting for expected fishing and natural mortality and projecting the associated harvest and yield. The fishing mortality rates were adjusted in these projections to match upper bounds on fishing effort, fishery harvest, or total mortality while satisfying State and Tribal allocation as defined in the Consent Decree.

Statistical Catch-Age Analysis

A catch-at-age model was fit to the available data in each unit. Each model consisted of two components. The first was a sub-model that described the population dynamics of the stock. The second was a sub-model that predicted observed data, given the estimated population each year. The agreement between the model predictions and observed data was measured by statistical likelihood. Both the population and observation sub-models included adjustable parameters. Any given set of these parameters corresponded to a specific sequence of stock abundances, mortality rates, and predicted data. The set of such parameters and associated stock dynamics and mortality rates that maximized the likelihood (the maximum likelihood estimates) was taken as the best estimate.

Population sub-model

The basic population model was quite simple. Except for the first age and first year, abundance-at-age at the start of each year was calculated recursively as the proportion of the cohort surviving from the start of the previous year:

$$N_{a+1,y+1} = N_{a,y} P_{a,y}$$

The proportion surviving was modeled as

$$P_{a,y} = e^{-Z_{a,y}},$$

where $Z_{a,y}$ was the instantaneous mortality rate for age *a* and year *y*. Total annual mortality ($A = 1 - P$) increases with increasing Z, but asymptotes at 1.0. Mortality targets were usually expressed in terms of *A*, but could be expressed in terms of the equivalent *Z*.

A primary challenge in developing the stock assessment models was to break the total instantaneous mortality rate into components of interest that can be calculated from a suite of parameters, which can be estimated from available data. All the models include fishing mortality (*F*) and background natural mortality (*M*). All lake trout models and whitefish models for Lake Huron include sea lamprey induced mortality (*ML*). In addition, fishing mortality was usually broken into two subcomponents. Thus:

$$Za,y = F(1)_{a,y} + F(2)_{a,y} + M_a + ML_{a,y}\,,$$

where *F*(1) and *F*(2) represent two fishery components (e.g., gill nets and trap nets, or sport and commercial). It was not possible to estimate all these rates as independent age- and year-specific components. To reduce the number of parameters, for each fishery component, the age- and year-specific fishing mortality rates are products of age-specific "selectivity" and year-specific "fishing intensity". In a purely separable model, selectivity was constant and thus each fishing mortality component was the product of an age (*S*) and year (*F*) effect:

$$F(i)a,y = S(i)_a\, f(i)_y$$

In many of our assessment models we have relaxed the separability assumption, to account for changing selectivity resulting from changes in size-at-age, fishery behavior, or other causes. To do this we modeled the relationship between selectivity and age with a four-parameter double logistic function that provides a flexible dome-shaped relationship between selectivity and age, and includes asymptotic increases with age as a special case (e.g. trap-net fisheries). When time-varying selectivity was desired, one of the parameters of this function (that controls selectivity for younger ages) was allowed to vary gradually over time, following a quadratic function in time. Thus, selectivity patterns over time were described by the three parameters of the quadratic function and the three other parameters of the logistic function.

Fishing intensity was the fishing mortality rate for ages that had a selectivity of 1.0. Fishing intensities were not estimated freely, but instead were assumed to be proportional to effort, up to a multiplicative deviation:

$$f(i) = q(i)E(i)_y\,\zeta(i)_y\,,$$

where *q* was catchability (the proportionality constant), *E* was observed effort, and ζ was the deviation. During model fitting, large estimated deviations were penalized. However, in cases where fishery effort was not considered to be very informative regarding fishing mortality (generally for the lake trout models), this penalty was reduced to near zero making the procedure nearly identical to estimating the *f*(*i*) directly.

The background natural mortality was assumed to be constant over time. For lake whitefish models and models of wild lake trout in Lake Superior, *M* was assumed constant for all ages modeled, whereas for other lake trout models, *M* was allowed to be higher for the younger ages. For the whitefish models *M* was assumed known based on a published relationship between *M* and growth model parameters and water temperature (Pauly 1980). For lake trout, while *M* was estimated during model fitting, deviations from prior estimates, based on the same relationship used for whitefish, were penalized.

The process for estimating sea lamprey wounding rates was changed in 2005. Previously, mean fall and spring wounding rates were converted to mortality based on the probability of surviving an attack and the average length of a lake trout (Sitar et al. 1999). Now, only spring wounding rates are used and are fit to a logistic curve with an asymptotic wounding rate according to Rutter and Bence (2003). Beginning in 2011, the MSC more explicitly defined "spring" to refer to marking data collected during April 1 to June 30. Three parameters are estimated from the logistic curve, α and β, which describe the steepness and position of the curve, and θ, which represents the asymptotic wounding rate, or the average wounding rate on large fish. These parameters are then used to convert wounding rates to mortality rates based on survivability of an attack and growth parameters of fish in each unit.

Lake Huron sea lamprey-induced mortality on lake whitefish

In past stock assessments for Lake Huron lake whitefish, sea lamprey-induced mortality was calculated for specific length classes of whitefish in the spring, then an age-length distribution was applied to the length-specific mortality rates to estimate age-specific sea lamprey mortality of whitefish (Bence 2002). These age-specific mortality rates were assumed to be constant across years and constant across management units and input as data to the stock assessments in Lake Huron as a matrix of age- and year-specific sea lamprey mortality rates.

The method for calculating sea lamprey-induced mortality of whitefish in Lake Huron changed during calculations of the 2003 harvest limit. Marking rate data collected during August through December was used to estimate sea lamprey mortality, because the probability of survival used to estimate sea lamprey mortality of whitefish was collected during late summer and fall (Spangler et al. 1980). Age-specific marking rates for whitefish were estimated from year-specific marking rates and a long-term average marking rate in each management unit as:

$$m_{a,t} = \frac{m_{a,y}}{1-\left(\dfrac{m_t - m_y}{m_t}\right)},$$

where m is the average number of sea lamprey marks per fish, a is age class, t is year, and y is the time series under consideration. The time series varied somewhat by management unit but typically covered 1980-2003 in Lake Huron units. Essentially, the average marking rate on an age class was a function of the annual deviation in sea lamprey marking in a management unit from the long-term average marking rate in that unit and the average long-term marking rate on each age class. Sea lamprey-induced mortality was then calculated as in past years (Bence 2002) given that 25% of lake whitefish survived a sea lamprey attack.

In summary, 4 to 6 parameters were estimated during the fitting of the SCAA models to describe each fishery's selectivity pattern, and a year-specific parameter was estimated associated with each fishery's fishing intensity. We estimated from zero parameters (whitefish) up to two parameters (stocked lake trout) to describe background natural mortality. No additional parameters were estimated during model fitting to describe sea lamprey mortality, as these rates were calculated directly from wounding data.

In order to complete the population model and describe stock dynamics over time it was necessary to specify the initial numbers at age in the first year and the recruitment of the youngest age in each subsequent year. In the simplest cases each of these would be estimated as a free parameter during model fitting. We deviated from this simplest case in various ways. Prior to 2007 in Lake Huron and 2009 in Lake Michigan, we modeled recruitment as the number of yearling equivalents actually stocked and calculated to move into an area (see Movement Matrices) multiplied by a year-specific "survival adjustment" factor. In this case the "survival adjustment" factors were estimated as parameters, with values deviating from 1.0 being penalized. In these stocked units, this methodology allowed estimated recruitment to exceed the actual number of yearling stocked (and moved) into a particular unit. To address this, the "survival adjustment" factor was abandoned and age one abundance was set equal to the number of fish stocked and moved into the unit. Survival to age 2 is estimated by applying time varying mortality (M1),
with variations above or below a prior specified values being penalized. This constrains the numbers surviving to age 2 to be less than the number recruited to the unit. Wild lake trout recruitment was modeled as a random walk function which was the product of the prior year's recruitment and a multiplicative deviation. The recruitment in the starting year of the model was estimated as a formal model parameter. Lake whitefish recruitment was estimated for each year based on a Ricker stock-recruitment function (with parameters estimated during model fitting). Deviations from calculated recruitment were expected and penalized. For stocked lake trout stocks, when age composition data was limited in earlier years, initial age compositions were based on the known number of lake trout that were stocked and a rough estimate of annual mortality, rather than being estimated during model fitting. For all the hatchery lake trout stocks, initial numbers for year classes known not to be stocked were set to zero.

Movement Matrices and the calculation of yearling equivalents stocked

Assessment models for lake trout on lakes Michigan and Huron were for hatchery-reared lake trout stocked into the lakes. The effective number of yearling lake trout stocked into a management unit was calculated as follows. First, we assumed that lake trout recruitment was based on stocked yearlings or fall fingerlings. The numbers of yearling equivalents were calculated as the number of yearlings stocked that year plus 0.40 times the number of fall fingerlings stocked the year before. Next the numbers stocked at various locations were adjusted for movement soon after stocking (before substantial spatially-varying mortality comes into play). This was done by apportioning fixed proportions of the numbers stocked at each location as being effectively stocked into each of the management areas (recruitment location) on the lake. These translations of numbers from stocking location to recruitment location were in the form of a "movement matrix." The numbers effectively stocked to a management unit (recruitment location) were then summed over the stocking locations. These effective numbers stocked were the input that was then adjusted upward or downward to account for year-specific variations (see above).

The observation sub-model

The observation sub-model predicts numbers of lake trout or lake whitefish killed by each fishing component by age. For the lake trout models survey catch per unit effort (CPUE) by age is also provided. Fishery kill was then converted into proportions-at-age and total number killed for comparison with data. Likewise, age-specific CPUE was converted into proportions-at-age and total CPUE for comparison with observed data.

Fishery kill was predicted using Baranov's catch equation:

$$C(i)a,y = \frac{F(i)_{a,y}}{Z_{a,y}} N_{ay} A(i)_{ay},$$

note that no additional parameters needed to be estimated.

Survey CPUE was predicted assuming proportionality between population abundance and expected CPUE, with selectivity following a logistic or double logistic function of age:

$$CPUE_{a,y} = q(s) S(s)_a N_{a,y},$$

where $q(s)$ was survey catchability, and $S(s)$ was survey selectivity. In some cases survey selectivity was allowed to vary over time in the same way as was fishery selectivity. The parameters of the survey selectivity function and survey catchability were new parameters that needed to be estimated which were not needed for the population sub-model.

The Likelihood (*defining the best fit*)

For numerical and coding reasons it was convenient to maximize the likelihood by minimizing the negative log likelihood. Let L stand for the total log-likelihood. This was calculated as the sum of a set of K independent components:

$$L = L_1 + L_2 + L_3 + \ldots + L_K$$

Each component represents a data source or penalty, and the number of components varied among stocks and species. For each fishery that was included in the model there were three components: one for the total fishery kill each year, one for the fishery age composition each year, and one for the effort deviations for each year. These likelihood components were calculated under the assumption that total fishery kill and effort deviations were lognormal and that the proportions-at-age were determined by a multinomial distribution. When a survey was available, this provided two likelihood components: one for the total CPUE (lognormal) and one for the age composition (multinomial). An additional component came from variation about stock-recruit functions or numbers based on stocking. In the calculation of this penalty term, the deviations were treated as lognormal. When variation about a prior estimate of M was allowed, this contributed another term to the likelihood, and these variations were also assumed to be lognormal.

These various components were weighted by either the inverse of the variance associated with them (lognormal components) or the effective sample size (multinomial components). Here if X was lognormally distributed, variance refers to the variance of ln(X). In the case of effort deviations, in those cases where effort was assumed to provide little information on fishing mortality these components were down-weighted by an arbitrarily small value. The square root of the log-scale variances for the lognormal variables was approximately equal to the coefficient of variation (CV) on the arithmetic scale. In the case of a multinomial variable:

$$CV(p) = \sqrt{\frac{p(1-p)}{N}}$$

With these relationships in mind the modeling group considered information on the likely measurement error associated with the various data sources and specified default variances for each type of data, which were adjusted in cases where additional information was available on data quality.

In the case of variations about recruitment expected based on either the stock-recruit function or the numbers stocked, an iterative approach was followed during model fitting. An initial value for the standard deviation for variations about expected values was specified and the model was fit. Then the standard deviation of the resulting deviations was calculated. The model was refit, adjusting the value of the input standard deviation until the deviation between the standard deviation value specified prior to model fitting and the value calculated after model fitting was minimized. A minimum deviation was defined when the ratio of pre- to post-standard deviation was closest to 1.0.

Calculation of Recommended Harvest Regulation Guidelines, Total Allowable Catch (TAC), and Total Allowable Effort (TAE)

In general, upper bound recommendations on yield and effort were calculated by first estimating population abundance-at-age at the start of the year and then adjusting fishing mortality either to meet mortality targets or to follow guidelines established in the Consent Decree for phasing in the targets. The resulting projection of yield or the effort associated with the fishing mortality then formed the basis of the recommendations.

We start by describing how we determined the maximum amount of yield that could be taken, consistent with a specific upper bound on total mortality. This was the procedure that underlies the modeling group's recommendations regarding harvest regulation guidelines, TACs, and TAEs. We then describe how the procedures were modified to account for specific details that only apply to some areas. For some areas these details include how the target mortality rates were "phased-in" as documented in the Consent Decree.

Target Mortality Rates

The Consent Decree specifies a "fully-phased in" upper bound target for total mortality (i.e., A = the proportion of the population that dies in a year). These rates were either 40-47% (depending on area) for lake trout or 65% for lake whitefish. As demonstrated by the Interagency Modeling Group (IMG) during the period that the Consent Decree was negotiated, these target rates require additional structure in order to be uniquely defined. This occurs because mortality rates vary among ages, so whether or not a population was above a mortality target depends upon what ages were considered and how the mortality rates for the different ages were combined.

Following the procedure of the IMG, we uniquely define mortality rates by making use of the idea of spawning stock biomass per recruit (SSBR). For lake trout, we first calculate spawning stock biomass for a default target mortality schedule. Any age-specific mortality schedule that produces as much spawning stock biomass as the default schedule was considered to be at or below the target mortality rate. The default schedule was to have only natural mortality (excluding sea lamprey-induced mortality) for ages below a specified age, and mortality equal to the target rate for ages equal to or above the specified age. The specified age at which the target rate first applied varied among areas depending upon maturity schedules and precedent.

For whitefish a somewhat different procedure was used to ensure both that an adequate amount of spawning stock was achieved per recruit and that more than one age was contributing substantially to the spawning population. This was done following a two-stage approach. First, overall fishing mortality rates were adjusted so that during the projection period total annual mortality on the age experiencing the highest projected fishing mortality rate was equal to 65%. Then the spawning stock biomass per recruit was calculated for that scenario. Spawning potential reduction (SPR) was calculated by dividing this by the spawning stock biomass per recruit, calculated assuming only background natural mortality. If SPR was less than 0.2, fishing mortality was decreased until SPR was equal to 0.2. The approach was developed by examining various different "rules" and ascertaining that this approach generally ensured more than one age class was contributing substantially to spawning. A SPR of 0.2 was aggressive by standards applied in other fisheries and reflects a perception that lake whitefish are generally robust to fairly high fishing rates.

Population at the Start of the 2012 Fishing Year

The SCAA stock assessment models for lake trout directly estimate population abundance at the start of the year and mortality rates. As a result these estimates can be used in a straightforward fashion to project abundance for all ages other than the age of recruitment (the youngest age in the model) at the start of next year. Recruitment was set at a value reflecting recent levels of recruitment (Lake Superior) or expected stocking. Note that assumed recruitment has little influence on calculations of harvest during the next year, as these fish are either not selected or only weakly selected by the fishery.

Lake whitefish SCAA stock assessment models were similar to lake trout models except that the estimates were based on data two years behind the year for which a harvest limit was being calculated. Thus for lake whitefish there was one additional step, which was projecting the population for two years. For this projection, age-specific mortality rates by source (i.e., trap-net and gill-net fishing mortality, sea lamprey-induced mortality, natural mortality) were set equal to rates averaged over the last three years for which estimates were made. Recruitment of lake whitefish for the two projection years was set to the average recruitment during the last 10 years for which SCAA estimates were available.

Projections during the 2012 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2012, the population was projected forward over the year accounting for age-specific mortality rates by source, using the same equations described above for the SCAA models. Numbers harvested-at-age were calculated by application of the Baranov catch equation. Harvest-at-age was converted to yield by multiplying numbers harvested-at-age by weight-at-age for the fishery and summing over ages.

In these calculations, background natural mortality (*M*) was left at the same value as was used or estimated in the SCAA assessments. Although this was calculated as the average rate in recent years in most of the projection sheets, currently *M* was assumed constant over time in the assessment models. Sea lamprey-induced mortality was set to the average of the values in the last three years of the SCAA for lake trout and the last year's values for lake whitefish.

Fishing mortality rates by type (either sport and commercial or trap net and gill net for lake trout and lake whitefish, respectively) were based on average rates in recent years. These average rates were adjusted to account for changes stipulated in the Consent Decree or known changes in fishing activity by multiplying the baseline age-specific rates by an appropriate multiplier. For example, if a gill-net fishery existed in an area prior to 2011, but did not in 2011, then in projecting whitefish yield the multiplier for gill-net fishery was set to zero. When fishing mortality was adjusted to account for a specified change in fishing effort, or when fishing effort was calculated to correspond with a specific level of fishing mortality rate, effort and fishing mortality were treated as being directly proportional. This basic approach to fishing mortality assumes that selectivity and catchability for each source will remain the same as it was on average in recent years. Detail on how fishing mortality rates were adjusted is covered in the next section.

Setting Fishing Mortality Rates for 2012

Fishing mortality rates were adjusted depending on specific details of how an area was designated in the Consent Decree. We begin by considering lake trout. The simplest case was for areas calculated under the assumption of no phase-in (also called 'fully phased-in' areas) and meeting Consent Decree mortality rate and allocation standards: MM-67, MH-1, MH-2, MI-5, MI-6, and MI-7. This was accomplished by setting the multipliers for the recreational and commercial fisheries so as to simultaneously meet the mortality target (expressed in terms of SSBR) and the designated allocation. The process of finding the correct multipliers was expedited by making use of the Solver utility within Microsoft Excel spreadsheets.

In the Lake Superior units adjustments were made as appropriate when reporting yield limits to account for the harvest of hatchery lake trout since tabled yield limits were taken as applying to all lean lake trout (wild and hatchery). This was necessary because hatchery lake trout, which were not part of the modeled population, do constitute a small proportion of the yield. The recommended yield limits do not include siscowet lake trout. Sport fishery harvest was reported for lean lake trout. In MI-5, commercial yield was reported separately for lean lake trout. In MI-6 and MI-7 reported commercial yield included both lean and siscowet lake trout. The lean-siscowet composition has been periodically measured in commercial monitoring. (Note that the harvest and survey data were adjusted so it reflected only lean, wild fish before they were compared with model predictions.)

The Final 2012 TACs for MM-123, MM-4, and MM-5 were set in accordance with Court Orders and agreements between the Parties reached at Executive Council Meetings or other negotiations. The final 2012 TACs for all other units were calculated per the Consent Decree, in some cases utilizing the 15% rule.

Lake whitefish recommended yields were calculated generally following the approach used for fully phased-in lake trout areas. Details differed because of the different way that target mortality was defined for whitefish, and because for many areas (non-shared units) there was no allocation between state and tribal fisheries. In cases where there was no specified allocation, the first step was to adjust the multipliers for trap nets and gill nets to account for known changes in fishing effort (generally changes expected to arise from conversions or movement of operations). This step merely adjusts the relative contributions of the two gears. Then an overall multiplier (that is applied to both gears) was adjusted until the target mortality rate was reached for the fully-selected age. When an allocation was specified (i.e. “shared units”) the multipliers for the two gears were adjusted simultaneously (as was the case for lake trout) to match both mortality and allocation targets. At this point SPR was examined, and if it was below 0.20 the fishing multiplier was reduced until SPR reached 0.20. In units where the whitefish harvest is shared between the State and the Tribes, the allocation rules were followed, as specified in the Consent Decree. In units where the whitefish harvest is not shared between the State and CORA, Harvest Regulation Guidelines (HRG) are established by CORA according to section III.B of the Tribal Management Plan.

Total Allowable Effort

The Decree specifies that the TFC shall establish “reasonable commercial effort limits…based upon the lake trout harvest limits and catch per effort data” that would be used to manage commercial lake trout harvest. Prior to 2010, for units which were not subject to special phase-in effort rules, the MSC used recent commercial fishing mortality estimates and fishing effort to determine the TAE. For the most recent three-year period, maximum commercial fishing mortality (F^C_{max}), as estimated during model fitting, was divided by actual commercial gill-net effort to approximate q. In this case, F^C was assumed to be directly proportional to effort. The TAE was derived by utilizing the current year’s commercial multiplier, and three-year average values for F^C_{max} and q, to calculate the amount of effort expected to result in yield commensurate with the TAC.

$$TAE = multiplier \left(\frac{\bar{x}\, F^{C} max}{\bar{x}\ q} \right)$$

This methodology was subsequently found to produce declining effort limits as actual fishing effort declined, regardless of population trajectory. To address this, beginning in 2010 a simpler methodology was employed. Effort limits were calculated by dividing the calculated TAC by the most recent three-year average lake trout CPUE in the commercial gill-net fishery. For units with specific phase-in effort rules, TAEs were calculated in accordance with the provisions described in the Decree.

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PRIORITY WORK FOR FUTURE ASSESSMENTS

Prepared by the Modeling Subcommittee

The MSC continually explores ways to improve stock assessments in the 1836 Treaty waters and these potential improvements are identified during discussions held at semiannual meetings. Some improvements are the result of recommendations provided by Michigan State University's Quantitative Fisheries Center (QFC) or other researchers. History has demonstrated that our meetings offer insufficient opportunity to conduct wholesale evaluations of proposed technical changes to model/data structure, the result being that many such endeavors are carried out on an ad hoc basis by individual modelers as time permits. Thus, we have accumulated a list of priority technical evaluations, the most pressing of which are detailed in this section (including comments on progress). The list is not meant to be exhaustive, nor are the items presented in any particular order.

A note on evaluating and documenting technical changes

The MSC has agreed that substantive changes to 1) the basic structure of an assessment; or 2) the treatment of data inputs, must be reviewed by the committee in advance of their incorporation into an assessment used to generate a harvest limit recommendation. If such changes impact only an individual assessment unit, the change will be documented in the individual report for that unit. Technical changes that have broader implications (e.g. all lake trout assessments) would be described in the "Stock Assessment Models" section of this report.

Priority Technical Evaluations

- Incorporate recreational harvest of lake whitefish into the stock assessment models.

In 2010, the harvest estimates and biological data from recreational whitefish fisheries were evaluated. It was determined that sufficient harvest and biological data were present in two units (WFM-05 and WFS-05) to warrant inclusion in these stock assessment models. During 2011, evaluations of ways to incorporate this information were performed and their inclusion should be complete for 2012. Increased spatial and temporal creel coverage in some areas could improve data availability for recreational whitefish fisheries; however, current budgets preclude the State of Michigan from expanding creel effort. In the event that funds become available, these surveys should be initiated.

- Improve estimates of hooking mortality on lake trout released in recreational fishery.

The State of Michigan creel program quantifies released lake trout of both legal and non-legal size. Currently the models use a hooking mortality rate of 15%, based on an individual study from 1986. A five-year study evaluating this hooking mortality rate was initiated in 2010. Upon its *completion the MSC will utilize the results to update hooking mortality estimates.*

- Review and revise current estimates of natural mortality for lake trout and lake whitefish.

Empirical estimates of lake whitefish natural mortality (M) have been incorporated into SCAA models in certain units in northern lakes Huron and Michigan. Doing so has generally improved model performance. In units that lack empirical estimates, the MSC has also made strides in standardizing how von B parameters (and hence M) are calculated. This standardization should be periodically evaluated.

Natural mortality has been assumed to be constant after age 2 and over time in the LAT models. The MSC is currently evaluating a change in Lake Huron unit MH-1 that allows M to vary by age and through time. Preliminary results suggest this approach improved model performance in MH-1. The MSC should explore the possibility of incorporating this procedure in other lakes.

- Continue to evaluate uses for the lake whitefish fishery-independent survey.

The use of survey data as an index of abundance may be more appropriate than, or at least might augment, the aggregate fishery catch-effort approach currently employed. However, preliminary attempts to utilize survey catch-per-unit-effort data in some whitefish units have been unsuccessful. As the time series of survey data lengthens, efforts to evaluate the effectiveness of these surveys and their possible use in the modeling process should continue. It should be noted that biodata collected from these surveys are utilized in estimating various population metrics, including growth and maturity.

- Explore alternative approaches to the existing practice of utilizing aggregate commercial catch and effort data to estimate fishery CPE in the lake whitefish models.

An alternative approach, which incorporates individual fisher catch and effort data, was introduced through research completed at the QFC (Deroba and Bence 2009). The MSC will evaluate mixed model estimates of commercial catch per unit effort, which incorporate individual fisher catch and effort data and implications for lake whitefish population assessments.

- Evaluate alternative approaches to estimating error variances for data sources utilized in the CAA models.

Research completed at the QFC (Linton and Bence 2008) suggests that stock assessments could be improved by allowing these variances to be estimated within the SCAA model. The MSC will work with the QFC to evaluate this alternative variance structure for use in the 1836 Treaty models.

- Continue to assess alternative approaches to modeling selectivity and catchability in the CAA models.

The need to assess fishery selectivity has long been recognized as a priority. Researchers at the QFC have conducted broad scale evaluations of the functions used to estimate selectivity, as well as the time-varying components for catchability. Individual modelers continue to evaluate these differing methodologies and some assessments now include alternative approaches. During 2011 members of the MSC attended a directed workshop (held by the QFC) to develop a more systematic approach to evaluating differing selectivity approaches.

References

Deroba, J. and J. Bence. 2009. Developing model-based indices of lake whitefish abundance using commercial fishery catch and effort data in lakes Huron, Michigan, and Superior. North American Journal of Fisheries Management 29:50-63.

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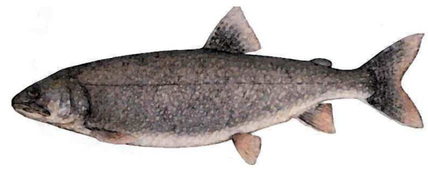
STATUS OF LAKE TROUT POPULATIONS



Lake Superior

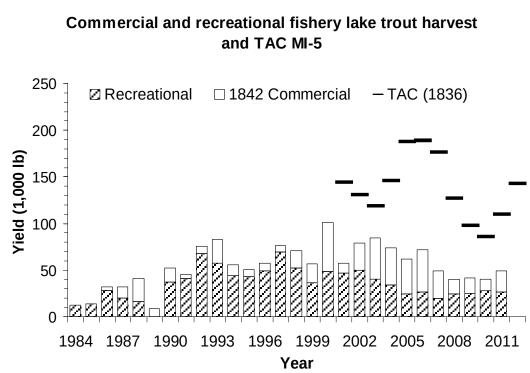
MI-5 (Marquette - Big Bay)

Prepared by Shawn P. Sitar

Lake trout management unit MI-5 extends from Pine River Point (west of Big Bay) to Laughing Fish Point (east of Marquette) covering 924,408 acres. This management unit includes Stannard Rock, an offshore shoal about 45 miles north of Marquette, and is in both the 1836 (618,614 acres) and 1842 Treaty waters (305,794 acres). The 1836 Treaty area extends east from the north-south line established by the western boundaries of grids 1130, 1230, 1330, 1430, and 1530. This unit has a wide bathymetric range with depths beyond 780 feet, and with 186,811 acres shallower than 240 feet.

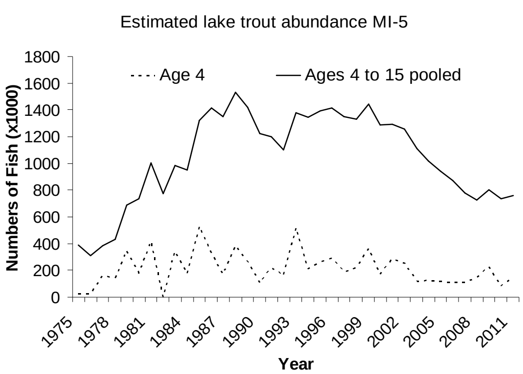
The only tribal commercial fishery is a large-mesh gill-net fishery that is centered around Marquette and Big Bay in 1842 Treaty waters. This fishery mainly targets lake whitefish with lake trout as bycatch. However, lake trout have been targeted near spawning reefs in Marquette during recent fall fisheries. There have been some low levels of tribal subsistence gill-net fishing in 1836 treaty waters. Tribal commercial yield of wild lake trout (in 1842 treaty waters) has ranged from 3,800 round lb in 1986 to a peak of 52,700 round lb in 2000. During 2007 to 2011, tribal yield averaged 19,100 lb and tribal large-mesh gill-net effort averaged 530,000 ft y^{-1}.

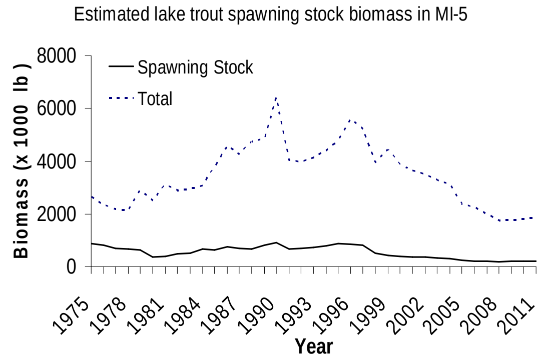
Generally, the commercial fishery is conducted from late winter through early October, with a dome-shaped selectivity with peak age between 7 and 10. The commercial fishery operates in a few grids near Marquette, and the overall impacts on the MI-5 population are nominal. However, in 2000, and 2003 through 2011, the commercial fishers were allowed to harvest lake trout through the end of October during the lake trout spawning season. During these years, total annual yield increased and in many years nearly 50% of the yield was from October. The concentration of commercial fishing during the spawning period has had a localized impact on lake trout in MI-5. Essentially all of the lake trout harvested in October were from the Presque Isle Harbor area of Marquette. Since 2000, fall survey relative abundance of spawners and length structure has declined at Presque Isle harbor.



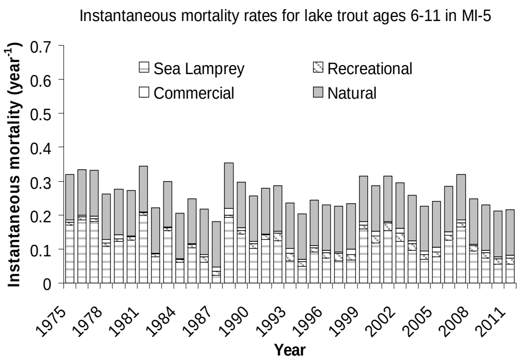
Recreational harvest of lake trout comprises both charter and sport angler fisheries. Most of this activity is centered around the port of Marquette, though some lake trout are harvested at Stannard Rock. There are no seasonal restrictions on the sport fishery, though most of the fishery occurs during the months of May through October. Daily bag limits of lake trout increased from 3 to 5 fish in 2010. Recreational harvest of wild lake trout has increased from 4,400 fish (12,400 round lb) in 1984 to a peak of 15,000 fish (69,200 lb) in 1997 but has been declining since 2003. Average harvest during 2007 to 2011 was 6,000 fish (24,800 lb) y^{-1}. Recreational effort has declined from 146,000 angler hours in 1986 to 30,370 angler hours in 2010.

Abundance of wild lake trout increased more than two-fold since 1975 and has averaged about 0.9 million fish (age 4 and older) during 2002 to 2011. Total biomass of age-4 and older lake trout averaged 2.4 million lb during 2002-2011. Lake trout biomass declined from 5.6 million lb in 1996 to 1.9 million lb in 2011. Spawning stock biomass averaged 248,000 lb during the last 10 years. Although lake trout abundance has increased since the mid 1970s, spawning stock biomass has declined due to significant decreases in growth.





Apart from background natural mortality, sea lamprey-induced mortality has been the dominant mortality source since 1975, although it declined to low levels in the mid-1990s. Since 1994, sea lamprey mortality has progressively increased and in 2007 was the highest level since 1988. With the exception of 1988 and 2005, recreational fishing mortality has been higher than commercial fishing mortality for ages 6-11 lake trout. However, commercial fishing mortality on older lake trout, due to harvest during the spawning season, is higher than recreational fishing (see 2006 Status of MI-5 lake trout report). Average total annual mortality (*A*) for lake trout age 6 to 11 averaged 21.7% during 2009 to 2011, a decline from the recent peak in 2007 driven by the steep drop in sea lamprey-induced mortality. Spawning stock biomass produced per recruit during 2009 to 2011 has been above the target minimum value indicating that mortality rates are not excessive and there is good population reproductive potential.

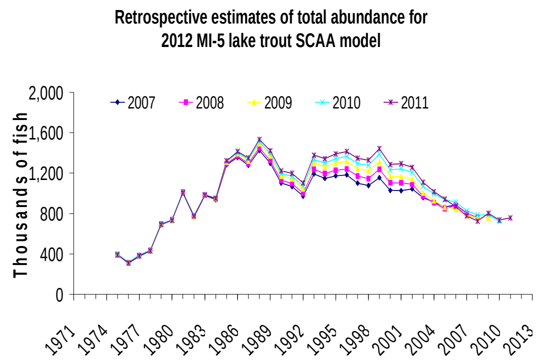


The recommended yield limit for 2012 in 1836 Treaty waters is 142,689 lb, allocated as 135,555 lb for the state recreational fishery and 7,134 lb for the tribal fishery. The recommended yield limit for 1842 Treaty waters is 198,498 lb. The 2012 TAC is higher than 2011 because of slightly higher abundance estimates in the 2012 model.

These recommended yield limits were based on the target mortality rate of 45% defined in the 2000 Consent Decree and allocating 40% of the total yield limit to 1836 waters. Within 1836 waters, the recommended yield is allocated 95% to the state and 5% to the tribes. Note that this yield limit applies to wild and hatchery lake trout caught, whereas target mortality rates apply only to wild lean lake trout. In recent years wild lean lake trout compose more than 95% of the total yield.

Notable stock dynamics – Commercial yield declined by more than 50% from 2006 to 2011. Relative abundance of age 4 and 5 lake trout in the summer pre-recruit survey has declined by 50% since 2002. Growth rates continue to be depressed due to density-dependent effects.

Model diagnostics – Improvements to model structure were implemented in 2012. These included the use of the gamma function to model fishery selectivity as opposed to using the double logistic function, which has been problematic. The MCMC simulations yielded good results in trace plots and non-autocorrelation of key quantities. There was a slight systematic retrospective pattern in abundance estimates between 1986 and 2002. However, recent abundance estimates were generally consistent.



Summary Status MI-5 Lake Trout	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	2.19 lb
Age at first spawning	7 y
Size at 50% maturity	4.54 lb
Age at 50% maturity	12 y
Spawning biomass per recruit	
Base SSBR	6.172 lb (5.109-7.639)
Current SSBR	1.54 lb (1.329-1.79)
SSBR at target mortality	0.191 lb (0.184-0.199)
Spawning potential reduction	
At target mortality	0.249 (0.225-0.271)
Average yield per recruit	0.580 lb (0.475-0.708)
Natural mortality (*M*)	0.134 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	15
Sport fishery (2009-2011)	10
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.006 y^{-1} (0.005-0.008)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.017 y^{-1} (0.014-0.021)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.061 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.231 y^{-1} (0.219-0.245)
Recruitment (age 4)	
(average 2002-2011)	143,780 fish (119,333-179,764)
Biomass (age 4+)	
(average 2002-2011)	2,376,400 lb (2,006,320-2,890,480)
Spawning biomass	
(average 2002-2011)	247,760 lb (204,656-307,164)
MSC recommended yield limit in 2012	142,689 lb
Actual yield limit in 2012	142,689 lb

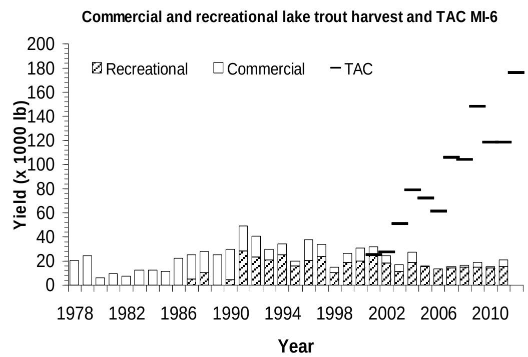
MI-6 (Au Train - Munising)

Prepared by Shawn P. Sitar

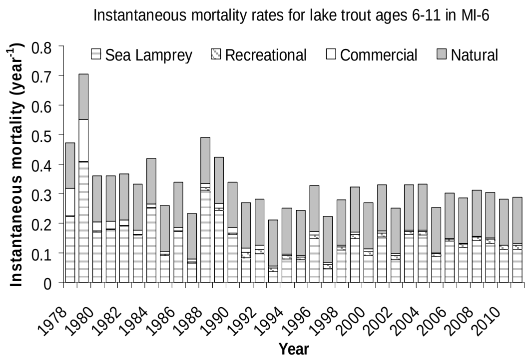
Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 1.8 million acres. This management unit includes Big Reef, an offshore reef complex about 20 miles northeast of Munising. This management unit contains the deepest waters of Lake Superior with soundings deeper than 1,300 ft, and only 185,000 acres of the total area is shallower than 240 ft.

The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery that is centered east of Grand Island. This fishery mainly targets lake whitefish with lake trout as bycatch. Tribal commercial yield of wild lake trout increased through the 1980s following the population increase at the time. Commercial yield and effort decreased in the early 1990s and remains at a low level. Yield peaked in 1989 at 25,600 lb with 2.4 million ft of gill net and declined to an average of 2,700 lb during 2007 to 2011. Total effort averaged 235,000 ft during the last five years.

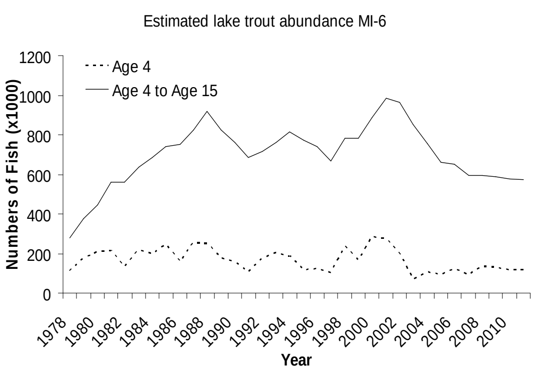
Recreational harvest of lake trout comprises fish caught by both charter and sport angling. Most of the recreational harvest was from the Au Train Bay and Grand Island areas, although some harvest was also from Big Reef. Recreational harvest of wild lake trout has increased through the late 1980s and peaked at 6,300 fish (28,500 lb) in 1991. Harvest has steadily declined since 2001 and corresponded to declines in effort. During 2007 to 2011, recreational fishery harvest and effort averaged 3,700 fish (14,800 lb) and 43,700 angler hours. In the last five years, wild fish composed nearly all (> 98%) of the total recreational and commercial harvest of lean lake trout.

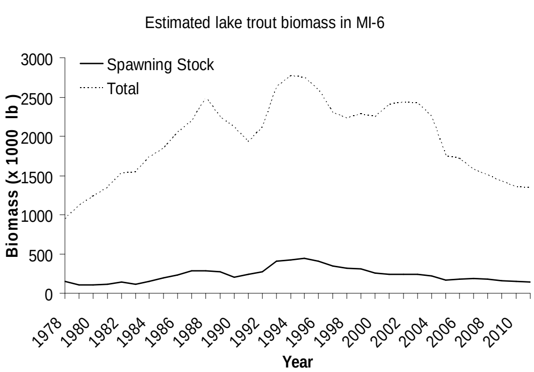


Sea lamprey mortality has been increasing since 1997, and in recent years it has been the highest mortality source for age 6 to 11 lake trout in MI-6. Average sea lamprey mortality during the last five years was nearly three fold higher than in 1997 and is ten times higher than fishing mortality. Recreational fishing mortality has been higher than commercial fishing mortality since 1991. Fishing mortality has been relatively stable since the early 1990s. Between 1978 and 2000, total annual mortality (*A*) was highest in 1979 at 51% and declined to 19% in 1993. Subsequently, *A* increased to an average of 25.2% during 2009 to 2011, which is below the target maximum rate (45%). Total mortality has been increasing since 2005 primarily due to sea lamprey mortality.



In the last five years, lake trout abundance averaged 586,000 fish, while population biomass trended downward in this unit due to declines in somatic growth. During 2002-2011, population biomass averaged 1.8 million lb while average annual spawning stock biomass was 185,000 lb. Recruitment of age 4 lake trout in the last 10 years averaged 119,700 fish.



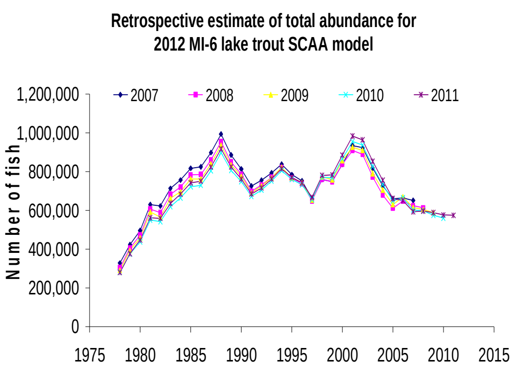


The recommended yield limit for 2012 is 176,116 lb, of which 88,058 lb is allocated to the state recreational fishery and 88,058 lb to the tribal commercial fishery.

While mortality rates apply only to wild lean lake trout, the yield limit includes both wild and hatchery lean lake trout. In calculating the limit, the Modeling Subcommittee assumed that 0.003% of the yield would be hatchery fish. Since 2002, recreational releases of lake trout in MI-6 have been estimated in the creel survey. Since 2004, the MSC has assumed that there is no under reporting in the commercial yield, so the TAC represents the total allowable catch without any under reporting adjustment for commercial fishing. Recreational catch and release mortality was estimated by multiplying the creel survey estimates of released lake trout by 15%, which was based on the hooking mortality estimated by Loftus et al. (1988). Reported total recreational harvest included estimated harvest and hooking deaths.

Notable stock dynamics – The commercial fishery for lake trout in this unit has declined to low levels. Consequently, no commercial monitoring data for age and size structure of harvest have been available since 2001. Recruitment (as indexed by CPUE of age 4 and 5 fish) has steadily declined since 1985 to low levels in recent years. However, spring survey CPUE (adult index) has remained steady.

Model diagnostics – Confidence in this model has been rated as low because of the strong assumptions necessary to generate stock quantities—mainly relying on a population scaling parameter from the adjacent stock (MI-5, Marquette). Since 2003, the model parameter for large-mesh survey catchability has been fixed at the value estimated for MI-5 to reduce the parameter load and stabilize the MI-6 model's solution. Improvements to the 2011 and 2012 MI-6 model have allowed the fixed catchability assumption to be relaxed using a Baysian approach, where the MI-5 spring survey catchability was used as a starting value to estimate the MI-6 spring survey catchability parameter. Markov Chain Monte Carlo (MCMC) simulations were successfully conducted to generate probability intervals for key population quantities and yielded good trace plots and non-autocorrelation of key quantities. There were no major retrospective patterns in the 2012 MI-6 model estimates of total abundance.



Summary Status MI-6 Lake Trout	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	2.45 lb
Age at first spawning	7 y
Size at 50% maturity	4.22 lb
Age at 50% maturity	11 y
Spawning biomass per recruit	
Base SSBR	4.432 lb (3.417-5.407)
Current SSBR	0.99 lb (0.818-1.131)
SSBR at target mortality	0.243 lb (0.23-0.254)
Spawning potential reduction	
At target mortality	0.223 (0.207-0.241)
Average yield per recruit	0.126 lb (0.097-0.166)
Natural mortality (*M*)	0.155 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	10
Sport fishery (2009-2011)	11
Commercial fishing mortality (*F*) (average 2009-2011, ages 6-11)	0.005 y^{-1} (0.003-0.006)
Sport fishing mortality (*F*) (average 2009-2011, ages 6-11)	0.012 y^{-1} (0.009-0.016)
Sea lamprey mortality (ML) (average ages 6-11, 2008-2010)	0.12 y^{-1}
Total mortality (*Z*) (average ages 6-11, 2009-2011)	0.291 y^{-1} (0.276-0.311)
Recruitment (age 4) (average 2002-2011)	119,680 fish (95,628-150,544)
Biomass (age 4+) (average 2002-2011)	1,777,900 lb (1,432,250-2,188,670)
Spawning biomass (average 2002-2011)	184,810 lb (144,711-229,956)
MSC recommended yield limit in 2012	176,116 lb
Actual yield limit in 2012	136,128 lb

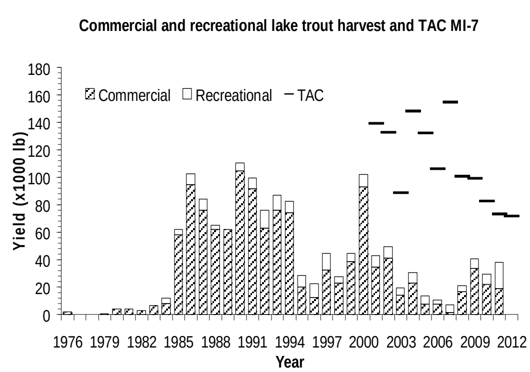
MI-7 (Grand Marais)

Prepared by Shawn P. Sitar

Lake trout management unit MI-7 extends from Au Sable Point (west of Grand Marais) to Little Lake Harbor (east of Grand Marais), encompassing 987,000 acres. This management unit has complex bathymetry with many lacustrine ridges, trenches, and slopes. There is approximately 92,000 acres of lean lake trout habitat (depth less than 240 ft).

The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery that is mostly based out of Grand Marais. This fishery mainly targets lake whitefish with lake trout as bycatch. Tribal commercial yield of wild lake trout peaked in 1990 at 104,400 lb and declined to 12,400 lb in 1996. In the last three years, average yield was 24,900 lb. In recent years, yield of wild lean lake trout composed about 56% of the total lake trout yield, with the rest consisting of siscowet (41%) and hatchery lake trout (0.008%). Tribal large-mesh gill-net effort has shown the same temporal pattern as commercial yield, with a peak effort of 8.2 million ft in 1990. Total annual effort during 2009 to 2011 has averaged 1.6 million ft. Presently, there is only one commercial operator in MI-7.

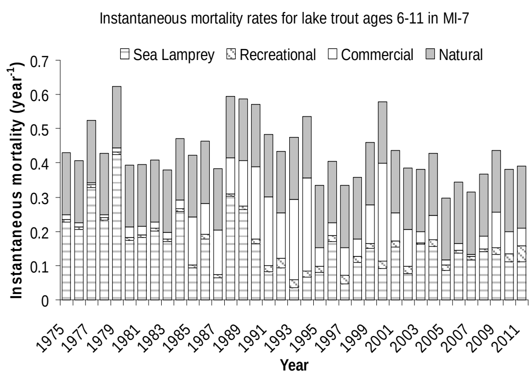
The standardized creel survey began at Grand Marais in 2001. Sport harvest and effort in MI-7 prior to 2001 were estimated using the average sport CPUE and effort index ratio between MI-7 and MI-5 (from MDNR creel mail survey data from 1971 to 1982) applied to MI-5 sport harvest and effort during 1984 to 2000. The estimates from this procedure indicate that recreational harvests in MI-7 are about half those of MI-6. This procedure required strong assumptions, hence there is much uncertainty regarding the true magnitude of the recreational harvest in MI-7 prior to 2001. Average annual recreational harvest of lake trout during 2008 to 2010 was about 1,700 fish (6,400 lb), but increased to 5,400 (19,000 lb) in 2011. The state TAC in 2011 was 24,535 lb. Changes in angler effort did not explain the rise in harvest in 2011. Recreational effort during 2009-2011 was 23,100, 20,200, and 22,300 angler hours, respectively. Based on discussions with the creel analyst, the current estimator used to calculate recreational harvest and effort in MI-7 may be biased. Further work is underway to review the recreational harvest and effort estimators used for Lake Superior ports.



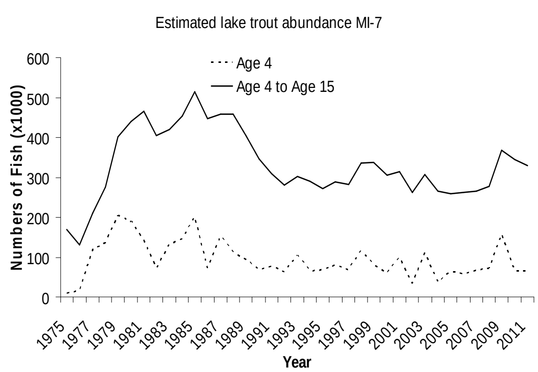
Sea lamprey predation has generally been the dominant mortality source for lake trout in MI-7 with the exception of 1990 to 1994. Commercial fishing mortality increased significantly in 1985 and exceeded sea lamprey-induced mortality from 1990 to 1994. In recent years, commercial fishing has declined to very low levels, but resurged in 2008.

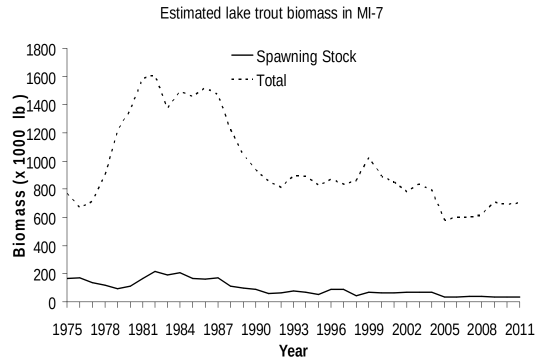
Sea lamprey-induced mortality has been the highest mortality source since 2002. The most recent estimate of sea lamprey mortality for this unit is nearly triple that of the 1997 level. Recreational fishing mortality has generally been low in this unit, but more than doubled in 2011 due to the surge in estimated harvest.

The most recent estimate of spawning stock biomass per recruit (SSBR) for MI-7 is above the target value, indicating that mortality rates are not exceeding the target.



Total abundance of lake trout has generally been level since a major decline between 1988 and 1992. Recent increases in recruitment have driven abundance up since 2008. During 2002-2011, population biomass averaged 691,000 lb and spawning stock biomass averaged 45,900 lb.



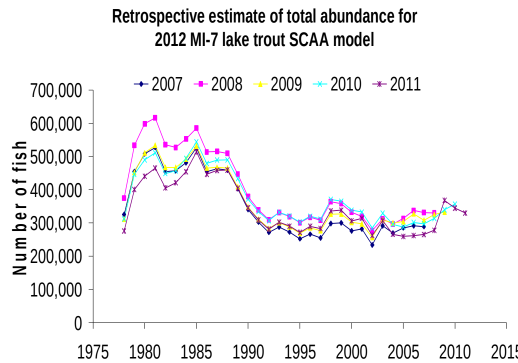


The 2012 TAC was based on running the updated MI-7 lake trout SCAA model. The recommended yield limit for 2012 is 71,407 lb with 21,422 lb allocated to the state recreational fishery and 49,985 lb to the tribal commercial fishery. These limits were calculated on the basis of the target mortality rate (*A*) of 45% and an allocation of 30% to the state and 70% to the tribes, in accord with the Consent Decree. These yield limits apply to all lean lake trout, but mortality targets only apply to wild lean lake trout. In determination of the yield limit it was assumed that none of the lean lake trout yield would be hatchery fish based on recent survey data. The yield limit does not include siscowet lake trout so actual commercial yields can exceed this limit by 41%, to allow for the portion of the commercial yield that siscowets are expected to compose.

Notable stock dynamics – Relative abundance of adult lake trout as indexed from the spring survey has been increasing in recent years. However, recruitment of age 4 and 5 fish (based on summer pre-recruit survey) has been declining since 2001. Recreational yield in 2011 increased by two and a half-fold from 2010 and was only 5,500 lb below the state TAC.

Model diagnostics – Key improvements to the 2012 model include the shift from the double logistic function to the use of the gamma function to model fishery selectivity patterns.

The model converged to a solution meeting the maximum gradient criteria. Further improvements are underway to make the model more robust. Some issues in the current model include the retrospective pattern in estimates of abundance, though they are not systematic. Furthermore, MCMC simulations yielded poor trace plots and autocorrelation of key quantities. However, this may be due to poorly estimated parameters that do not have significant influence on final key model parameter estimates.



Summary Status MI-7 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	2.53 lb
Age at first spawning	7 y
Size at 50% maturity	4.60 lb
Age at 50% maturity	12 y
Spawning biomass per recruit	
Base SSBR	3.083 lb (SE 0.369)
Current SSBR	0.43 lb (SE 0.06)
SSBR at target mortality	0.223 lb (SE 0.006)
Spawning potential reduction	
At target mortality	0.14 lb (SE 0.018)
Average yield per recruit	0.482 lb (SE 0.066)
Natural mortality (*M*)	0.181 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	11
Sport fishery (2009-2011)	11
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.073 y^{-1} (SE 0.015)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.03 y^{-1} (SE 0.006)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.118 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.412 y^{-1} (SE 0.02)
Recruitment (age 4)	
(average 2002-2011)	73,496 fish (SE 10,036)
Biomass (age 4+)	
(average 2002-2011)	691,330 lb (SE 97,311)
Spawning biomass	
(average 2002-2011)	45,887 lb (SE 8,649)
MSC recommended yield limit in 2012	71,407 lb
Actual yield limit in 2012	71,407 lb

Lake Huron

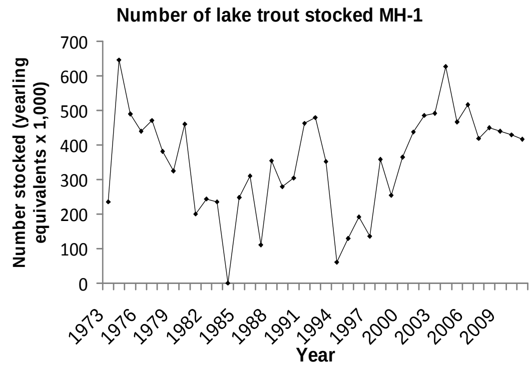
MH-1 (Northern Lake Huron)

Ji X. He, Mark P. Ebener, and Adam Cottrill

The lake trout management unit of northern Lake Huron (MH-1) covers Michigan statistical district MH-1 and Ontario quota management area (QMA) 4-1. This management unit includes the Drummond Island Refuge. The time-series of relative abundance is based on data from spring and summer fishery independent gill-net surveys. Major sources of mortality include natural, sea lamprey predation, commercial fishing, and sport fishing. Observed recruitment in this unit includes both hatchery stocked and naturally produced fish.

Wild recruitment became noticeable in all sources of lake trout samples only in the past two years of data, but it has increased rapidly. Between 2010 and 2011, the proportion of wild lake trout increased from 13 to 19% in CORA commercial fisheries, 26 to 60% in Ontario commercial fisheries, 23 to 51% in Michigan recreational fisheries, 33 to 43% in CORA fall surveys, 20 to 27% in CORA and USFWS summer surveys, and 10 to 17% in MDNR spring surveys.

The total number of age-1 lake trout stocked in 2011 was 417,194 (Figure 1), including 122,516 in the Drummond Island Refuge, and 99,904 planted by the state. After adjusting for the movement among areas, estimated age-1 lake trout recruitment in MH-1 was 577,481 in 2011.



Sea lamprey induced mortality was based on wounding rate as a logistic function of lake trout body length, and estimated length distributions at ages. The wounding rate in a given year was based on spring (April-June) samples from U.S. waters, reflecting sea lamprey induced mortality in the previous year. The estimated asymptotic wounding rate decreased after 1998, and since 2001 has been substantially lower than the 1998 level (Figure 2). The estimated instantaneous mortality from sea lamprey predation on age 7 lake trout was 0.221 y^{-1} in 1998, and the average was 0.111 y^{-1} during 2008-2010.

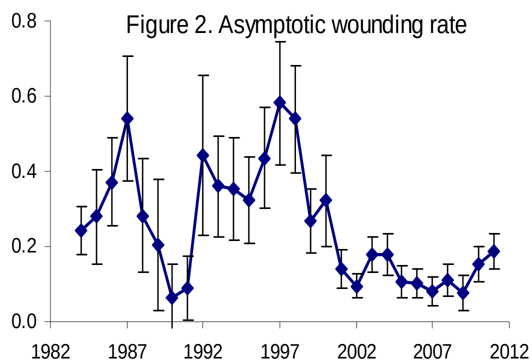
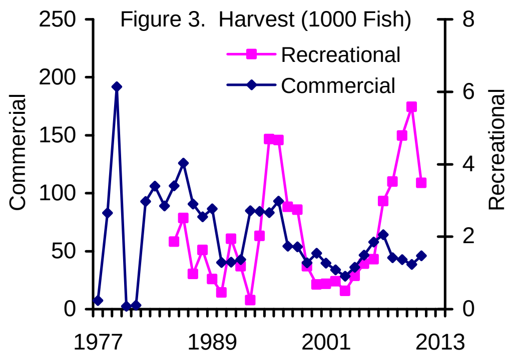


Figure 2. Asymptotic wounding rate

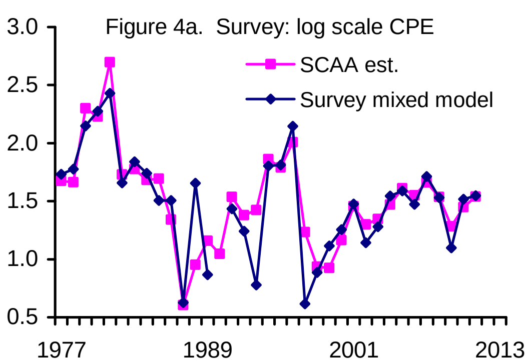
The total commercial harvest was 265,310 lb in 2011, of which the CORA fisheries accounted for 235,427 lb or

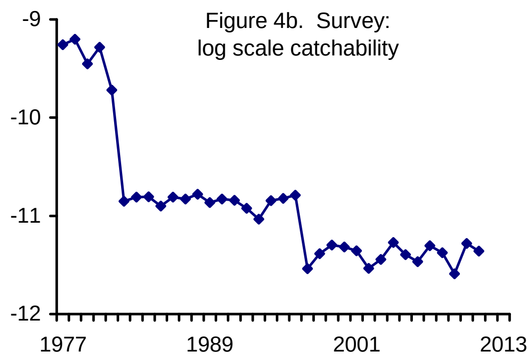
89%. The CORA harvest included the estimated discard kill of 7,132 lb. The weight-based percentages of wild lake trout were 13% in CORA harvest and 57% in Ontario harvest.

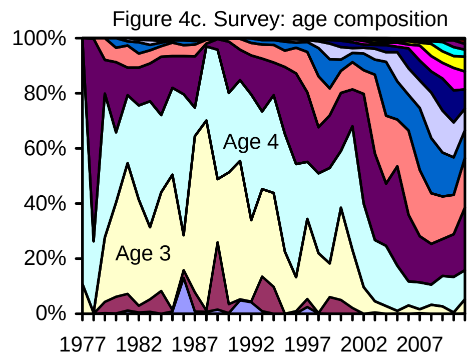
The recreational harvest was 14,544 lb in 2011, including an estimated discard kill of 571 lb. The weight-based wild percentage was 47%. Overall, the recreational harvest is a small portion of the total commercial and recreational harvest combined (Figure 3).



Survey catch per effort (CPE) has been relatively stable since 2005, after the increases from the late 1990s (Figure 4). Over the full time series, the pattern of survey CPE includes major changes in survey catchability, age composition, and selectivity of small and young lake trout (Figure 4a, b, c).

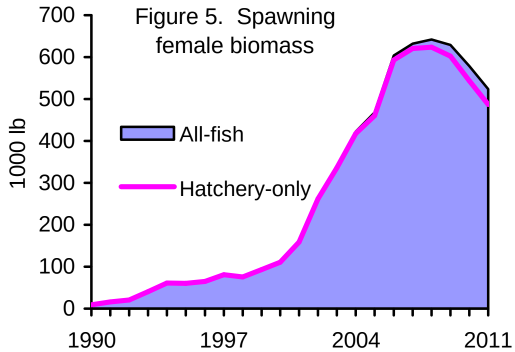






For 2012, all fisheries and survey data were organized into two versions: one included all fish caught in fisheries and surveys (the “all-fish” model) and the other included only hatchery fish (the “hatchery-only” model). Other model-based data inputs such as time-varying length at age, time-varying length-weight relation, time-varying maturity schedule, and sea lamprey induced mortality were the same for both versions of the model. The all-fish model did not show major differences in age structures from the hatchery-only model. The all-fish model over estimated post-stocking survival of hatchery fish, and we recognized those biases based on wild proportion of each age group. The hatchery-only model, however, had slightly lower, but similar estimates for post-stocking survival.

Female spawning stock biomass was almost negligible until the late 1990s, then increased steadily through 2006 and has slightly declined since 2008 (Figure 5). The two versions of the model produced very similar estimates.



Estimated age-specific total mortalities were far below the annual mortality limit of 45%. Weak year classes after 2001 (stocked yearlings after 2002) likely contributed to the recent declines in spawning biomass.

Two major improvements in the SCAA model structures were reviewed and implemented. The first was age-specific natural mortality that was allowed to vary through time. The second was time-varying selectivity, which was a log-normal function of median length at age. The estimated average natural mortality for age 5 and older fish was much lower than the estimate from previous years, and the low estimate was consistent with the recent rapid increase in older fish. The estimate of natural mortality for age 5 and older fish differed between MH-1 and MH-2 (0.08 vs 0.14). It is unlikely that actual natural mortality rates differed that much between the units. Although the difference was not statistically significant, in practice it was meaningful. For example, we could not adequately evaluate the implication of spawning potential ratio (SPR) with the MH-1 estimate of natural mortality. Previous analyses on code-wire tagged fish and the recent MDNR tagging study have shown adult migration between the two management units although quantitatively it is not clear how this movement may have influenced the estimates of natural mortality.

There were also two refinements in the SCAA model structures that made the model convergence more stable. The first was to use time-block specific priors for catchability and selectivity. Previously, we either managed a time-varying vector using a single prior or we only allowed the parameter to vary among time blocks. The second refinement was to use variance ratios instead of predetermined standard deviations (SD). Those variance ratios were relative to a baseline SD and were applied to all time-varying vectors and observation errors of fishery harvests. The baseline or reference SD was an input value, which was the average of year-specific SD for the survey-based relative abundance index.

A TAC of 517,791 lb was calculated for the U.S. fishery from the SCAA model using data for hatchery fish only and adjusting for the proportion of wild fish observed at each age in all data sources. The result was a 44% overall increase from the hatchery-only TAC. Three assumptions in these procedures were potentially problematic. The first was that the SCAA model could estimate pre-recruitment abundance for the recent year classes. This assumption is misleading because we do not have adequate data until a year class is fully recruited to the fisheries and survey. The second was that a year-class fully recruits to the fisheries and survey by age 5. This assumption is no longer true because the recruitment has been delayed from age 5 to age 7 for many years. The third was that wild recruitment was in addition to stable numbers of hatchery fish, rather than replacing hatchery fish. The survey and fishery data have indicated the opposite.

Future assessment should use the all-fish model with additional development for explicitly estimating wild recruitment based on the current data structure and the observed wild proportion at each age through the years. This will be a better starting point to further address various issues identified through the model diagnostics, and various concerns about assumptions used in calculating a TAC.

Summary Status MH-1 Lake Trout	Value (Standard Error)
Female maturity	
Size at first spawning	0.95 lb
Age at first spawning	3 y
Size at 50% maturity	3.25 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	3.708 lb (SE 0.281)
Current SSBR	0.506 lb (SE 0.040)
SSBR at target mortality	0.195 lb (SE 0.012)
Spawning potential reduction	
At target mortality	0.052 (SE 0.002)
Average yield per recruit	0.191 lb (SE 0.010)
Natural mortality (*M*)	0.08 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	8
Sport fishery (2009-2011)	7
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.131 y^{-1} (SE 0.004)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.014 y^{-1} (SE 0.001)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.113 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.337 y^{-1} (SE 0.006)
Recruitment (age 4)	
(average 2002-2011)	136,350 fish (SE 3,950)
Biomass (age 4+)	
(average 2002-2011)	2,281,700 lb (SE 69,911)
Spawning biomass	
(average 2002-2011)	510,360 lb (SE 19,729)
MSC recommended yield limit in 2012	517,791 lb
Actual yield limit in 2012	410,000 lb

MH-2 (North-central Lake Huron)

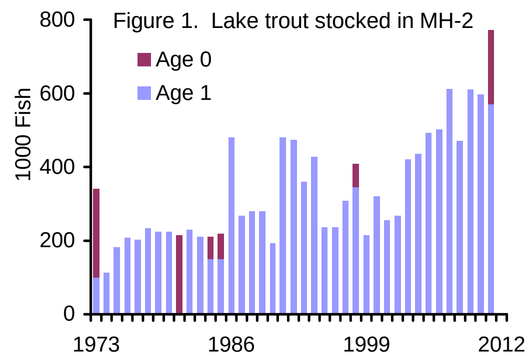
Ji X. He and Adam Cottrill

The lake trout management unit of north-central Lake Huron (MH-2) covers Michigan statistical district MH-2, and Ontario quota management areas (QMA) 4-2, 4-3, and 4-7. This management unit includes about 50% of the Six Fathom Bank Refuge, where Ontario waters less than 40 fathoms deep are also free of commercial fisheries. Michigan waters in MH-2 include both 1836 Treaty waters and non-treaty waters, divided by a line running north-east from the tip of North Point of Thunder Bay to the international border.

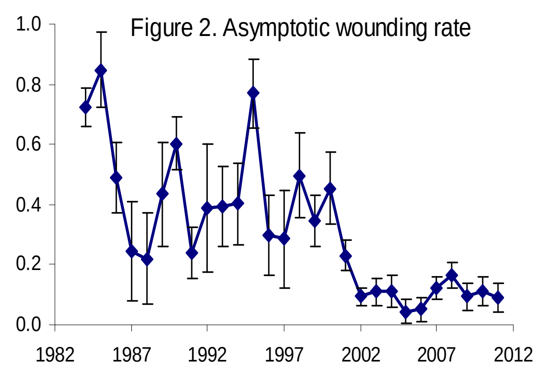
The time-series of relative abundance is based on data from spring and summer fishery independent gill-net surveys. Major sources of mortality include natural, sea lamprey predation, commercial fishing, and sport fishing. Observed recruitment in this unit comes from both naturally produced and hatchery fish.

Wild recruitment became noticeable in all data sources only in the last two years, but it has increased rapidly. Between 2010 and 2011, the proportion of wild lake trout increased from 32 to 61% in the Ontario commercial fishery, 11 to 18% in the Michigan recreational fishery, and 8 to 16% in MDNR spring surveys. The proportion of wild fish slightly declined from 20 to 14% in the USFWS summer survey.

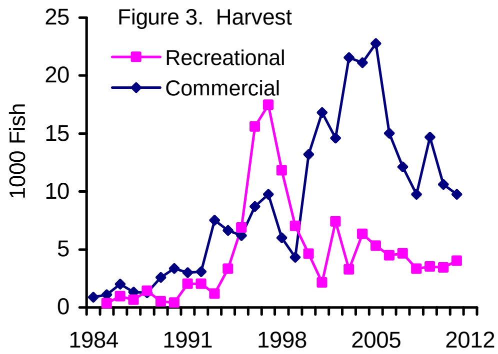
There were 569,877 age-1 and 201,241 age-0 lake trout stocked into MH-2 in 2011 (Figure 1). After adjusting for movement among the management units of the main basin, the estimated number of age-1 lake trout recruits in MH-2 was 579,336.



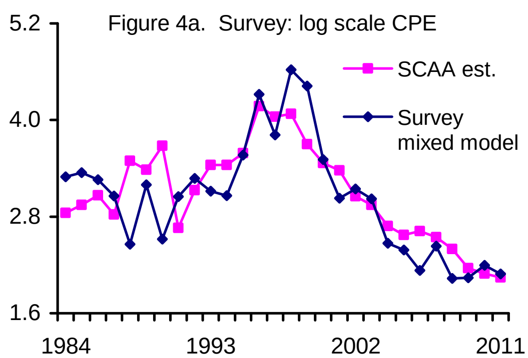
Sea lamprey induced mortality was based on wounding rate as a logistic function of lake trout body length, and estimated length distribution at ages. The wounding rate in a given year was based on spring (April-June) samples from U.S. waters, reflecting sea lamprey induced mortality in the previous year. The estimated asymptotic wounding rate decreased after 1998, and since 2001 has been substantially lower than the 1998 level (Figure 2). The estimated instantaneous mortality from sea lamprey predation on age 7 lake trout was 0.249 y^{-1} in 1998, and the average was 0.074 y^{-1} during 2008-2010.

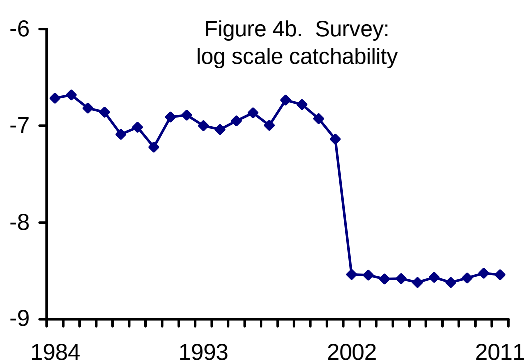


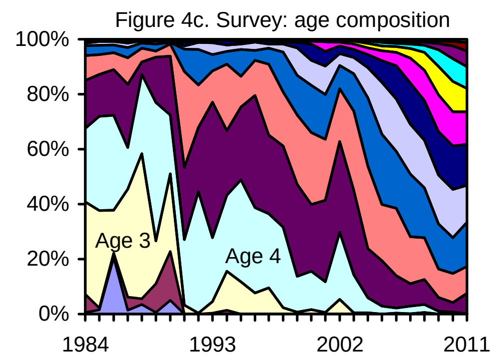
Both commercial and recreational harvests were important in this region of Lake Huron (Figure 3). The 2011 commercial harvest from Ontario waters was 43,583 lb, of which wild lake trout accounted for 27,650 lb or 63%. The 2011 recreational harvest from Michigan waters was 30,015 lb, including an estimated discard kill of 727 lb. The weight-based percentage of wild lake trout from recreational harvest was 15%.



The over-year patterns of survey catch per effort (CPE) involved major changes in catchability, age composition, and selectivity on small and young lake trout (Figure 4a, b, c).

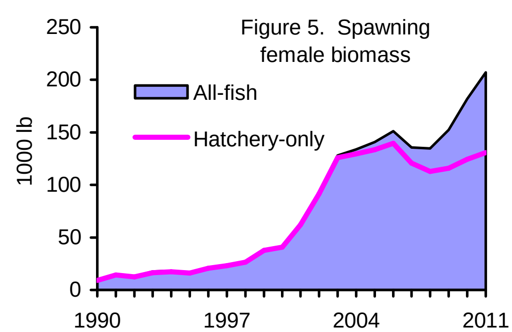






All fisheries data and survey data were organized into two versions: one included all fish caught in fisheries and surveys (the "all-fish" model) and the other included only hatchery fish (the "hatchery-only" model). Other model-based data inputs such as time-varying length at age, time-varying length-weight relationship, time-varying maturity schedule, and sea lamprey-induced mortality were the same for both versions of the model. Commercial age compositions for the recent three years substantially differed between the two versions of data set or model.

The estimated female spawning stock biomass (SSB) was very low until the late 1990s. It then steadily increased and has exceeded 133,000 lb each year since 2004 (Figure 5). The two versions of the model had different estimates of SSB only for the most recent years.



A harvest limit of 177,335 lb was calculated for the U.S. fishery from the SCAA model using data for hatchery fish only and adjusting for the proportion of wild fish observed in all data sources. The result was a 67% from the hatchery-only harvest limit.

All recent major improvements in the MH-1 model structure were also applied to MH-2. The assumptions regarding the TAC calculation procedure are also similar to MH-1, as are the proposed improvements for future assessments.

Summary Status MH-2 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	2.12 lb
Age at first spawning	4 y
Size at 50% maturity	4.43 lb
Age at 50% maturity	7 y
Spawning biomass per recruit	
Base SSBR	1.239 lb (SE 0.128)
Current SSBR	0.337 lb (SE 0.041)
SSBR at target mortality	0.113 lb (SE 0.012)
Spawning potential reduction	
At target mortality	0.091 (SE 0.004)
Average yield per recruit	0.12 lb (SE 0.01)
Natural mortality (*M*)	0.14 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	8
Sport fishery (2009-2011)	10
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.005 y^{-1} (0.003-0.006)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.012 y^{-1} (0.009-0.016)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.12 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.291 y^{-1} (0.276-0.311)
Recruitment (age 4)	
(average 2002-2011)	119,680 fish (95,628-150,544)
Biomass (age 4+)	
(average 2002-2011)	956,820 lb (SE 48,965)
Spawning biomass	
(average 2002-2011)	145,770 lb (SE 7,770)
MSC recommended yield limit in 2012	177,335 lb
Actual yield limit in 2012	177,335 lb

Lake Michigan

MM-123 (Northern Treaty Waters)

Prepared by Jory L. Jonas, Erik J. Olsen, and Mark P. Ebener

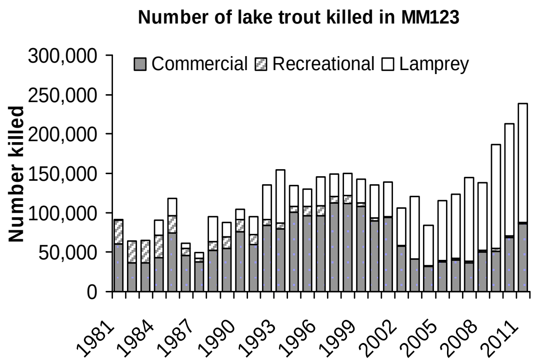
Management unit MM-123 is made up of statistical districts MM-1, MM-2 and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay, covering 5,000 square miles. Water depths in the northern portion of the unit are generally less than 150 feet, and approximately 3,800 square miles (two-thirds of the area) are less than 240 feet. In southern portions of the unit, depths can be greater than 550 feet. Most of the historically important lake trout spawning reefs in Lake Michigan are located in MM-123. The unit contains many islands including the Beaver Island complex (Beaver, Hat, Garden, Whiskey, Trout, High and Squaw Islands), North and South Fox Islands, and Gull Island in Lake Michigan. Another series of islands form a line separating Green Bay from Lake Michigan; these include Little Gull, Gravely, St. Martins, Big and Little Summer and Poverty Islands.

Except for the southern one-half of MM-1 in Green Bay, this management unit is entirely in 1836 Treaty-ceded waters, and contains a lake trout refuge. The "northern refuge" is nearly 900 square miles and occupies the southern ½ of grids 313 and 314, grids 413, 414, 513-516, the northwest quarter of grid 517, grid 613, and the northern ½ of grid 614. Retention of lake trout by sport or commercial fisheries is prohibited in the refuge. Both commercial and subsistence gill-net fishing are prohibited in the refuge, while commercial trap-net operations are permitted to harvest lake whitefish.

Outside of the refuge commercial fishing is also prohibited in the innermost area of Little Traverse Bay (grid 519) and portions of grid 306 in northwestern Green Bay.

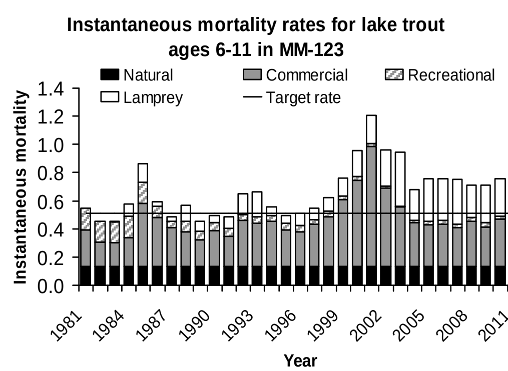
Recruitment of lake trout in MM-123 is currently based entirely on stocking of hatchery-reared fish. In each of the last ten years, on average, 1.11 million yearling lake trout have been stocked into MM-123 and approximately 53% of these fish were stocked into the northern refuge. To more accurately estimate recruitment to MM-123, a movement matrix was developed to account for movement among Lake Michigan management units. Coded-wire tag returns were used to estimate the contribution of fish stocked in each management unit to adjacent management units. After adjustments, the resulting estimates of age-1 recruitment in MM-123 have averaged 682,982 fish from 2002-2011.

Both state and tribal commercial fisheries operate in MM-123. State-licensed commercial fisheries target lake whitefish primarily with trap nets in Green Bay. The tribal commercial gill net and trap net fishery primarily targets lake whitefish, with lake trout often harvested as by-catch. Commercial fishing mortality peaked in 2001 at 0.85 y^{-1} and in recent years (2004-2011) has been lower and relatively consistent at 0.31 y^{-1}. From 1981 until 2002, commercial fishing accounted for 66% of the mortality of lake trout in MM-123. The combination of reduced fishing pressure and the increase in sea lamprey mortality has reduced the contribution of commercial fishing as a mortality source in recent years to around 52% to the total mortality rate on lake trout in MM-123.



The tribal commercial fishery in MM-123 uses large- and small-mesh gill nets as well as trap nets. The large-mesh gill-net fishery accounts for the majority of the lake trout yield. Total commercial yield increased from 350,682 lb in 1991 to 880,248 lb in 1999. After the implementation of the 2000 Consent Decree, the tribal commercial yield of lake trout declined to 105,763 lb in 2004. Since then, harvest has been gradually increasing and was 333,634 lb in 2011. Large-mesh gill-net effort declined from 23 million feet in 1992 and 1993 to 4.2 million feet in 2004. During the most recent 4 years large-mesh gill-net effort has increased from 4.5 million feet in 2007 to 10.3 million feet in 2011. The number of lake trout harvested from MM-123 by the commercial fishery increased from 42,940 fish in 1987 to 145,270 fish in 1997. More recently, following implementation of the 2000 Consent Decree, the number of lake trout harvested by the commercial fishery declined to an all time low of 29,310 fish in 2004. Commercial harvest has since increased to 78,279 fish in 2011.

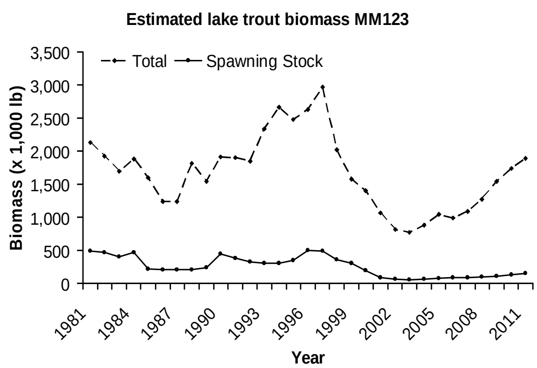
The recreational fishery for lake trout is comprised of both charter and sport anglers. Since 1986, recreational fishing mortality of lake trout in MM-123 has been significantly lower than commercial fishing or sea lamprey predation. In 1991, the minimum size limit for sport fishing in MM-123 was increased from 10 to 24 inches and a decline in recreational yield resulted. In 2003, the bag limit was raised from 2 to 3 fish, but the change had little effect on harvest. The 24-inch minimum size limit and 3-fish bag limit remained in effect through 2010. The recreational yield of lake trout declined by over 97% from 1998 (75,820 lb) to 2003 (2,300 lb). Recreational fishery yield has been relatively consistent for the last six years averaging 14,700 lb. The numbers of lake trout harvested fell to just under 400 fish in 2003 and has averaged 2,400 fish from 2006 to 2011. Recreational fishing effort is relatively low in this unit and had been declining. In 2006 124,800 angler hours were spent in the unit and only 59,200 hours were spent in 2010. Size regulations were changed in 2011 from a 24” minimum size limit to a 20 to 25” harvestable slot limit, while allowing for harvest of one trophy fish over 34”. In 2011, effort increased to 104,100 hours and the numbers of fish harvested stayed consistent with 2010. The new size limit resulted in a decline in the average weight of a harvested fish from 6.1 lb in 2010 to 4.4 lb in 2011.



Sea lamprey mortality rates in northern Lake Michigan had averaged

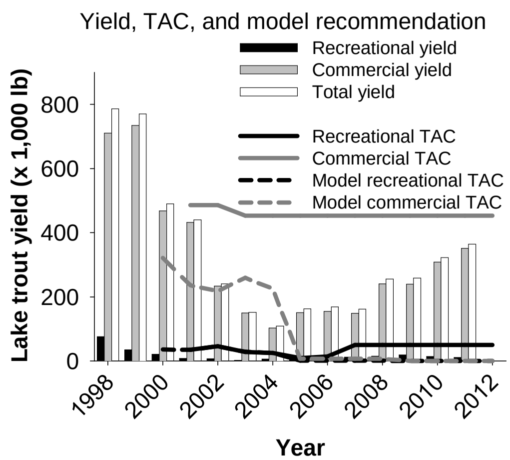
0.09 y^{-1} from 1983-2000. Lamprey mortality rates have been higher since, averaging 0.27 y^{-1} from 2001-2010. Prior to the year 2000 and back to 1987, sea lamprey killed an average of 27,200 fish y^{-1}. Since this time the number of lake trout killed by sea lamprey has increased substantially peaking at an estimated 150,650 fish in 2011.

The biomass of lake trout in northern Lake Michigan nearly tripled between 1986 and 1997, increasing from 1.2 to 3.0 million lb. The biomass of lake trout then steadily declined to 0.8 million lb by 2003. The estimated biomass has since been increasing and was 1.9 million lb in 2011. Most of the biomass is composed of young fish as similar increases in the spawning stock were not observed.



The spawning stock biomass produced per recruit (including the refuge population) during 2011 was substantially below the target value indicating that mortality rates for the combined refuge/non-refuge population are above the 40% mortality target for this area.

The stipulated yield limit for 1836 Treaty waters of MM-123 in 2011 is 50,000 lb for the state recreational fishery and 453,000 lb for the tribal commercial fishery. These values reflect an extension of the phase-in requirements from the 2000 Consent Decree. In 2007, harvest limits for 2005 and 2006 were re-assessed, and the phase-in period extended until lamprey mortality is significantly below the 1998 baseline for three consecutive years, at which time management of this unit will be re-evaluated. Phase-in options allow for a temporary increase in mortality above the 40% target. When fully phased to the 40% mortality target, yield allocations in this management unit will be 10% to the State of Michigan and 90% to tribal fisheries. The model generated harvest limits for 2011 are zero because the mortality from all sources combined is above the target level and there are therefore no surplus fish available to allocate to fisheries.



Model evaluation and changes – The 2012 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except the P3 and P4 parameters for commercial gill-net selectivity and the P1 and P2 parameters for survey selectivity were fixed and not estimated Survey CPE fits were not as good as in the past, perhaps because of the fixed P1 and P2 values. The MCMC simulations yielded good results. Residual patterns were acceptable, but did show some trends. The retrospective analysis of this year’s model did not show any systematic temporal patterns in estimates of total biomass, spawner biomass, or abundance. Catchability is now time-varying for the commercial and recreational fisheries. Work will continue to resolve ongoing selectivity issues.

Summary Status MM-123 Lake Trout	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	2.19 lb
Age at first spawning	3 y
Size at 50% maturity	6.69 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	8.44 lb (6.61-10.44)
Current SSBR	0.26 lb (0.16-0.38)
SSBR at target mortality	1.22 lb (0.98-1.47)
Spawning potential reduction	
At target mortality	0.146 (0.135-0.157)
Average yield per recruit	0.540 lb (0.456-0.625)
Natural mortality (*M*)	0.134 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	6
Sport fishery (2009-2011)	7
Commercial fishing mortality (*F*) (average 2009-2011, ages 6-11)	0.337 y^{-1} (0.266-0.425)
Sport fishing mortality (*F*) (average 2009-2011, ages 6-11)	0.022 y^{-1} (0.017-0.028)
Sea lamprey mortality (ML) (average ages 6-11, 2008-2010)	0.255 y^{-1}
Total mortality (*Z*) (average ages 6-11, 2009-2011)	0.749 y^{-1} (0.673-0.843)
Recruitment (age 4) (average 2002-2011)	109,366 fish (SE 11,900)
Biomass (age 3+) (average 2002-2011)	1,216,367 lb (1,114,880 - 1,326,110)
Spawning biomass (average 2002-2011)	92,567 lb (79,432-107,538)
MSC recommended yield limit in 2012	0 lb
Actual yield limit in 2012	503,000 lb

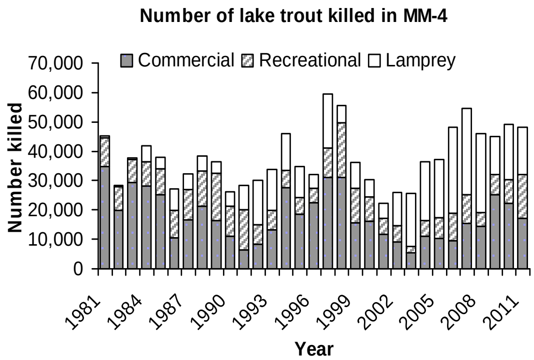
MM-4 (Grand Traverse Bay)

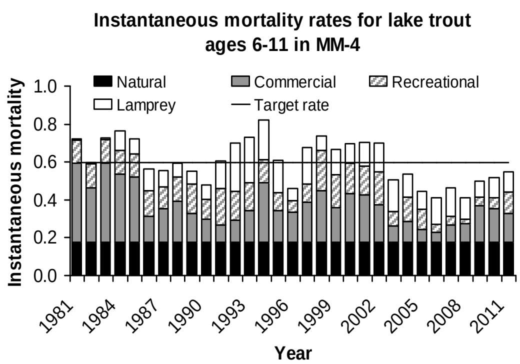
Prepared by Jory L. Jonas and Erik J. Olsen

Lake trout management unit MM-4 encompasses the Grand Traverse Bay region of Lake Michigan. There are two islands in this management unit, Bellow and Marion Island. A large peninsula bisects the southern half of the bay. For the most part water depths in the bay range up to 280 feet. However, waters on either side of the peninsula are much deeper, ranging to 440 feet in the west arm and 640 feet in the east arm. This management unit is entirely in 1836 Treaty waters. There are no refuge areas allocated, however commercial fishing is prohibited in the southern most portion of the bay (grids 915 and 916). The total area of the unit is 255 square miles of which 168 square miles are less than 240 feet in depth. Based on estimates from historical commercial catch rates only a small amount of lake trout spawning habitat is located in the management unit. However, Grand Traverse Bay is one of the only areas of Lake Michigan where the recruitment of naturally reproduced lake trout has been documented. In the mid-1980s the frequency of unclipped fish in the bay increased significantly leading biologists to believe that rehabilitation efforts were succeeding. Unfortunately, in more recent evaluations few unclipped lake trout have been seen. This area constitutes an area of high use by both Tribal and State interests.

The recruitment of lake trout in Grand Traverse Bay is based entirely on stocking. The U.S Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. Since 2002, the average number of yearling lake trout stocked into Grand Traverse Bay has been 294,777. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for movement among the various regions in Lake Michigan. After adjustments, the resulting estimate of age-1 recruitment in the Grand Traverse management unit has averaged 342,787 fish from 2002-2011.

Only tribal fishermen licensed by the Grand Traverse Band of Ottawa and Chippewa Indians may commercially harvest fish in this management unit. There are three types of tribal commercial fisheries, large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill-net fishery while primarily targeting lake whitefish is responsible for the greatest number of harvested lake trout. The commercial harvest of lake trout in tribal large-mesh gill-net fisheries peaked at 33,300 fish in 1998 and had declined to 4,789 fish in 2003. Harvest had increased to 27,161 fish in 2009 and has decreased to 17,882 fish in 2011. Accordingly, the yield of lake trout captured in tribal commercial fisheries peaked in 1998 at 160,977 lb and declined by nearly 86% to 22,920 lb in 2003. Yield had increased to 135,984 lb in 2009 and was down to 78,069 lb in 2011. Large-mesh gill-net effort in tribal fisheries had declined from 2.0 million feet in 1996 to only 0.3 million feet in 2006. Effort had increased to 1.2 million feet of net in 2010 and was down in 2011 to 0.8 million feet.

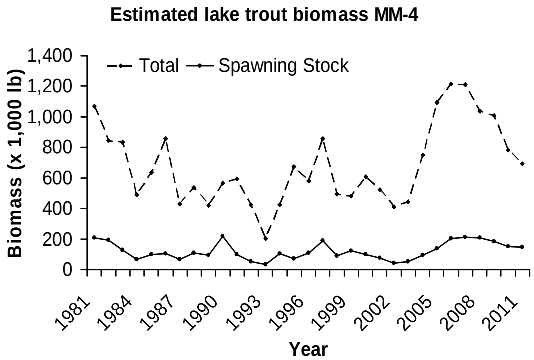




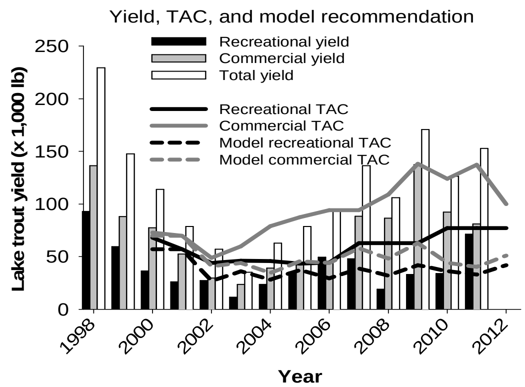
The recreational fisheries for lake trout are comprised of both charter and sport anglers. The sport fishing harvest regulations in the Grand Traverse Bay management unit have changed significantly over the last 15 years, affecting recreational fishing mortality rates and harvest levels. The season for harvesting lake trout is Jan 1 through September 30 and the bag limit is 3 fish. In 2006, a slot limited was adopted where anglers were only allowed to keep fish between 20 and 25”, while allowing for the harvest of one fish greater than 34”. In 2011, this regulation was changed to allow for one of the three fish in the bag to be larger than 25”. The mortality rates of lake trout from recreational fishing had been declining from 1991 (0.19 fish y^{-1}) to 1997 (0.09 fish y^{-1}). Recreational fishing mortality was relatively consistent from 1998 to 2002 averaging 0.17 y^{-1}. The lowest recreational fishing mortality rate of the time series occurred in 2008 (0.02 y^{-1}). Recreational fishing mortality increased in 2011 to 0.11 y^{-1}, likely the result of the newly enacted more liberal harvest regulations. The greatest harvest in numbers (18,582 fish) and yield (92,993 lb) of lake trout occurred in 1998. The lowest harvest (2,111 fish) and yield (11,634 lb) levels occurred in 2003. The numbers of lake trout harvested increased to 8,229 fish in 2010 and 15,789 fish in 2011. Modifications to size limits are likely responsible. While harvest has increased yield has been relatively low, averaging 29,838 lb from 2008-2010. Yield doubled to 71,356 lb in 2011.

Sea lamprey mortality rates in Grand Traverse Bay have been the highest single source of harvest mortality in four of the past ten years. Recently they decreased from 0.15 y^{-1} in 2007 to 0.08 y^{-1} in 2009. In 2010 rates increased to 0.11 y^{-1}. The highest lamprey mortality rate was observed in 1992 (0.25 y^{-1}) and the lowest in 1996 (0.07 y^{-1}). An estimated 29,411 fish were killed by lamprey in 2006 and this declined to 12,933 fish in 2009. Lamprey killed an estimated 19,000 fish in 2010 and 16,000 fish in 2011.

In the Grand Traverse Bay management unit, lake trout are recruited into sport and commercial fisheries by age 6. Female lake trout first spawn at age 3 and 50% or more are spawning by age 6. The total biomass of lake trout over age 3 was highest in 2006 at 1.2 million lb. The total biomass of lake trout has been declining since 2006 and was estimated at 694,130 lbs in 2011.



Total instantaneous mortality rates in 2011 (0.52 y^{-1}) are only slightly below target levels of 0.60 y^{-1} in Grand Traverse Bay. Additionally, the spawning stock biomass produced per recruit is below the target value. The model recommended harvest limit for 2012 in the Grand Traverse Bay management unit is 93,044 lb of which 41,870 lb was allocated to the state recreational fishery and 51,174 lb to the tribal commercial/subsistence fishery. The allocation among the parties is 45 percent state and 55 percent tribal. In August 2009 the Parties agreed to a stipulation to the 2000 Consent Decree which described how harvest limits would be set for MM-4 from 2007 until sea lamprey mortality is significantly below 1998 levels for 3 consecutive years, at which time the method of establishing the harvest limit will be reviewed by the Technical Fisheries Committee. This stipulation stated that the Tribal harvest limit will not be less than 94,300 lb, and the State harvest limit will be 77,200 lb. The harvest limits for each party can be higher, if the model results warrant a higher limit. In addition, if the State does not harvest their full harvest limit, then the difference between the limit and the actual harvest will be added to the Tribal harvest limit for the next year. Because State harvest in 2011 did not reach the limit of 77,200 lb, the actual Tribal harvest limit in 2012 was determined to be 94,300 lb plus the State's balance from 2011 (5,677 lb) for a total of 99,977 lb.



Model evaluation and changes – The 2012 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except ln-initial for ages 12-15. The P3 and P4 parameters were fixed for recreational fishery selectivity estimates. The P4 parameter was fixed for commercial fishery selectivity. The MCMC simulations yielded poor results. Residual patterns were reasonable, but harvest residuals did show some trending. The retrospective analysis of this year's model was poor indicating systematic temporal patterns in estimates of total biomass, spawning biomass, and abundance.

Catchability is now time varying for the commercial and recreational fisheries. Issues with model selectivity will continue to be addressed for next year.

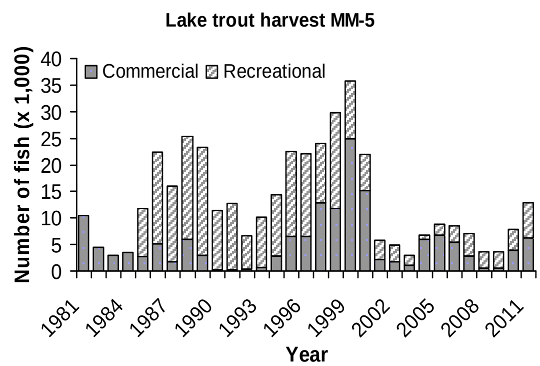
Summary Status MM-4 Lake Trout	**Value (95% probability interval)**
Female maturity	
Size at first spawning	2.67 lb
Age at first spawning	3 y
Size at 50% maturity	4.09 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.33 lb (0.93-1.79)
Current SSBR	0.15 lb (0.10-0.24)
SSBR at target mortality	0.18 lb (0.13-0.23)
Spawning potential reduction	
At target mortality	0.135 (0.121-0.151)
Average yield per recruit	0.146 lb (0.106-0.180)
Natural mortality (*M*)	0.176 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	6
Sport fishery (2009-2011)	6
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.171 y^{-1} (0.133-0.228)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.073 y^{-1} (0.059-0.088)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.101 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.524 y^{-1} (0.470-0.595)
Recruitment (age 4)	
(average 2002-2011)	64,494 fish (SE 8,527)
Biomass (age 3+)	
(average 2002-2011)	860,568 lb (805,769-931,799)
Spawning biomass	
(average 2002-2011)	140,330 lb (124,386-160,386)
MSC recommended yield limit in 2012	93,044 lb
Actual yield limit in 2012	177,177 lb

MM-5 (Leelanau Peninsula to Arcadia)

Prepared by Jory L. Jonas and Erik J. Olsen

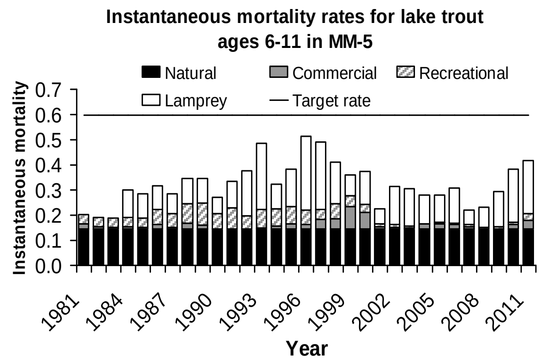
Lake trout management unit MM-5 is located in eastern central Lake Michigan and corresponds to the MM-5 statistical district. This area constitutes an area of high use by both Tribal and State interests. The unit covers 2,100 square miles and encompasses Michigan's waters of Lake Michigan from Arcadia north to the tip of the Leelanau Peninsula, extending to the state line bisecting the middle of the lake. There are two islands in this management unit, the North and South Manitou Islands. Some of the deepest waters and largest drop-offs in Lake Michigan occur in MM-5. Water depths range to 825 feet and for the most part are greater than 400 feet. Only 440 square miles (21%) of the unit are at depths less than 240 feet. The entire area is in 1836 Treaty waters and there are no refuges allocated within the management unit. Only a small amount of lake trout spawning habitat is located here, most of which is located in the near shore zone and around the North and South Manitou Islands.

The recruitment of harvestable lake trout in the MM-5 management unit of Lake Michigan is based entirely on stocking. The U.S. Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. The number of age-1 lake trout stocked into MM-5 over the past ten years has averaged 187,447 fish. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted for movement among the various regions in the lake. Over the last ten years (2002-2011) the recruitment to age one has averaged 280,089 fish in MM-5.



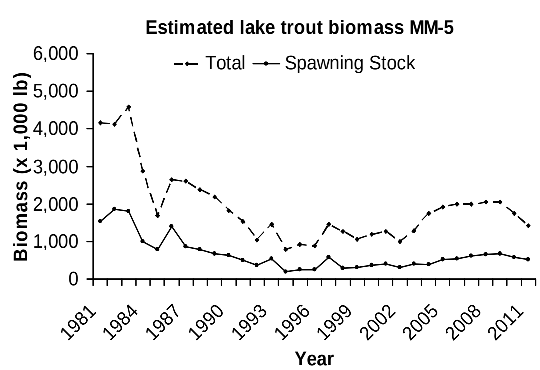
Although both State and Tribal commercial fishermen harvest fish in the management unit, state-licensed commercial fisheries are primarily trap-net operations targeting lake whitefish. State-licensed fishermen are not permitted to harvest lake trout, and as a result, are not included in lake trout harvest allocations. The Chippewa Ottawa Resource Authority oversees three types of tribal commercial fisheries in this area including large-mesh gill net, small-mesh gill net, and trap net. The 2000 Consent Decree resulted in the conversion of the regions largest gill-net fishers to trap-net operations. Commercial harvest and estimated mortality of lake trout have recently decreased. In 2009, commercial fishing mortality was a mere 0.002 y^{-1}. In 2010, mortality from commercial fishing was somewhat higher at 0.02 y^{-1} and in 2011 had increased yet again to 0.04 y^{-1}. The highest commercial mortality rates occurred in 1999 (0.09 y^{-1}) and the lowest occurred in 2008 and 2009 (0.002 y^{-1}). The commercial harvest of lake trout was highest in 1999 at 35,300 fish and was substantially lower in 2008 at 668 fish. In 2011, an estimated 9,550 fish were commercially harvested in MM-5. Large-mesh gill-net effort peaked at 2 million feet in 1999. After implementation of the 2000 Consent Decree, gill-net effort declined considerably. In 2008 and 2009, no commercial gill net was set in MM-5. In 2010 and 2011, large-mesh gill-net effort was between 120,000 and 135,000 feet each year.

Recreational fisheries for lake trout are primarily managed by the State of Michigan and include both charter and sport anglers. The fishing season for lake trout has been from May 1 - Sept 30 with a 3 fish bag limit. In 2006, regulations were changed to protect larger spawning lake trout. A maximum size limit was adopted where anglers were only allowed to keep fish less than 23.1" and one trophy fish greater than 34". In 2011 regulations were changed to a 20" minimum size limit and the season extended, with the beginning date moved from May 1 to January 1. In the MM-5 management unit from 1981 until 1998, recreational fishing mortality (averaged over ages 6-11) averaged 0.06 y^{-1} and exceeded the estimated mortality levels for commercial fishing. The highest recreational fishing mortality rate occurred in 1989 at 0.09 y^{-1} and the lowest was in 2004 at 0.002 y^{-1}. From 2003 to 2009 recreational fishing mortality rates have been extremely low, averaging 0.006 y^{-1}. In 2011 recreational mortality rates were higher at 0.03 y^{-1}. The number of lake trout harvested in recreational fisheries is up from 768 fish in 2004 to an estimated 6,500 fish in 2011. Recreational fishery yield increased from 3,800 lb in 2004 to 47,510 lb in 2011. Angling effort has been generally trending downward in the MM-5 management unit. Effort levels were highest in 1987 at 703,739 angler hours and had fallen to 137,400 angler hours in 2009. In 2011 the angler effort was estimated to be 170,100 hours.

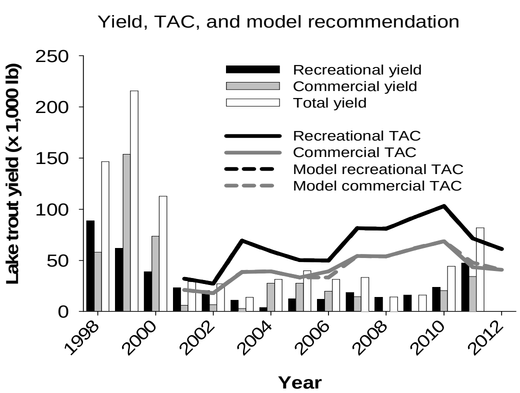


Estimates of lamprey mortality were relatively consistent from 2002 to 2006 averaging 0.13 y^{-1}. In 2007 and 2008 lamprey mortality appeared to have declined, averaging 0.07 y^{-1}. However, rates have increased substantially since and were 0.21 y^{-1} in 2010. Lampreys have killed more lake trout over the last 10 years than commercial and recreational fishing combined.

Fifty percent of lake trout are spawning by age 6 in MM-5. Lake trout fully recruit to recreational fisheries by age 5 and commercial fisheries by age 7. The biomass of lake trout older than age 3 increased from 1.0 million lb in 2002 to 2.0 million lb in 2009. In 2011, the biomass of lake trout was down to 1.4 million lb. The biomass of spawning age lake trout increased from 304,400 lb in 2002 to 668,000 lb in 2009. In 2011 the estimated spawning biomass was down to 508,500 lb.



The spawning stock biomass produced per recruit is above the target value. Instantaneous mortality rates (0.32 y^{-1}) in MM-5 are well below target levels (0.60 y^{-1}). The recommended yield limit for 2011 in unit MM-5 is 101,794 lb, and is based on a target total mortality rate of 45%. Of this yield, 61,054 lb was allocated to the state recreational fishery and 40,740 lb to the tribal commercial and subsistence fisheries. Allocations were based on a 60% allotment for the state of Michigan and 40% to tribal fisheries. In August 2009 the Parties agreed to a stipulation to the 2000 Consent Decree related to this unit. The stipulation established a floor for the Tribal harvest limit, and until sea lamprey mortality rates are significantly below 1998 levels for three consecutive years, the Tribal harvest limit cannot be less than 39,200 lb.



Model evaluation and changes – The 2012 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. The P1 and P3 parameters for commercial fishery selectivity were fixed and not estimated. The P3 and P4 parameters for recreational fishing selectivity vectors rf2, rf3, and rf4 were fixed and not estimated. The P3 and P4 parameters for survey selectivity were fixed and not estimated. Residual patterns were good for the survey, and not as good for the recreational and commercial harvest. The age residuals did show some trending. The MCMC simulations results were good and autocorrelation plots were close but not quite at zero. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, spawner biomass, or abundance. Catchability is now time varying for the commercial and recreational fisheries. Ongoing issues regarding selectivity will continue to be addressed in the coming years.

Summary Status MM-5 Lake Trout	Value (95% Probability Interval)
Female maturity	
Size at first spawning	2.89 lb
Age at first spawning	3 y
Size at 50% maturity	7.33 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.17 lb (1.54-2.94)
Current SSBR	0.54 lb (0.37-0.74)
SSBR at target mortality	0.29 lb (0.21-0.38)
Spawning potential reduction	
At target mortality	0.133 (0.120-0.146)
Average yield per recruit	0.068 lb (0.052-0.087)
Natural mortality (*M*)	0.145 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	7
Sport fishery (2009-2011)	5
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.018 y^{-1} (0.013-0.023)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.014 y^{-1} (0.011-0.018)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.142 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.319 y^{-1} (0.304-0.335)
Recruitment (age 4)	
(average 2002-2011)	66,001 fish (SE 7,658)
Biomass (age 4+)	
(average 2002-2011)	1,740,382 lb (1,585,820-1,904,010)
Spawning biomass	
(average 2002-2011)	524,917 lb (465,849-587,636)
MSC recommended yield limit in 2012	101,794 lb
Actual yield limit in 2012	101,794 lb

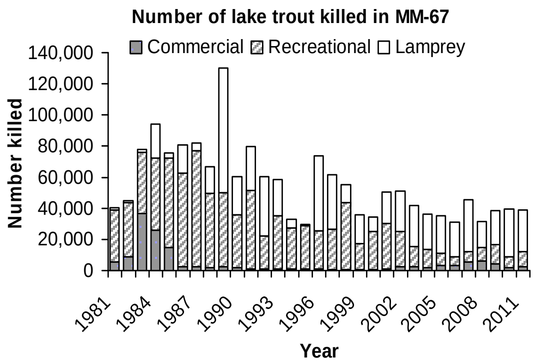
MM-67 (Southern Treaty Waters)

Prepared by Jory L. Jonas

Lake trout management unit MM-67 is located in eastern central Lake Michigan, and is made up of statistical districts MM-6 and MM-7. The area covers Michigan's waters of Lake Michigan from Arcadia to Holland, extending to the state line bisecting the middle of the lake. The management unit covers a total area of 4,460 square miles, of which 930 square miles are less than 240 feet in depth. The northern section of the region (MM-6) is deeper ranging in depth from 0 up to 900 feet and is characterized by greater slope than the southern section (MM-7). For the most part, water depths in MM-7 are less than 400 feet. There are no islands or structures in southern treaty waters, and there is little lake trout spawning habitat with the exception of offshore deepwater spawning reefs located within the mid-lake refuge. Stocked lake trout almost certainly attempt to spawn in the nearshore zones. However, the likelihood of successful recruitment is negligible. The southern treaty management unit is not entirely comprised of 1836 waters', the northern section (MM-6) is entirely treaty ceded territory while only the northern two-thirds of the southern section (MM-7) is within treaty territory. A total of 690 square miles in the unit are outside treaty waters. A line running parallel to the northern side of the Grand River (located approximately ¾ of the way through grids in the 1900 series) out to the state line in the middle of the lake delineates the southern boundary of treaty territories in the unit. Management unit MM-67 contains a portion of the deepwater mid-lake lake trout refuge, which comprises 850 square miles of the unit (grids 1606, 1607, 1706, 1707, 1806, 1807, 1906 and 1907). It is illegal for recreational, commercial and subsistence fishers to retain lake trout when fishing in the refuge area. Gill-net fishing (both commercial and subsistence) is prohibited in the refuge, State- and Tribal-licensed commercial trap-net operations are permitted to fish in the refuge; however, the retention of lake trout is prohibited.

The recruitment of lake trout in the southern treaty waters of Lake Michigan is based entirely on stocking. During the past ten years, an average of 162,333 yearling lake trout have been stocked into non-refuge southern treaty waters, while an additional 395,954 fish were stocked into the mid-lake refuge area, much of which is in Wisconsin waters. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for movement among the various regions in the lake. Over the last 10 years (2002-2011), the recruitment of age-1 lake trout has averaged 353,972 fish in the southern treaty management unit of Lake Michigan.

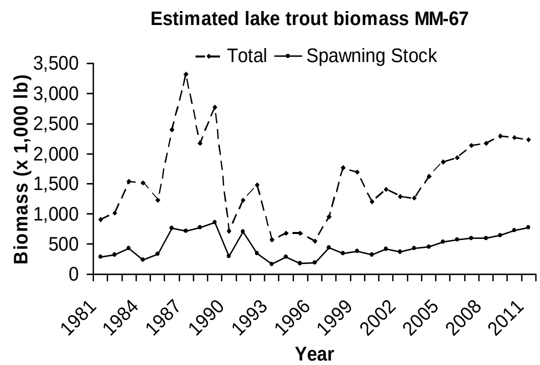
In 2011, the State's commercial fishery in southern treaty waters of Lake Michigan was comprised of two trap-net operations and one small-mesh gill-net chub operation. The 2011 Tribal commercial fishery within this area consisted of five permitted trap net, and five permitted small-mesh gill-net operations. State and tribal commercial fisheries primarily target lake whitefish and chubs, tribal trap-net operations are allowed 100 lb per day lake trout bycatch and state-licensed operations are not permitted to harvest lake trout. As a result, state commercial fishermen are not included in lake trout harvest allocations. The yield of lake trout in commercial fisheries is extremely low and has averaged 18,067 lb over the last 5 years (2007-2011). In 2011 the yield of lake trout was 12,399 lb.



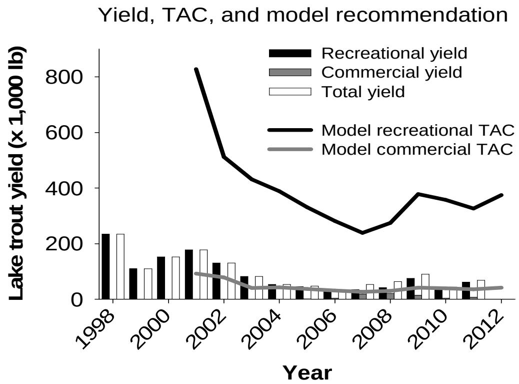
State recreational fisheries for lake trout are comprised of both charter and sport anglers. Size and bag limits did not change from 1981 until 2003. The fishing season had changed twice, once in 1984, in which it was restricted from the entire year to May 1 through August 15th, and again in 1989, when the season was extended through Labor Day. In 2003, the bag limit was increased from 2 to 3 fish, the size limit increased to 20 inches and the season expanded from May 1 to Sept 30. In 2011 the season was extended from January 1 through October 31. The harvest of lake trout has declined substantially in the MM-67 management unit, from 74,500 fish in 1987 to an estimated 9,442 fish in 2011. Recreational fishing mortality rates have also declined substantially, from 0.23 y^{-1} in 1998 to 0.03 y^{-1} in 2011. The average yield of lake trout from 2002-2011 was 58,566 lb and in 2011 was 57,165 lb.

Sea lamprey-induced mortality is lower in southern treaty waters of Lake Michigan relative to the northern management units. In recent years lamprey mortality rates had declined from 0.11 y^{-1} in 2007 to 0.05 y^{-1} in 2008. Lamprey mortality rates have since increased and were 0.09 y^{-1} in 2010. Despite the low mortality rates, lamprey have continued to kill more fish than other sources of mortality for the unit. During the last 9 yrs lamprey have killed an average of 25,039 fish y^{-1}.

The majority of lake trout in MM-67 are spawning by age 6, have recruited into recreational fisheries by age 7 and commercial fisheries by age 6. The biomass of lake trout age 3 and older is high, and reached 2.2 million lb in 2011. Spawning lake trout comprise a relatively high proportion of the total biomass in this unit, at over 781,720 lb in 2011.



The spawning stock biomass produced per recruit is substantially greater than the target value indicating that spawning stocks are doing well in this unit. Mortality rates in 2011 (0.29 y^{-1}) are well below target levels (0.51 y^{-1}). The model recommended yield limit for MM-67 in 2011 was 438,715 lb and was accepted by the parties. The state recreational fishery is allocated 90 percent (394,844 lb) and the tribal fishery 10 percent (43,871 lb). Both recreational and commercial fisheries are well below established harvest limits.



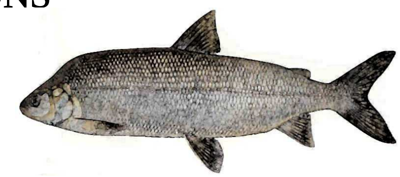
Model adjustments and changes – The 2012 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. The P2, P3 and P4 parameters were fixed and not estimated for commercial fishery selectivity. The P2 parameter was fixed and not estimated for survey selectivity. The MCMC simulations yielded reasonable results. Residual patterns were reasonable. There was some trending in the harvest and age residuals. The retrospective analyses of this year's model indicate that we may need to address time varying parameters to improve performance.

Attempts were made, without success, to incorporate time-varying catchability into this model run. As a result, the structure reverted back to constant catchability. This along with the ongoing selectivity issues will be addressed in the coming years.

Summary Status MM-67 Lake Trout	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.55 lb
Age at first spawning	3 y
Size at 50% maturity	5.92 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.26 lb (1.55-3.12)
Current SSBR	1.09 lb (0.75-1.51)
SSBR at target mortality	0.40 lb (0.29-0.54)
Spawning potential reduction	
At target mortality	0.179 (0.159-0.200)
Average yield per recruit	0.083 lb (0.060-0.110)
Natural mortality (*M*)	0.171 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2009-2011)	6
Sport fishery (2009-2011)	7
Commercial fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.005 y^{-1} (0.003-0.007)
Sport fishing mortality (*F*)	
(average 2009-2011, ages 6-11)	0.033 y^{-1} (0.027-0.039)
Sea lamprey mortality (ML)	
(average ages 6-11, 2008-2010)	0.076 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2009-2011)	0.274 y^{-1} (0.256-0.292)
Recruitment (age 4)	
(average 2002-2011)	94,976 fish (SE 8,326)
Biomass (age 3+)	
(average 2002-2011)	1,945,313 lb (1,688,330-2,228,980)
Spawning biomass	
(average 2002-2011)	582,985 lb (485,365-696,114)
MSC recommended yield limit in 2012	438,715 lb
Actual yield limit in 2012	438,715 lb

STATUS OF LAKE WHITEFISH POPULATIONS

Lake Superior

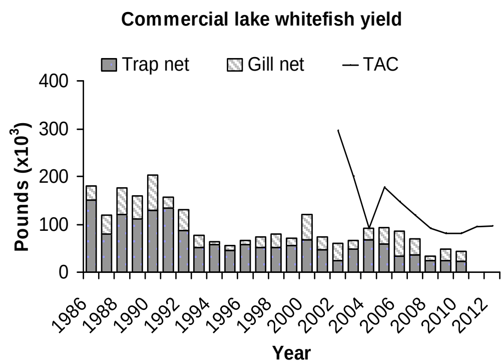


WFS-04 (Marquette - Big Bay)

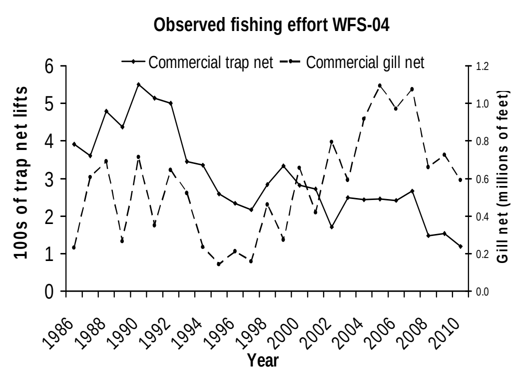
Prepared by Philip J. Schneeberger

Lake whitefish unit WFS-04 (1,201,498 surface acres) is located in Lake Superior near Marquette roughly between Big Bay and Laughing Fish Point. Near shoreline features of this zone include many points, bays, islands, and in-flowing rivers. Habitat suitable for lake whitefish growth and reproduction is associated with many of these features. This unit holds waters both within and outside the 1836 Treaty area. Based partly on the number of statistical grids on either side of the treaty line and partly on established protocol for a similar situation with lake trout, 70% of WFS-04 is considered to be in 1836 waters. Therefore, a quota for WFS-04 is calculated for the modeled stock which includes lake whitefish from the entire unit, and this quota is then multiplied by 0.70 (70%) to determine the yield limit in 1836 Treaty waters for the Consent Decree. (Note: this procedure was adopted and used starting with the issuance of the 2006 yield limit.)

The 2010 total yield in WFS-04 was 43,918 lb, with 22,031 lb taken by trap nets and 21,887 lb by gill nets. Yield from both gear types was down from 2009 and overall yield decreased 9% in 2010. In 1836 waters of WFS-04, 2010 lake whitefish yield (all from trap nets) was only 510 lb, or 1.2 % of the overall yield from the entire management unit.



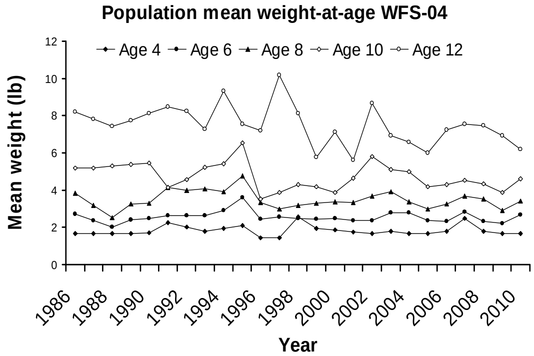
There was also a decrease in effort for both gear types between 2009 and 2010. Gill-net effort declined 18% from 0.72 to 0.59 million feet and trap-net effort was down 23% from 153 to 118 lifts during the annual fishing season. Only four trap-net lifts (3.4% of the total trap-net effort) occurred in 1836 Treaty waters of WFS-04.



Catch per unit effort (CPUE) increased 9% for gill nets and 21% for the trap-net fishery in 2010. Values for both gear types were still below long-term averages for the time series.

For lake whitefish aged 4-12+, overall mean weight-at-age increased

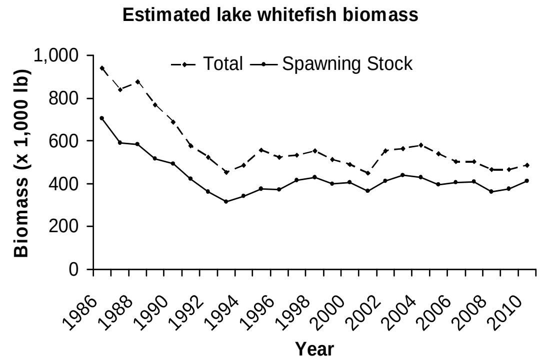
9.3% between 2009 and 2010. Fish between 6 and 10 years of age accounted for the gain.



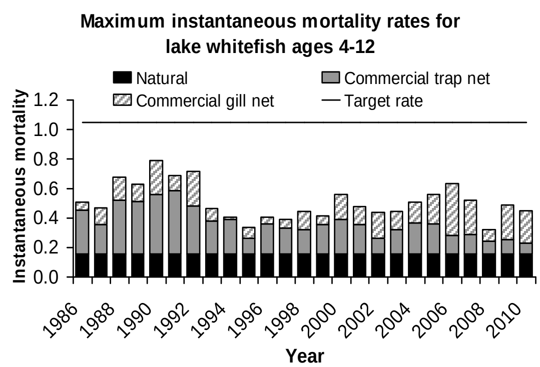
For the current model, von Bertalanffy growth parameters were calculated using length-at-age data from all fish caught in trap nets (1986-2010), with L∞ fixed at 750 mm. The resulting estimate for k was 0.139.

Recruitment (number of age-4 lake whitefish from the 2006 year class) was estimated at 47,000 fish in 2010. This estimate was slightly lower than the estimate for 2009.

The current model estimated fishable biomass at 488,000 lb and spawning stock biomass at 414,000 lb in 2010. Biomass estimates have remained relatively stable since the mid-1990s. The 2010 ratio of spawning stock biomass to fishable biomass was 0.85, which was higher than the average for the time series.



Based on outputs from the current model, total instantaneous mortality rate (*Z*) for the WFS-04 lake whitefish stock ranged between 0.25 and 0.44 y^{-1} from 1993 through 2009. The 2010 estimate for *Z* was 0.30 y^{-1}, down 9% from the value estimated for 2009 and well below the target maximum rate. Estimated instantaneous fishing mortality rates (*F*) were 0.09 y^{-1} for gill nets and 0.05 y^{-1} for trap nets in 2010. The instantaneous natural mortality rate was estimated to be 0.16 y^{-1}.



The 2012 yield limit calculated for lake whitefish in the entire WFS-04 management unit was 137,000 lb, nearly identical to the limit calculated for 2011. After applying the prescribed reduction to reflect the proportion of this management unit that is outside of 1836 Treaty waters, the 2012 yield limit for lake whitefish within the Consent Decree governed waters is 96,000 lb, up 1,000 lb from the 2011 yield limit.

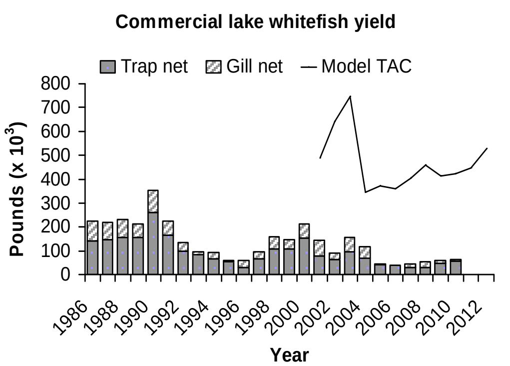
Summary Status WFS-04 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.83 lb
Age at first spawning	4 y
Size at 50% maturity	2.26 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	10.81 lb (10.78 - 10.84)
Current SSBR	4.78 lb (4.52 - 5.04)
SSBR at target mortality	0.295 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.442 (0.418 - 0.466)
Average yield per recruit	1.65 lb (1.60 - 1.70)
Natural mortality (*M*)	0.158 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	11
Fully selected age to trap nets	10
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.076 y^{-1} (0.067 - 0.086)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.060 y^{-1} (0.054 - 0.067)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.294 y^{-1} (0.280 - 0.310)
Recruitment (age 4)	
(average 2001-2010)	49,630 fish (44,460 – 55,860)
Biomass (age 3+)	
(average 2001-2010)	515,600 lb (478,000 – 556,600)
Spawning biomass	
(average 2001-2010)	406,500 lb (376,700 – 439,300)
MSC recommended yield limit for 2012	96,000 lb
Actual yield limit for 2012	96,000 lb

WFS-05 (Munising)

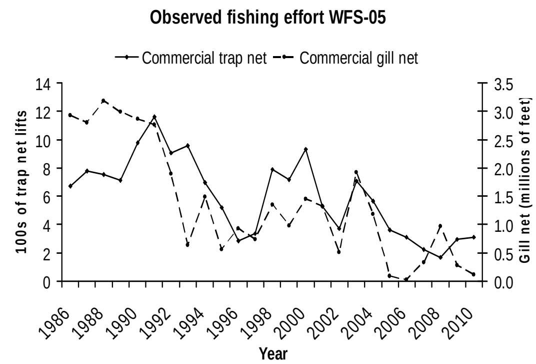
Prepared by Philip J. Schneeberger

The WFS-05 lake whitefish management unit extends approximately from Laughing Point to Au Sable Point in Michigan waters of Lake Superior. Surface area of the unit is 1,845,495 acres. Several bays (Shelter Bay, Au Train Bay, South Bay, and Trout Bay) and islands (Au Train Island, Wood Island, Williams Island, and Grand Island) are prominent in this area, providing substrate and depth contours suitable for lake whitefish habitat and spawning. Different whitefish stocks exist within this unit, including a smaller, slower-growing stock identified in Munising (South) Bay.

Lake whitefish yield in WFS-05 was 62,194 lb in 2010, about 2% higher than in 2009. Yields declined between 2000 and 2006 but have trended higher each year since then. Trap nets accounted for an average of 70% of the total yield during 1986-2009; in 2010 the percentage was 92%. Trap-net yield was 56,974 lb and gill-net yield was 5,220 lb in 2010.

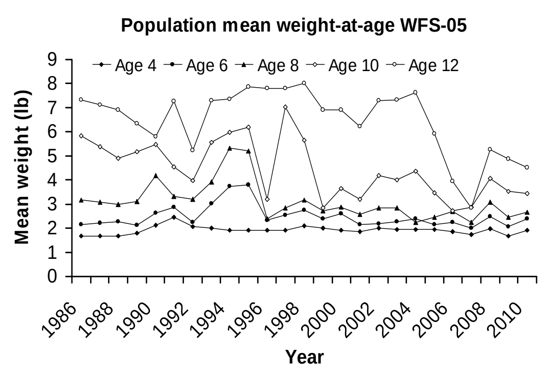


Trap-net effort increased 5% from 297 lifts in 2009 to 313 lifts in 2010. Gill-net effort, however, decreased by 52% from 0.23 million ft in 2009 to 0.11 million ft in 2010. Trap-net effort in 2010 remained well below the long-term average and gill-net effort was the third lowest value in the WFS-05 time series.



Trap-net catch per unit effort (CPUE) increased to 182 lb lift^{-1} in 2010, the highest value since 1997. Gill-net CPUE decreased from the previous year to 48 lb per thousand feet of net, but was still above average for the long-term time series.

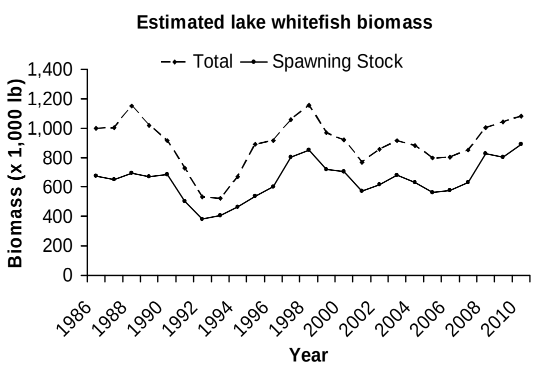
Weight at age increased 7% overall compared to 2009 for fish aged 4-12+. Younger fish showed the biggest gains whereas older fish remained relatively stable or declined slightly.



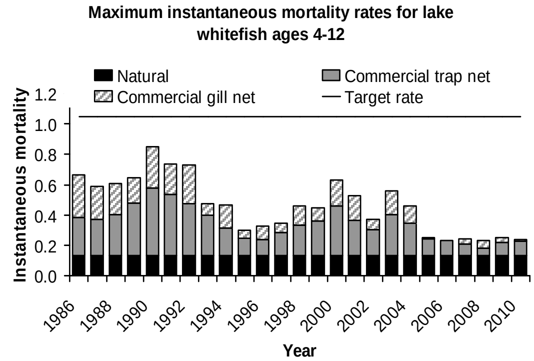
Length-at-age data from individual fish in the entire data set were used to calculate growth with L∞ fixed at 750 mm. The computed von Bertalanffy k value was 0.107.

Estimated recruitment has been relatively stable since 2003. The 2010 estimate of recruitment, reported as the number of age-4 lake whitefish in the population (2006 year class), was 93,000 fish.

Biomass estimates in 2010 were 1.08 million lb for the fishable stock (lake whitefish age-4 and older) and 892,000 lb for the spawning stock. Biomass estimates have generally trended upwards over the past decade. The 2010 ratio of spawning stock biomass to fishable biomass was 0.82, which was above average compared to previous years in the data series.



Estimates for total instantaneous mortality rate (Z) have remained consistently below 0.45 y^{-1} during most of the time series. The 2010 estimate for Z was 0.209 y^{-1}. Natural mortality rate (M), was estimated at 0.133 y^{-1}, which was 64% of the total mortality estimate. Instantaneous fishing mortality rate (F) was 0.006 for gill nets and 0.070 y^{-1} for trap nets for 2010.



The WFS-05 yield limit calculated for 2012 was 528,000 lb, representing a 29% increase from 2011.

Summary Status WFS-05 Whitefish	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	2.19 lb
Age at first spawning	4 y
Size at 50% maturity	2.59 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	10.06 lb (10.03 – 10.09)
Current SSBR	5.321 lb (4.951 - 5.703)
SSBR at target mortality	0.2532 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.529 (0.492 - 0.567)
Average yield per recruit	1.074 lb (0.995 - 1.148)
Natural mortality (*M*)	$0.133y^{-1}$
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	7
Fully selected age to trap nets	11
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.0160 y^{-1} (0.0139 - 0.0182)
Trap net fishing mortality (*F*)	
Average 2008-2010 , ages 4+	0.057 y^{-1} (0.049 - 0.066)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.206 y^{-1} (0.197 - 0.217)
Recruitment (age 4)	
(average 2001-2010)	87,630 fish (77,340 – 100,200)
Biomass (age 3+)	
(average 2001-2010)	902,800 lb (808,600 – 1,011,000)
Spawning biomass	
(average 2001-2010)	682,100 lb (607,700 – 767,700)
MSC recommended yield limit for 2012	528,000 lb
Actual yield limit for 2012	528,000 lb

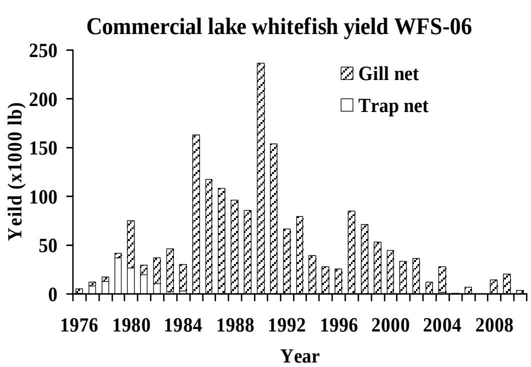
WFS-06 (Grand Marais)

Prepared by Mark P. Ebener

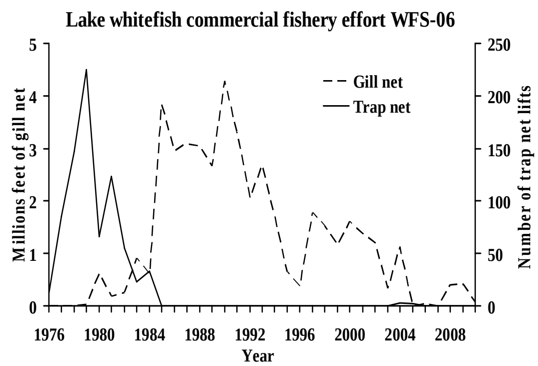
The Grand Marais stock of lake whitefish is probably one of the smallest in the 1836 ceded waters, certainly the smallest in terms of harvest levels in Lake Superior waters. There are typically only small aggregations of spawning lake whitefish in WFS-06 based on anecdotal information from commercial fishers that have regularly fished WFS-06 throughout the year.

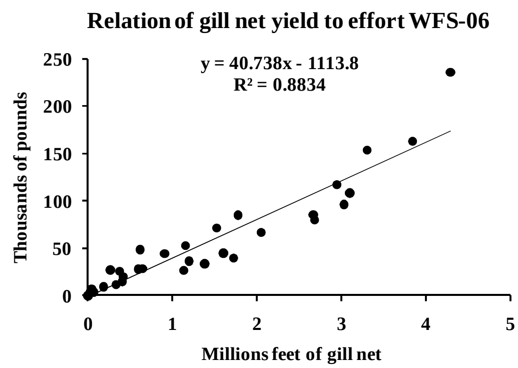
Commercial yields from WFS-06 have averaged only 59,400 lb during 1981-2010. Annual harvests ranged from a low of only 682 lb in 2005 to a peak of 236,000 lb in 1990. Since 1990 annual yield has declined continually and was only 3,600 lb in 2010. The 2010 harvest was the third lowest during 1981-2010.

The large-mesh gill-net fishery has accounted for the vast majority of commercial fishery harvests from WFS-06 through the years. There was a small trap-net fishery in WFS-06 from 1976-1985, but since 1985 the trap-net fishery has reported harvesting lake whitefish only in 2004 and 2005 and the combined harvest for these two years was less than 1,900 lb.

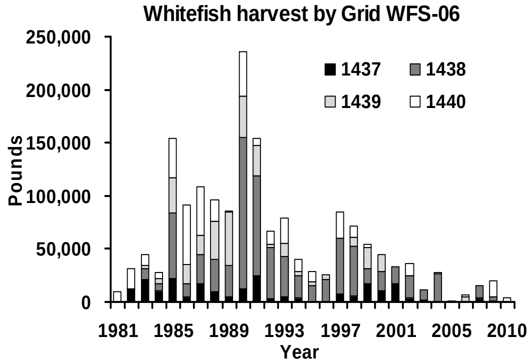


The decline is fishery yield since 1990 is directly related to declines in large-mesh gill-net effort in WFS-06. Gill-net effort increased from 31,000 ft in 1983 to 4.3 million in 1990, then declined to zero in 2005. Large-mesh gill-net effort was only 72,000 ft. in 2010. Large-mesh gill-net effort explained 88% of the variation in gill-net yield from WFS-06 during 1976-2010.





There has been a shift in the spatial distribution of lake whitefish yields from within WFS-06 through the years, with most of the recent harvests coming from eastern areas of the unit. During 1981 and 1982 most (61-100%) of the lake whitefish yield was taken from the eastern area in grid 1440 based on fishing effort put forth from the Little Lake Harbor landing site on the border of WFS-06 and WFS-07. During 1983-2004 most (67-100%) of the lake whitefish yield was taken from the central portion of the unit in grids 1438 and 1439 based on fishing effort put forth from the Grand Marais landing site. In 2009 and 2010 nearly all (77-100%) of the lake whitefish yield again came from grid 1440. Thus most the recent yields were taken from the fringes of WFS-06 and not from the central portion of the unit.



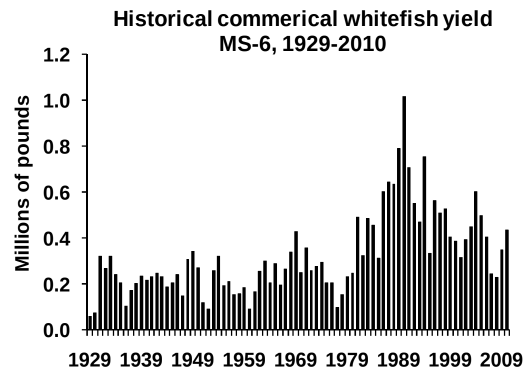
A stock assessment model has not been developed for lake whitefish in WFS-06 since 2004 primarily because there has been little fishing effort in the unit and because no biological data have been collected from there since 2004. The harvest regulating guideline for WFS-06 was set at 210,000 lb based on the 2004 stock assessment model and has remained there ever since.

WFS-07 (Tahquamenon Bay)

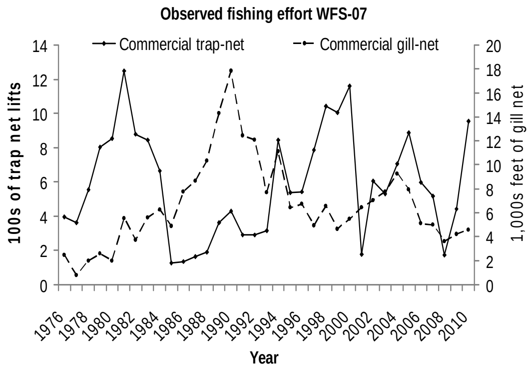
Prepared by Mark P. Ebener

Lake whitefish in WFS-07 spawn primarily in Tahquamenon Bay which is the southwestern portion of U.S. waters of Whitefish Bay, Lake Superior near Naomikong Point (see Tanner 1987 map 24). After spawning lake whitefish disperse north towards Whitefish Point and west from Whitefish Point into the main basin of Lake Superior. Some portion of the adult stock stays within U.S. waters of Whitefish Bay, and another portion disperses east into Ontario waters. Larval lake whitefish can be found in large aggregations along sandy shorelines in very shallow water of southern Whitefish Bay adjacent to the spawning grounds during May through June.

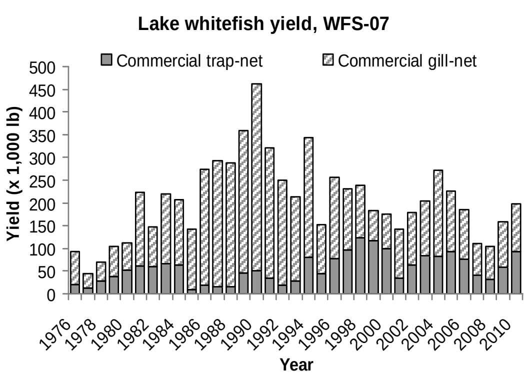
Whitefish Bay has been important fishing grounds for lake whitefish for centuries. Native Americans regularly fished spawning aggregations of lake whitefish during the fall in the Tahquamenon Bay area, and European settlers established substantial commercial fisheries for the species during the late 1700s and early 1800s (see Kinietz 1965, Cleland 1982, Tanner 1987). Commercial fishery yield from U.S. waters of Whitefish Bay (district MS-6), which includes both WFS-07 and WFS-08, has been remarkably stable over time averaging 324,000 lb during 1929-2010. Peak yield of 1.0 million lb occurred in 1990, but has declined regularly since then to slightly above (333,000 lb) the long-term average during 2006-2010.



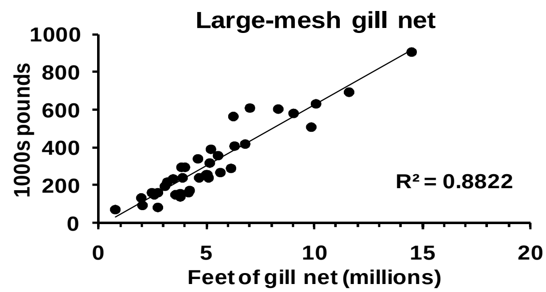
There have been substantial changes in fishing effort in WFS-07 since 1976. Annual trap-net effort has varied between 128 and 1,248 lifts and has generally been increasing since 1985. Trap-net fisheries have moved in and out of WFS-07 freely since the 1985 and 2000 Consent Decrees in response to changing fishing conditions in lakes Huron and Michigan, fuel costs, and opening of fishing grounds in WFH-05. Typically, 2-3 trap-net fisheries operate in WFS-07, but since 2009 the number of fishers has increased to 5-7. Gill-net effort peaked at 17.8 million feet in 1990 and has generally been declining since. As the number of trap-net operations have increased in WFS-07, they have squeezed out small-boat gill net fisheries, and as economic condition have improved in the surrounding area, the number of small-boat gill net fisheries have declined. Declining economic condition typically produced increases in gill-net fishing effort in WFS-07. Fishing effort in 2010 was 956 trap-net lifts and 4.7 million feet of gill net.

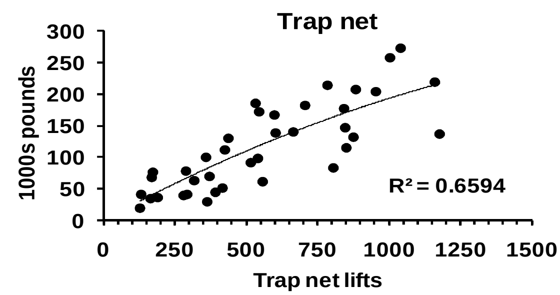


Although trap-net effort has been increasing the gill-net fishery has accounted for most of the lake whitefish harvest since 1976. The gill-net fishery has accounted for 73% of the lake whitefish yield from WFS-07 during 1976-2010, ranging from a low of 69,000 lb in 1977 to a high of 906,000 lb in 1990, and averaging 330,000 lb. The trap-net fishery yield ranged from 28,000 lb in 1977 to 272,000 lb in 1998, and averaged 122,000 lb during 1976-2010. In 2010 the trap-net fishery harvested 204,000 lb and the gill-net fishery 232,000 lb of lake whitefish from WFS-07.

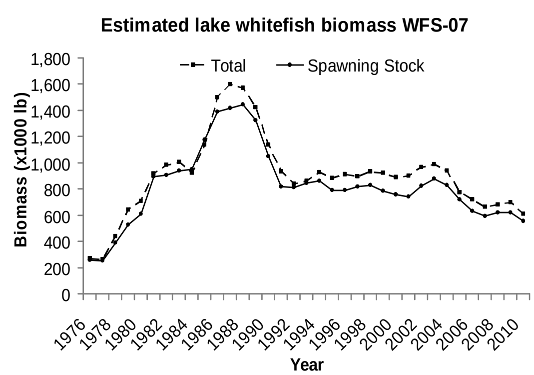


There was a highly significant positive relationship between fishing effort and harvest of lake whitefish from WFS-07. Large-mesh gill-net effort explained 88% of the variation in the gill-net harvest from WFS-07 during 1973-2010, i.e. the harvest in gill nets is strictly a function of gill-net effort. Conversely, trap-net effort explained only 66% of the variation in the trap net harvest from WFS-07 during 1973-2010. A second-order polynomial provided a little better fit to the data (R^2=66%) than a linear model (R^2=64%). The amount of habitat for setting trap nets is limited in WFS-07, thus it appears that gear competition may limit trap-net catch rates and harvest in WFS-07.



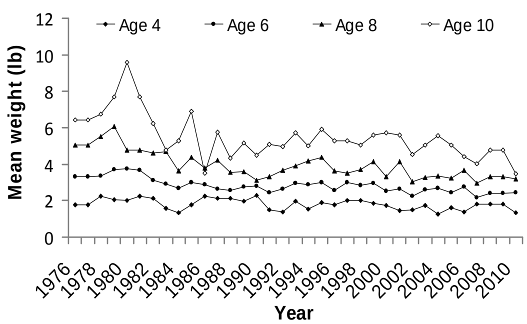


Estimated biomass of lake whitefish in WFS-07 has been on a long-term decline since 1988. Fishable biomass of age-4 and older lake whitefish peaked at 3.5 million lb in 1988 and since then has declined by 63,000 lb per year through 2010. In 2010 fishable biomass was estimated to be 1.34 million lb and spawning biomass was estimated to be 1.21 million lb. Biomass levels in 2010 were higher only than values observed during 1976-1978.



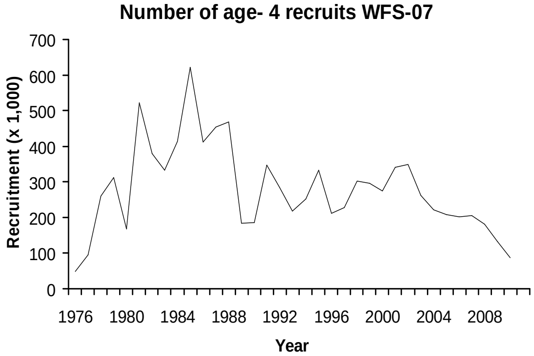
Growth of lake whitefish has remained relatively stable in WFS-07 in comparison to growth in lakes Huron and Michigan, but growth is declining in WFS-07. Growth, expressed as mean weight at age, has declined across most age classes in WFS-07 from 1976 to 2010 with the largest declines occurring for the older fish. In the 1970s, ages 8-10 year old lake whitefish commonly averaged 5 to 9 lb, but by 2010 these same age classes averaged only 3 to 4 lb. The rate of decline in mean weight at age was estimated to be 0.013 lb y^{-1} for age-4, 0.029 lb y^{-1} for age-6, 0.057 lb y^{-1} for age-8, and 0.072 lb y^{-1} for age-10 lake whitefish from 1976 to 2010.

Population mean weight-at-age WFS-07



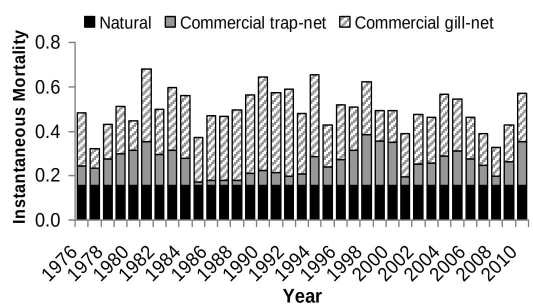
The observed changes in biomass and commercial yields were largely driven by changes in reproduction and recruitment of lake whitefish to the fishable population in WFS-07 during 1976-2010. The number of age-4 lake whitefish recruiting to the fishery increased nearly ten-fold from 48,000 fish in 1976 to 470,000 fish in 1988. Thereafter recruitment declined and remained stable averaging 280,000 fish during 1989-2008. Recruitment in 2009 and 2010 was estimated to be low at 132,000 and 86,000 fish, respectively.

Number of age- 4 recruits WFS-07



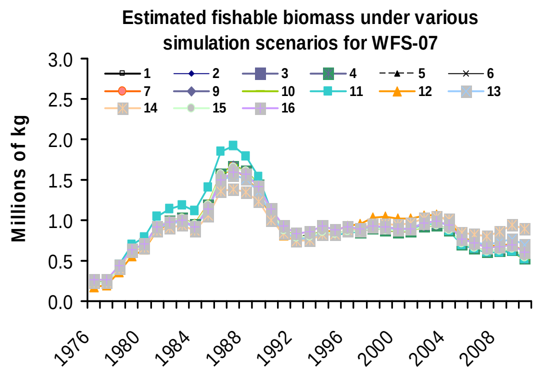
Total annual mortality of lake whitefish in WFS-07 has remained remarkably stable during 1976-2010 despite annual changes in fishing effort and allocation of that effort among gill nets and trap nets. Average annual instantaneous total mortality rate ranged from 0.32 y^{-1} to 0.68 y^{-1} and averaged 0.50 y^{-1} during 1976-2010. There was no observable trend in total annual mortality rate during 1976-2010. The allocation of fishing mortality between trap nets and gill nets did change substantially in WFS-07 though. Trap net-induced mortality varied 9.5 fold during 1976-2010 from 0.02 y^{-1} during 1985-1988 to 0.23 y^{-1} in 1998. Gill net-induced mortality varied 4.6 fold in WFS-07 during 1976-2010 ranging from 0.09 y^{-1} to 0.42 y^{-1}. Fishing mortality rates in 2010 were estimated to be 0.20 y^{-1} for trap nets and 0.22 y^{-1} for gill nets.

Average instantaneous mortality rates for lake whitefish ages 4-11 in WFS-07



The 2012 stock assessment for WFS-07 was updated from the 2010 and 2011 assessments by: (1) directly estimating the standard deviations for fishing catch and effort and the stock-recruitment relationship, and (2) not estimating abundance of the plus age group in the first year (1976). One of the most significant changes made to the WFS-07 stock assessment was to directly estimate standard deviations for fishing catch and effort and the stock-recruitment relationship (rhoSR). This was done by providing prior estimates of the ratios of the standard deviations between catch and fishing effort for each gear and for the stock-recruitment relationship and having ADMB determine the best estimate for the standard deviation of each parameter.

The stock assessment model for WFS-07 was relatively stable although the maximum gradient component was not achieved. Regardless of the starting values used the model arrived at the same estimates of fishable biomass for each year from 1976-2010. Even when starting values were changed for rhoSR the resulting estimates of fishable biomass did not deviate far from predicted values for other simulations.



The WFS-07 stock assessment model also produced reasonable retrospective patterns although there was some deviation in estimates of biomass, population size, and recruitment in the last five years of the simulations. Sizable deviations of -7 to -27% in estimated biomass were evident in the retrospective analysis between the full model and the model that used data only through 2006. Population size for the model with data through 2006 was 5 to 34% lower than the full model, and recruitment was 8 to 54% lower through 2006 than the full model.

Because total annual mortality on the most fully vulnerable age class was less than 1.05 y^{-1} and the spawning potential reduction was greater than 0.20, the stock assessment model projected an increase of 1.70 in the average fishing mortality rate. Because biomass has been declining, the increase in allowable fishing mortality did not translate into a higher total allowable catch in 2012 than in 2011. The estimated total allowable catch for 2012 was 420,200 lb compared to 871,500 lb in 2011.

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Summary Status WFS-07 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.38 lb
Age at first spawning	4 y
Size at 50% maturity	2.07 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	8.88 lb (0.0014 SE)
Current SSBR	1.54 lb (0.17 SE)
SSBR at target mortality	0.24 (0.00 SE)
Spawning potential reduction	
At target mortality	0.026
Average yield per recruit	1.64 lb (0.016 SE)
Natural mortality (*M*)	0.156 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	7
Fully selected age to trap nets	6
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.171 y^{-1} (0.020 SE)
Trap net fishing mortality (*F*)	
Average 2008-2010 , ages 4+	0.115 y^{-1} (0.014)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.442 y^{-1} (0.03 SE)
Recruitment (age 4)	
(average 2001-2010)	302,689 fish (2,280 SE)
Biomass (age 3+)	
(average 2001-2010)	793,632 lb (44,758 SE)
Spawning biomass	
(average 2001-2010)	700,180 lb (36,065 SE)
MSC recommended yield limit for 2012	420,200 lb
Actual yield limit for 2012	420,200 lb

WFS-08 (Brimley)

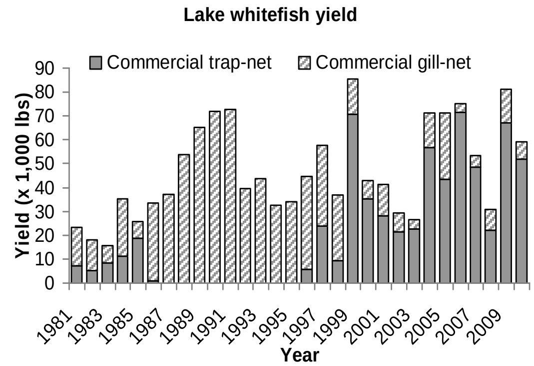
Prepared by Paul Ripple

WFS-08 is located in the southeast portion of Whitefish Bay, Lake Superior. WFS-08 is spatially the smallest of the management units in the 1836 ceded waters of Lake Superior, and it contains 160,000 surface acres of water less than 240 ft deep. A substantial commercial fishery targeting whitefish also exists in adjacent Canadian management units 33 and 34.

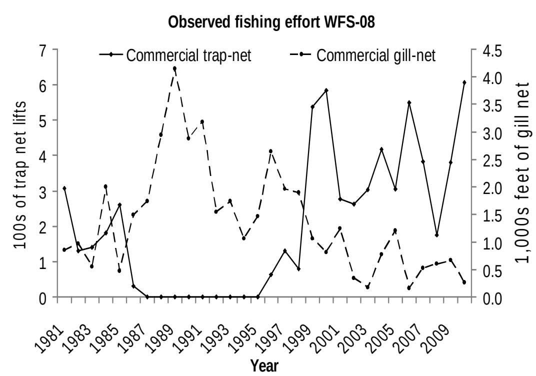
It is thought that four reproductively isolated stocks of whitefish contribute to the commercial fishery in WFS-08. There are two spawning areas in WFS-08, a probable contributing spawning population in Canadian waters of management unit 34 as well as contributions from spawning fish in WFS-07 directly west of WFS-08.

WFS-08 supports a traditional ice and small boat commercial gill-net fishery as well as a commercial trap-net fishery and a sport fishery for whitefish. There is one developed public landing and one private landing as well as multiple undeveloped landing sites.

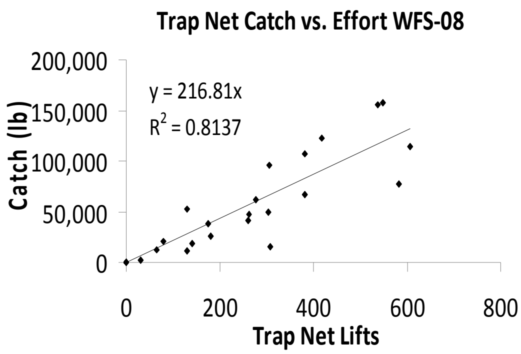
The commercial yield of whitefish from WFS-08 averaged 100,150 lb from 1981 to 2010. Annual yields from this period ranged from 35,000 lb in 1983 to 188,000 lb in 1999. Peak yield in this unit was 195,000 lb in 1979, just prior to the creation of COTFMA. The large-mesh gill-net fishery accounted for most of the commercial gill-net yield from 1981 to 1999. Since 2000 trap nets have dominated commercial yield.

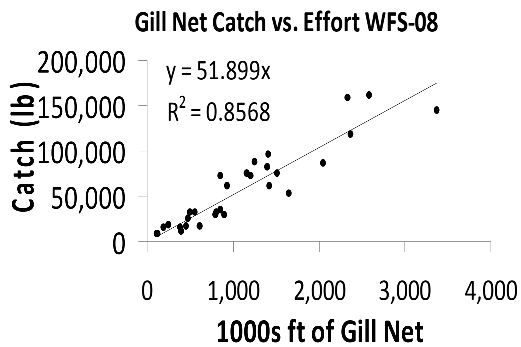


Gill-net effort has been declining in WFS-08 while trap-net effort has increased tremendously. From 1981 to 2010 gill-net effort ranged from a high of 3.4 million feet in 1989 to a low of 120,000 feet in 2006. In 2010 gill-net effort was 200,000 feet. Trap-net effort peaked at 738 lifts in 1979, declined to zero from 1987 to 1995 and has generally increased since then. There were 607 trap-net lifts in 2010.

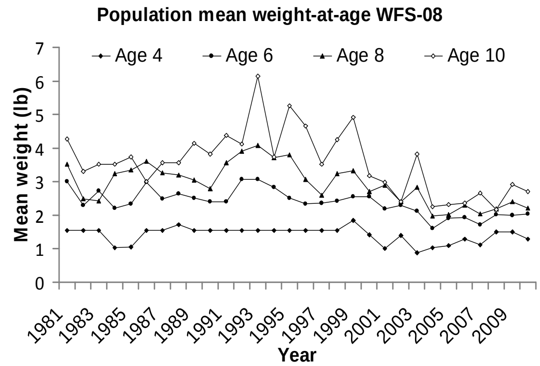


Gill-net and trap-net harvests were directly related to their respective fishing efforts. Effort explained 86% of the variation in gill-net harvest and 81% of the variation in trap-net harvest in WFS-08 from 1981 to 2010. Average gill-net CPUE was 53 lb 1000 ft^{-1} and average trap net CPUE was 202 lb $lift^{-1}$ from 1981-2010.



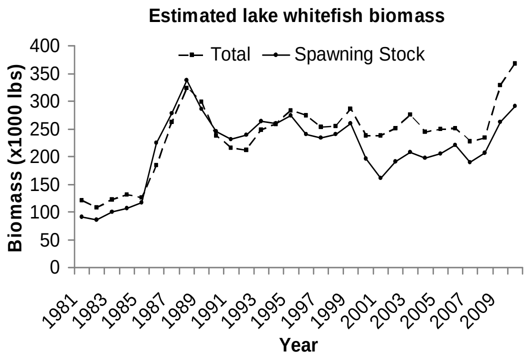


While growth of whitefish in WFS-08 appears to have remained fairly stable during 1981 to 2010, there has been a slow long-term decline in mean weight at age of most age classes. Mean weight-at-age generally declined slowly during 1981 to 2004 and has since stabilized or increased slightly in the last few years. Overall, during 1981 to 2009, mean weight at age for 6, 8 and 10 year-old fish has declined 0.03, 0.04, and 0.05 lb y^{-1}, respectively.



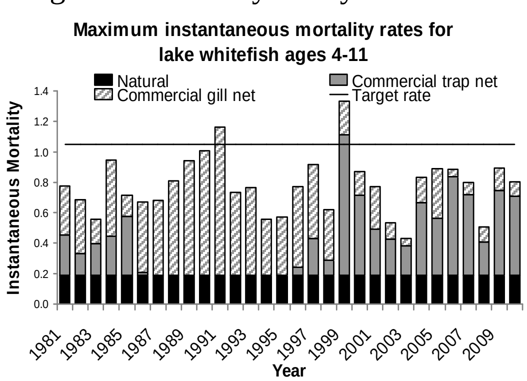
Recruitment of age-4 whitefish in WFS-08 generally increased during 1981 to 2010. There was a sharp increase in recruitment during 1981 to 1987 (57,241 to 138,067 age-4 fish) followed by a sharp decrease to 1989 (51,439 age-4 whitefish). Recruitment of age-4 fish has increased steadily with some variation since 1989, to a high of 217,538 in 2010. The stock assessment model estimated that an average of 101,094 age-4 fish recruited to the population each year during 1981 to 2010.

Total fishable biomass in WFS-08 was relatively stable from 1990 to 2007 and has increased since then. Spawning stock biomass declined slightly during 1995 to 2007 and has increased since then. Total biomass of whitefish averaged 522,046 lb during 1981 to 2010 and spawning stock biomass averaged 473,491 lb during the same period. In 2010 total biomass was 811,376 lb and spawning stock biomass was 641,847 lb.



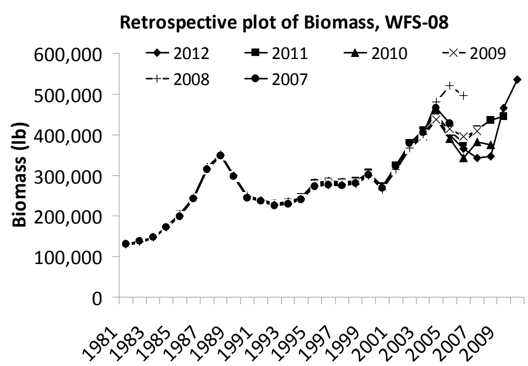
Using Pauly's relationship between average water temperature occupied by a fish (4°C) and von Bertalanffy growth parameters L∞ (71.6 cm) and k (0.1506), natural mortality was estimated to be 0.187 y^{-1} in the WFS-08 stock assessment model. The von Bertalanffy growth model was updated with mean length-at-age data for whitefish caught in commercial gill nets and trap nets, graded-mesh survey gill nets, and beach seines in all months of the year during 1980-2007.

Total annual mortality of age-4 and older whitefish has been fairly high but stable in WFS-08 during 1981-2010. Instantaneous total annual mortality of age-4 and older whitefish averaged 0.58 y^{-1} from 1981-2010 and was 0.63 y^{-1} in 2010. Fishing mortality averaged 0.39 y^{-1} from 1981-2010 and was 0.44 y^{-1} in 2010. Trap-net mortality was 0.38 y^{-1} and gill-net mortality 0.06 y^{-1} in 2010.



Total annual mortality on age-4 and older whitefish has been less than the target rate of 1.05 y^{-1} since 2000 and was 0.81 y^{-1} in 2010. The projection model estimated that the fishing mortality rate in 2012 could be increased 1.58 times from levels experienced during 2008-2010. The projected recommended yield limit at this rate of fishing was estimated to be 242,000 lb in 2012.

Convergence criteria were met for the WFS-08 stock assessment model, and the Markov Chain Monte Carlo simulations were acceptable. Retrospective patterns of biomass were reasonable reflecting reliability of the assessment model. Consequently the stock assessment model was given a high rating.



Summary Status WFS-08 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.57 lb
Age at first spawning	4 y
Size at 50% maturity	1.81 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	3.63 lb (0.003 SE)
Current SSBR	1.08 lb (0.042 SE)
SSBR at target mortality	0.199 lb (0.000 SE)
Spawning potential reduction	
At target mortality	0.121 (0.010 SE)
Average yield per recruit	1.11 lb (0.007 SE)
Natural mortality (*M*)	0.187 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	7 y
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.067 y^{-1} (0.054 SE)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.285 y^{-1} (0.197 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.571 y^{-1} (0.236 SE)
Recruitment (age 4)	
(average 2001-2010)	139,616 fish (17,326 SE)
Biomass (age 3+)	
(average 2001-2010)	587,539 lb (37,716 SE)
Spawning biomass	
(average 2001-2010)	470,539 lb (40,644 SE)
MSC recommended yield limit for 2012	242,000 lb
Actual yield limit for 2012	242,000 lb

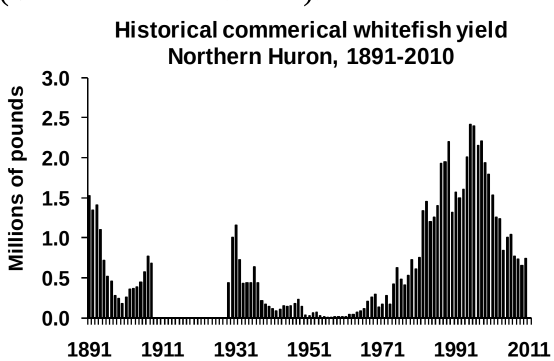
Lake Huron

Northern Huron (WFH-01 to WFH-04)

Prepared by Mark P. Ebener

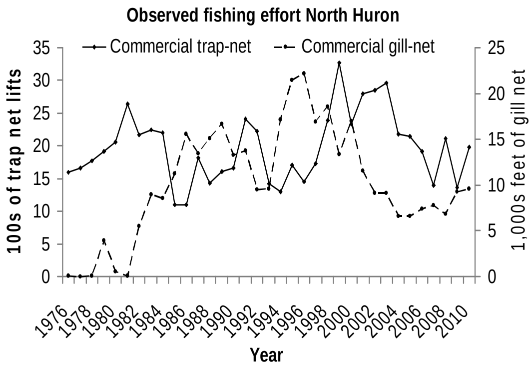
The catch-at-age model for lake whitefish in Northern Lake Huron was created in 2009 after mark-recapture data showed fluid movement of adult fish between management units WFH-01, WFH-02, WFH-03, and WFH-04 (Ebener et al. 2010). The consolidated stock assessment model was an attempt by the Modeling Subcommittee to estimate population parameters for a mixed stock fishery exploited by only one agency (CORA).

The commercial fishery for lake whitefish in Northern Lake Huron has been ongoing for centuries. Records detailing commercial fishery catch and effort data were first required by the State of Michigan in 1929, but aboriginal subsistence fisheries and European settler commercial fisheries for lake whitefish were occurring in the Straits of Mackinac and Northern Lake Huron as early as the mid 1700s (Spangler and Peters 1995, Brown et al. 1999). Few historic fishery records are readily available for northern Lake Huron before 1891 and between 1909 to 1928, but it appears that peak yields of lake whitefish between 1.5 and 2.4 million lb during 1987-2000 were much greater than any time during 1891-2010 (Van Oosten et al. 1946).

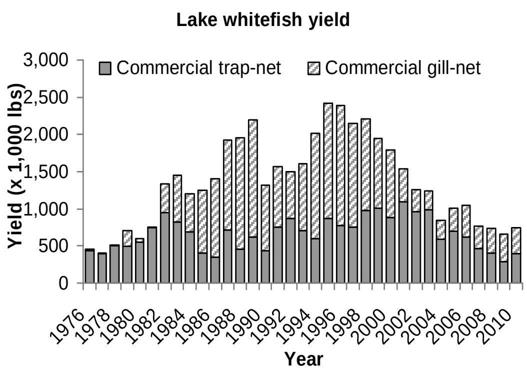


Annual commercial yields, converted to round weight, averaged 645,000 lb during 1891-1908, 268,000 lb during 1929-1957, and 942,000 lb during 1958-2010. The long-term average yield from northern Lake Huron was 704,000 lb during 1929-2010. Considering that yield of lake whitefish from northern Lake Huron bottomed-out in 1957, commercial yields after 1980 were 2-5 times greater than during most years prior to 1980. Commercial yield declined by 130,000 lb y^{-1} from the peak of 2.4 million lb in 1995 to 657,000 lb in 2009. The commercial yield of lake whitefish was 744,000 lb in 2010, very near the long-term average.

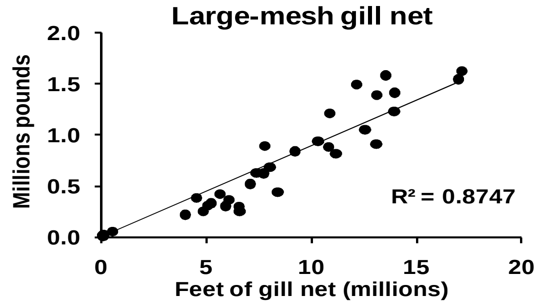
Large-mesh gill nets and pound nets were traditionally used to harvest lake whitefish in northern Lake Huron because the deep trap net was not introduced into the commercial fishery until 1930. The deep trap net did not develop into the primary gear for harvesting lake whitefish in northern Lake Huron unlike in other areas of Lake Huron (Van Oosten et al. 1946). Pound net harvests of lake whitefish declined to low levels in northern Lake Huron by the late 1970s. Gill nets were banned as a commercial gear for lake whitefish in the 1960s, but since the CORA fishery began in earnest in 1982 large-mesh gill nets and trap nets have accounted for nearly 100% of the commercial yield from northern Lake Huron.

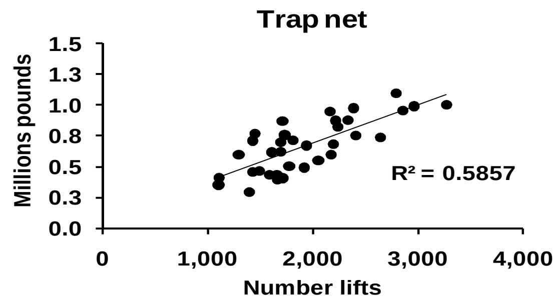


Allocation of the commercial lake whitefish yield among fishing gears has changed substantially since the 1970s. Trap net fisheries accounted for 67-98% of the annual commercial yield from 1976-1982, gill nets accounted for 43-77% of the yield from 1985-1998, and since 1998 the trap-net fishery has accounted for 44-80% of the annual lake whitefish commercial yield.

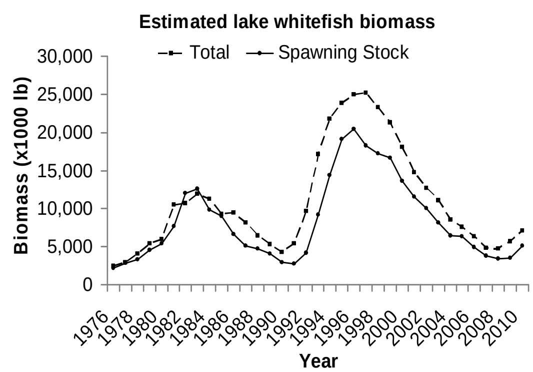


Changes in commercial fishery yields were directly related to both fishing effort and lake whitefish biomass. There were highly significant relationships between fishing effort and subsequent catch for both the gill-net and trap-net fisheries, but variations in gill-net effort explained a much higher proportion (R^2 = 87%) of the variation in yield than variation in trap-net effort (R^2 = 59%).

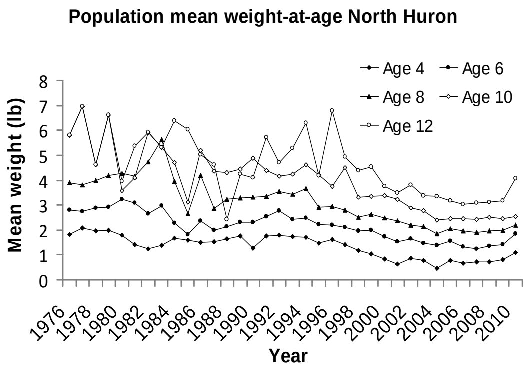




Trends in commercial fishery yields followed trends in biomass but were offset by several years. Fishable biomass was high during 1981-1986 and 1993-2001, whereas large harvests occurred during 1987-1989 and 1994-2000.

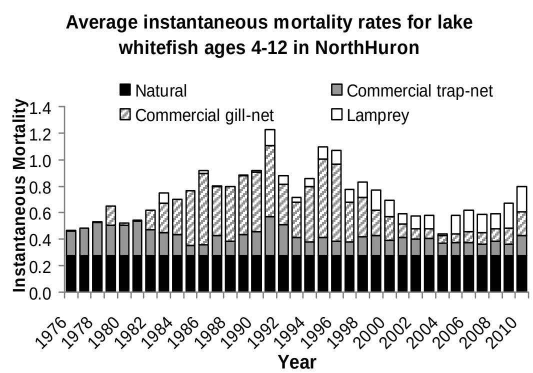


After declining for the better part of three decades, growth rates, expressed as mean weight at age of lake whitefish appear to have stabilized and increased slightly since 2005. Growth declined most rapidly from the early 1990s, when biomass levels increased tremendously, to 2005 when biomass had reached its lowest level in many years. Mean weight at age has increased across most age classes since 2005, particularly for ages 4-7, which was greater in 2010 than most other years since the late 1990s. These age classes experiencing better growth were produced during years when biomass levels were generally less than 10 million lb.



Changes in reproduction and recruitment to the fishable population have largely driven biomass and subsequent commercial fishery yields from northern Lake Huron. The large 1977 year class helped foster increases in biomass during the early to mid 1980s, while the abundant 1989-1995 year classes drove both biomass and commercial yields in northern Lake Huron to the highest levels observed during 1976-2010. Reproduction and recruitment declined substantially after 1996. Peak recruitment was 4.3 million fish at age 4 for the 1977 year class in 1981 and 4.6 to 5.7 million age-4 fish for the 1989-1995 year classes during 1993-1999. While recruitment appeared to increase during 2007-2010, these levels of recruitment are only average and will not substantially increase abundance of adult lake whitefish or commercial fishery yields.

Total annual mortality increased from 2008 to 2010 primarily due to increased estimates of sea lamprey-induced mortality on adult lake whitefish in northern Lake Huron. The estimated total instantaneous mortality rate was amazingly constant at 0.55 y^{-1} during 2001-2008, and then increased to 0.63 y^{-1} in 2009 and 0.71 y^{-1} in 2010. The sea lamprey mortality rate has been increasing in northern Lake Huron since the early 1990s, and was greater in 2009 (0.188 y^{-1}) and 2010 (0.193 y^{-1}) than in all other years. There were slight increases in both trap-net and gill-net mortality rate on lake whitefish from 2008 to 2009 but these values were well within the range of values observed during 2001-2008. The maximum mortality rate on the most fully vulnerable age class of lake whitefish exceeded the target mortality rate of 1.05 y^{-1} in both 2009 and 2010 because of the increases in sea lamprey predation.



Several modifications were made to the northern Lake Huron stock assessment model to improve its stability. These changes included:

1) Directly estimating the standard deviations of fishing catch and effort and the stock-recruitment relationship;
2) Not estimating abundance of the age-11 or age-12 + age groups in the first year;
3) Not estimating the inflection point or the slope of the descending limb of the double

logistic gill-net selectivity function; and

4) Providing new initial values for the inflection point and slope of the descending limb of the gill-net selectivity curve.

One of the most significant changes made to the northern Lake Huron stock assessment was to directly estimate standard deviations for fishing catch and effort and the stock-recruitment relationship. This was done by providing prior estimates of the ratios of the standard deviations between catch and fishing effort for each gear and for the stock-recruitment relationship and having ADMB determine the best estimate for the standard deviation of each parameter. These modifications produced estimates of biomass that did not change substantially after small changes were made to starting values unlike in previous years. Maximum gradients tended to be much closer to the convergence criteria of 1.00E-4, and gill-net selectivity curves appeared much more appropriate.

The stock assessment model for northern Lake Huron projected a decrease in the total allowable catch of lake whitefish in 2012 primarily because high sea lamprey mortality caused total mortality on the most fully vulnerable age class (age 11+) to exceed the target mortality of 65% (Z=1.05). Spawning potential reductions (SPR) was estimated to be 0.39, which is substantially greater than the target of at least 0.20. Consequently, the model projected spawning biomass to be sufficient, but mortality to be excessive due to sea lamprey, so the model reduced trap-net mortality 27% and gill-net mortality 18% in 2012 from levels observed during 2008-2010. The projected total allowable catch for northern Lake Huron was estimated to be only 432,000 lb and represents a 40% reduction in the 2011 TAC of 719,600 lb.

Summary Status Northern Huron	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.38 lb
Age at first spawning	4 y
Size at 50% maturity	2.11 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.0 lb (0.035 SE)
Current SSBR	0.84 lb (0.026 SE)
SSBR at target mortality	0.24 lb (0.00 SE)
Spawning potential reduction	
At target mortality	0.121 (0.001 SE)
Average yield per recruit	0.285 lb (0.025 SE)
Natural mortality (*M*)	0.271 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	12
Fully selected age to trap nets	10
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.087 y^{-1} (0.018 SE)
Trap net fishing mortality (*F*)	
Average 2008-2010 , ages 4+	0.103 y^{-1} (0.015 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	0.164 y^{-1} (0.026 SE)
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.632 y^{-1} (0.056 SE)
Recruitment (age 4)	
(average 2001-2010)	2,890,000 fish (63,236 SE)
Biomass (age 3+)	
(average 2001-2010)	9,540,000 lb (932,606 SE)
Spawning biomass	
(average 2001-2010)	7,150,000 lb (771,114 SE)
MSC recommended yield limit for 2012	414,400 lb
Actual yield limit for 2012	539,700 lb

WFH-05 (Alpena)

Prepared by Ji He and Mark Ebener

The WFH-05 management unit includes U.S. waters of Lake Huron from Presque Isle south to the southern end of grids 809-815. Before August 2000, this area was fished exclusively by state-licensed commercial trap-net fishermen. After the signing of the 2000 Consent Decree, this unit became an exclusive unit for tribal trap-net operations.

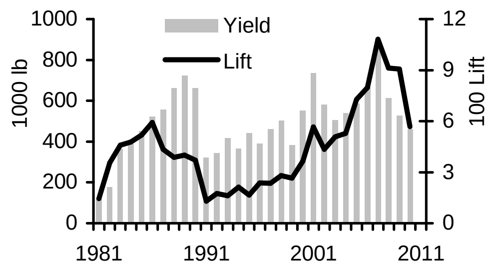
There are two commercial fishing zones in WFH-05. One is the Southern Lake Huron Trap Net Zone (SLHTN), which is the southern end of 1836 Treaty Water. Four trap-net operations from two tribes can fish in the SLHTN, with each being limited to no more than twelve trap nets. All of these CORA trap-net operations have a minimum length limit of 17”, and there is no limit on water depth where trap nets can be set.

The second fishing zone is between SLHTN and a straight line running northeast from the tip of Thunder Bay’s North Point to the international border. This is the so called “grey” zone, where the same four tribal fishers from the SLHTN can apply for state fishing permits, but the total number of trap nets in this zone cannot be more than sixteen. The state sets a minimum length limit of 19 inch and a maximum depth limit of 150 feet in this zone.

Annual trap-net harvest ranged from 123,651 lb in 1981 to 857,866 lb in 2007 (Figure 1). Before 2007, the first peak of the harvest (723,742 lb) was in 1989, and the second peak (736,224 lb) was in 2001. The 2010 harvest was 461,685 lb, the lowest in the recent four years and below the average annual harvest during 1983-2006 (505,590 lb).

The relationship between annual harvest and fishing effort differed among three periods. The first was 1981-1986, the second was 1987-2002, and the third was 2003 to present. The catch rates were higher during 1987-2002 than the early and recent periods.

Figure 1: Trapnet effort and harvest



Overall, there was an inverse relationship between the total number of fish harvested and the average weight of a harvested fish. The average weight of a harvested fish was 4.1 lb during 1981-1986, 3.1 lb during 1987-2002, and 2.6 lb during 2003-2010. There were dynamic variations between 2.2-3.7 lb during 1986-1990 and a sharp decline from 3.5 lb in 1998 to 2.6 lb in 2001. During 2008-2010, the average weight increased back to 2.9 lb. Weight at age rapidly declined during 1981-1986, continued to vary and decline during 1987-2002, and slowly increased in recent years.

Figure 2: Average individual weight and total numbers of harvest

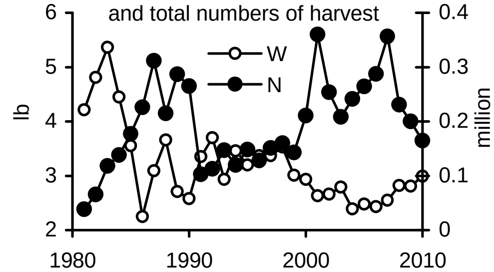


Figure 3: Average weight at age

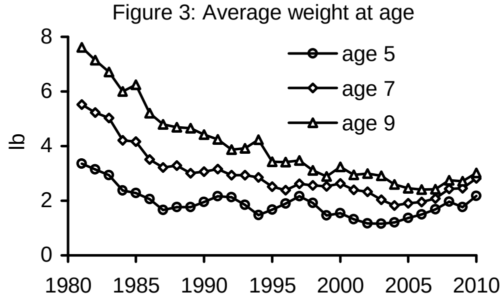
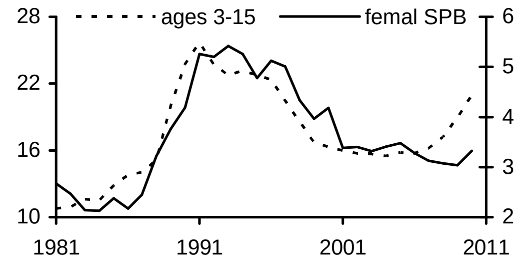
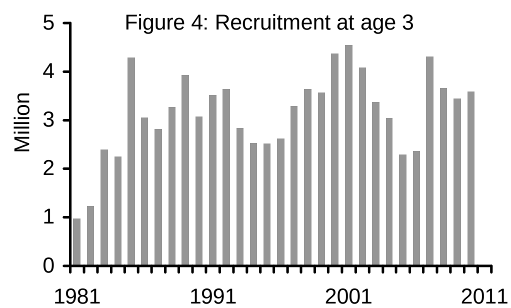


Figure 5: Biomass (million lb)



The estimates of recruitment at age 3 averaged 3.3 million during 1983-2010. The first peak was 4.3 million in 1985, followed by a relatively low period after 1992 with an average of 2.9 million, and an increasing period from 1997 to 2001. In 2005 and 2006 recruitment was 2.3 to 2.4 million fish, the lowest observed since 1985.

Figure 4: Recruitment at age 3



Female spawning stock biomass (SSB) increased rapidly from 2.7 million lb in 1981 to 5.4 million lb in 1993, followed by rapid declines to about 3.3 million lb by 2001. Total biomass of age 3 and older fish had similar patterns as female SSB, except for the increases during the last three years corresponding to the estimated high recruitments during 2007-2010. Both spawning-stock and total biomass were influenced by recruitment, weight at age, and the average weight of individual fish.

Natural mortality (*M*, 0.265 y^{-1}) was the largest source of total mortality, followed by sea lamprey (0.217 y^{-1}, three-year average ages 4 and older), and then trap-net fishing mortality (0.086 y^{-1}, three-year average ages 4 and older). The estimated total mortality at every age was lower than the limit of 1.05 y^{-1}. The model recommended yield limit for 2012 was 787,795 lb, much lower than the recommended yield limit 1,142,750 lb for 2011, but it was still higher than the 2008-2010 average annual harvest of 534,806 lb. The continuous increases in TAC for previous years were due to retrospective patterns in the estimated recruitments and biomass.

The 2012 SCAA model incorporated for the first time an expanded age structure, including ages 3-15. With the expanded age structure, the base-model would not run with raw data of size at age because the data available could not fill every cell of the year by age matrix. To resolve this problem, a time-varying growth model and a time-varying length-mass relationship model were used to produce a matrix of length at age and a matrix of weight at age. The updated von Bertalanffy growth parameters were used to estimate annual mortality. The second problem was strong retrospective pattern in the estimated recruitment and spawning stock biomass. To resolve this problem, the model code was reorganized to implement a complete set of retrospective analyses, and trap-net selectivity was modified as a lognormal function of length at age. The SD parameter of the function was allowed to change over years, and the parameter of size at peak selectivity was allowed to vary among three blocks of years. The model converged with a maximum gradient of 0.0001. The model estimates were similar among years of 2008-2010 in retrospective analyses.

Additional refinements of the model were made during a December 2011 MSC workshop, including the use of variance ratios, and further refinements in time-varying catchability and selectivity. Those additional refinements were not implemented in the model that was used for recommending the 2012 TAC, but will be incorporated in the future. Another major concern about the model was the fact that the estimates of sea lamprey induced mortality borrowed data from the unit of WFH-04. Alternative options for resolving this issue were discussed and will be further investigated.

Summary Status WFH-05 Whitefish	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.37 lb
Age at first spawning	3 y
Size at 50% maturity	2.18 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.934 lb (1.674 – 2.194)
Current SSBR	0.990 lb (0.900 – 1.080)
SSBR at target mortality	0.300 lb (0.290 – 0.311)
Spawning potential reduction	
Current SPR	0.512 (0.483 – 0.541)
SPR at target mortality	0.155 (0.140 – 0.171)
Average yield per recruit	0.147 lb (0.105 – 0.189)
Natural Mortality (M)	0.266 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	8
Average gill-net F, ages 4+	N/A
Average trap-net F, ages 4+	0.086 y^{-1} (0.056 – 0.116)
Sea lamprey mortality (ML)	
Average ages 4+, 2008-2010	0.217 y^{-1}
Total mortality (Z)	
Average ages 4+, 2008-2010	0.569 y^{-1} (0.532 – 0.605)
Recruitment (age-3)	
Average 2001-2010	3,469,800 fish (2,509,988 – 4,429,612)
Biomass (age 3+)	
Average 2001-2010	16,768,000 lb (12,954,232 – 20,581,768)
Spawning biomass	
Average 2001-2010	3,282,700 lb (2,530,119 – 4,035,281)
Model recommended yield limit for 2012	787,795 lb
Actual yield limit for 2012	758,300 lb

Lake Michigan

WFM-01 (Bays de Noc)

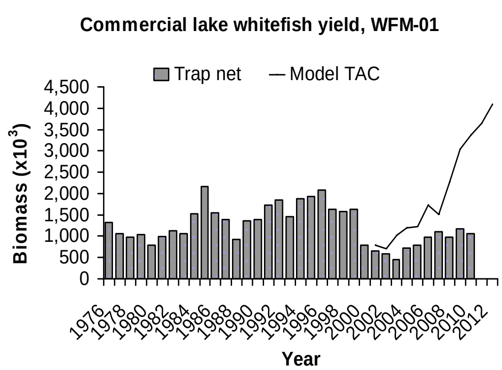
Prepared by Philip J. Schneeberger

Lake whitefish management unit WFM-01 is located in the 1836 Treaty waters of northern Green Bay. Prominent features of this area include two large bays (Big and Little Bay de Noc), numerous small embayments, several islands (including St. Martins Island, Poverty Island, Summer Island, Little Summer Island, Round Island, Snake Island, and St. Vital Island), as well as various shoal areas (Gravelly Island Shoals, Drisco Shoal, North Drisco Shoal, Minneapolis Shoal, Corona Shoal, Eleven Foot Shoal, Peninsula Point Shoal, Big Bay de Noc Shoal, Ripley Shoal, and shoals associated with many of the islands listed above). Little Bay de Noc is the embayment delineated by statistical grid 306. Its surface area is 39,880 acres. Shallow waters characterize the northern end and nearshore areas, but there is a 40- to 100-ft deep channel that runs the length of the bay. Rivers that flow into Little Bay de Noc include the Whitefish, Rapid, Tacoosh, Days, Escanaba, and Ford. Big Bay de Noc is a larger embayment of 93,560 acres delineated by statistical grids 308 and 309. Big Bay de Noc is relatively shallow with over half the area less than 30-ft deep and a maximum depth of 70 ft. Rivers that empty into Big Bay de Noc include the Big, Little, Ogontz, Sturgeon, Fishdam, and Little Fishdam.

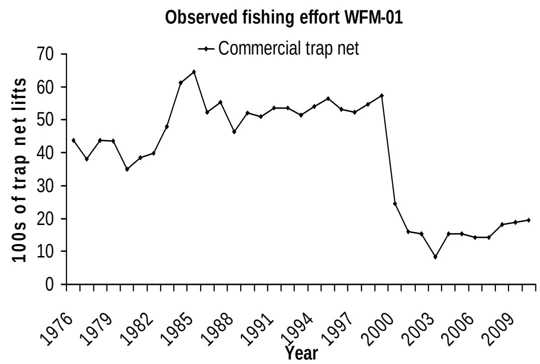
Waters in WFM-01 (380,652 total surface acres) offer extensive areas where suitable habitat is available and is likely used by spawning whitefish. The Big Bay de Noc Shoal is documented as being a very important area for lake whitefish reproduction. Consistent, fairly favorable conditions on this shoal result in relatively stable whitefish recruitment from year to year. The bay areas are important nursery grounds for whitefish larvae and fry.

Trap netting has accounted for 98.4% of the WFM-01 commercial lake whitefish yield since 1986. Commercial gill netting in this management zone ceased after 1985. Trawl yield was basically negligible through 2000 and non-existent thereafter. Biological data were lacking from both the gill-net and trawl fisheries. For these reasons, and to simplify computations and analytics, catches from trawls and gill nets were converted to trap-net yield and effort for WFM-01 starting with the 2011 catch-at-age model and continuing this year. Yield, effort, and fishing mortality figures below reflect these conversions.

Trap-net yield for lake whitefish in WFM-01 was 1,065,330 lb during 2010. Yield has exceeded a million lb three of the last four years in the data set.

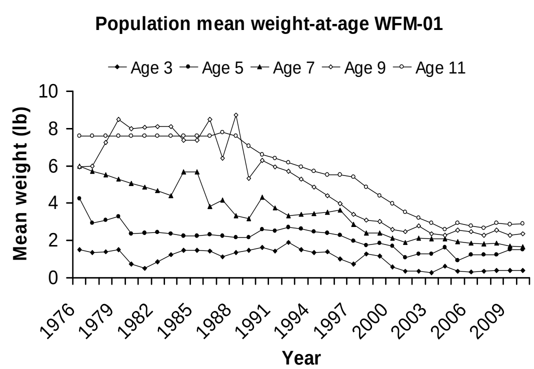


Fishing effort increased 4% from 1,874 trap-net lifts in 2009 to 1,955 lifts in 2010. The current level of effort is still only about a third of the average for years prior to the 2000 Consent Decree (1976-1999).



Catch-per-unit effort (CPUE) has ranged from 197 lb lift^{-1} in 1988 to 780 lb lift^{-1} in 2007. CPUE was 545 lb lift^{-1} in 2010.

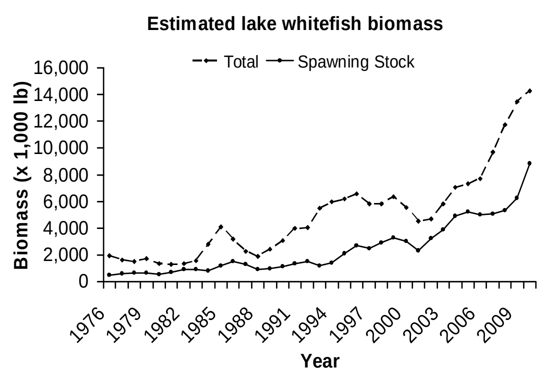
Weight-at-age values have been relatively stable during the last 4-5 y following declines, especially for older fish in the 1990s and early 2000s. Overall average weight at age for lake whitefish 3-12+ years old was 1.8% higher in 2010 compared to 2009.



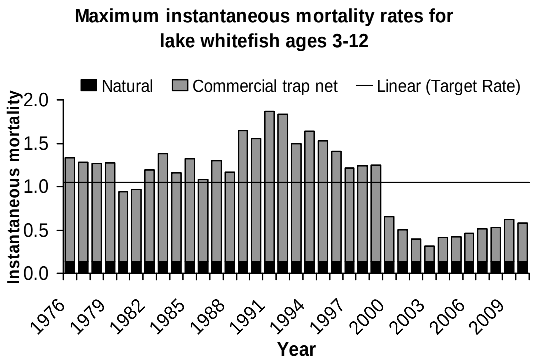
Length-at-age data from individual fish in the entire data set were used to calculate growth with L∞ fixed at 550 mm, but the computed von Bertalanffy k value resulted in a natural mortality value deemed unrealistically high and corresponded with a model that would not converge. In order to get model convergence and other parameter values that were judged to be more reasonable, a k of 0.07 was used in the model.

Estimated recruitment (numbers of age-3 fish, representing the 2007 year class) was 1.6 million in 2010. The two largest year classes in the data set have occurred within the previous five years and recruitment estimates have averaged about 1.8 million fish since 1993 in WFM-01.

Based on the latest model estimates, fishable biomass was 14.2 million lb in 2010, up for the ninth year in a row. Estimated spawning stock biomass (8.8 million lb) represented 62% of the total biomass estimate. Considering the entire data set, both fishable biomass and spawning stock estimates have generally trended upward, especially since the late 1980s.



Estimates of total instantaneous mortality (*Z*) declined dramatically starting in 2000 and have remained relatively low since then. The 2010 estimate was 0.32 y^{-1}, with 0.13 y^{-1} attributable to instantaneous natural mortality (*M*) and 0.19 y^{-1} due to instantaneous fishing mortality (*F*).



The projected 2012 yield limit for WFM-01 is 4.08 million lb. This value is a 12% increase from the 2011 yield limit of 3.64 million lb.

Summary Status WFM-01 Whitefish	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	1.57 lb
Age at first spawning	6 y
Size at 50% maturity	1.73 lb
Age at 50% maturity	7 y
Spawning biomass per recruit	
Base SSBR	5.646 lb (5.628 - 5.665)
Current SSBR	1.557 lb (1.397 - 1.706)
SSBR at target mortality	0.08355 lb (0.08350 – 0.8359)
Spawning potential reduction	
At target mortality	0.276 (0.248 – 0.302)
Average yield per recruit	0.982 lb (0.970 – 0.991)
Natural mortality (*M*)	0.133 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to trap nets	11
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.198 y^{-1} (0.171 – 0.227)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.331 y^{-1} (0.304 – 0.360)
Recruitment (age 3)	
(average) 2001-2010	2,212,000 fish (1,431,000 – 3,405,000)
Biomass (age 3+)	
(average) 2001-2010	8,962,000 lb (7,235,000 – 11,290,000)
Spawning biomass	
(average) 2001-2010	5,081,000 lb (4,446,000 – 5,794,000)
MSC recommended yield limit for 2012	4,080,000 lb
Actual yield limit for 2012	4,080,000 lb

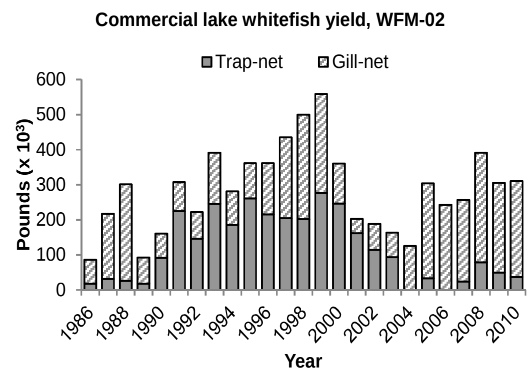
WFM-02 (Manistique)

Prepared by Ted Treska and Mark P. Ebener

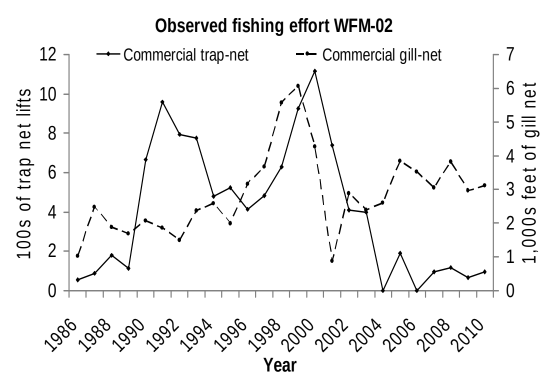
WFM-02 is located in the northwest portion of Lake Michigan. There are 387,000 surface acres of water less than 240 feet deep in the unit. The only known spawning population of whitefish in the management unit is located in Portage Bay; this population is not as abundant as other stocks in Lake Michigan. Many of the whitefish inhabiting WFM-02 move into the unit from adjacent units.

WFM-02 has been an exclusive CORA fishing zone since 1985. One trap-net operation and up to four large gill-net boats have regularly fished WFM-02 through the years, but only two large gill-net boats currently fish in the unit. Very little small-boat gill-net effort occurs in this unit. Besides whitefish, the large-boat gill-net fishery routinely targets bloaters in offshore waters.

Commercial fishery yield from WFM-02 has averaged 285,000 lb per year from 1986-2010. As is the case in many Lake Michigan units, yield peaked in the mid to late 1990s with an average yield from 1990 to 1999 of 358,000 lb, with peak yield in 1999 at 558,000 lb. Since 2000, the commercial yield has averaged 259,000 lb and the 2008 yield was the highest recorded since 1999 at nearly 400,000 lb. During the 1990's the trap-net fishery accounted for about 60% of the commercial yield, but yield has been quite low in recent years. Since 2004, trap-net yield has averaged only 32,000 lb. In the 1980s and again during the 2000s, the gill-net fishery dominated. Since 2004, the gill-net fishery has accounted for more than 90% of the commercial yield in this unit. The 2008 gill-net yield of 313,000 lb was the highest recorded in the time series.

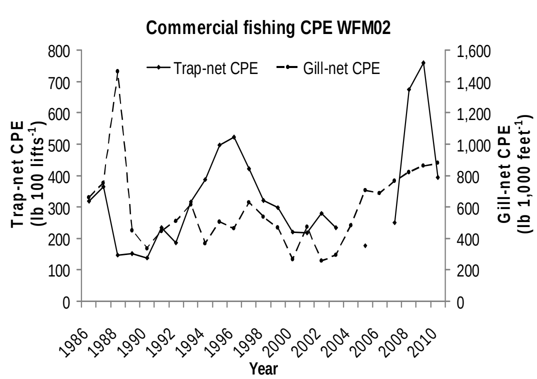


Trap-net effort has been highly variable throughout the time series modeled. During the 1990s, the trap-net fishery averaged more than 700 lifts, peaking at 1,116 lifts in 2000. During 2001 to 2010, average effort declined to less than 215 lifts and effort has not exceeded 200 lifts since 2003. After reporting more than 6 million feet of effort in 1999, gill-net fishery effort declined to less than 1 million feet in 2001. Since then, gill-net effort has increased steadily to a plateau at a level around 3.3 million feet from 2006 to 2010.



After reaching a peak in the mid-1990s, catch rates in the trap-net fishery declined steadily through 2005. With the sporadic nature of the fishery in the past few years, it is somewhat difficult to assign significance to the dramatic increase in catch rates that occurred in the 2008 and 2009 trap-net fishery; the highest in the modeled time series at 674 and 759 lb lift^{-1} respectively. 2010 saw a decline in trap net catch rates to those more similar to values to the 1990's. It is important to note that in these years the trap net fishery consisted entirely of fall effort, likely artificially inflating catch rates over those seen in previous years. In addition to this, all trap net effort in the unit is concentrated near the western border with WFM-01 (targeting fish moving into the bay) and may not be representative of the entire unit. However, gill-net catch rates have increased substantially in the past seven years and the 2010 gill-net CPUE of 88 lb 1000 ft^{-1} is the second highest since 1988. These data suggest an increasing trend in abundance since the middle part of the decade.

The relationship between fishing effort and harvest was linear and positive for the trap-net fishery, but the relationship between effort and harvest was much less clear for the gill-net fishery. Trap-net effort explained 72% of the variation in trap-net catch during 1986-2010 in WFM-02. Gill-net effort explained only 47% of the variation in gill-net harvest during 1986-2010.



The stock assessment model projected a total allowable catch of 800,900 lb from WFM-02 for 2012, but given the recent model performance, a harvest regulating guideline (HRG) of 558,000 lb was established by CORA, corresponding to the peak historic harvest was 558,000 lb for 2012. This is the fifth consecutive year that the HRG was established at this level.

Model Diagnostic Summary – The WFM-02 assessment model has received a low performance rating by the MSC for the past few years and this trend continues in the 2012 assessment. The main reason for low model performance was thought to be the limited number of age classes that were used in the model, though increasing the maximum age to 12+ has not improved performance. The expansion of age classes led to the need to extrapolate and borrow values to fill a number of important input matrices for some age-year combinations for which sample sizes were small or nonexistent. Furthermore, the sporadic nature of the trap-net fishery has prevented biological samples from being obtained in the past six years. In addition, the biological sample representing the gill-net fishery was very low the past two years, comprising of only 35 and 73 fish. This, in turn, has restricted sample size for key population-level parameters (female maturity, growth, etc). Given these issues, the estimates of abundance and biomass from the assessment model are highly uncertain. For this reason, graphical output included in this report has been restricted to fishery harvest and effort. Select model-derived output is provided in the standard table that follows (probability intervals for parameter estimates were unavailable, so standard errors are reported).

The 2012 assessment indicates that the population level has declined from the peak in 2007 to levels similar to those of the early 2000's. The model generated TAC of just over 800,000 lb is more realistic than values returned over the last few years, with total biomass estimated at just under 4 million lb. The age structure seems to be improved, with a number of year classes showing strength, unlike previous assessments that were driven by 2 year classes. The 2012 assessment model did meet minimum convergence criteria though key diagnostics (fit to observed age composition, MCMC results, and retrospective analyses) suggest a low performing model at best.

Summary Status WFM-02 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	0.69 lb
Age at first spawning	3 y
Size at 50% maturity	1.87 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.024 lb (SE 0.002)
Current SSBR	0.681 lb (SE 0.18)
SSBR at target mortality	0.123 lb (SE 0.0004)
Spawning potential reduction	
At target mortality	0.119 (SE 0.002)
Average yield per recruit	0.240 lb (SE 0.012)
Natural mortality (*M*)	0.372 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	11
Fully selected age to trap nets	5
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.187 y^{-1} (SE 0.029)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.011 y^{-1} (SE 0.0004)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.550 y^{-1} (SE 0.028)
Recruitment (age 4)	
(average 2001-2010)	870,085 fish (SE 132,129)
Biomass (age 3+)	
(average 2001-2010)	3,195,173 lb (SE 249,442)
Spawning biomass	
(average 2001-2010)	2,121,249 lb (SE 154,654)
MSC recommended yield limit for 2012	800,883 lb
Actual yield limit for 2012	558,000 lb

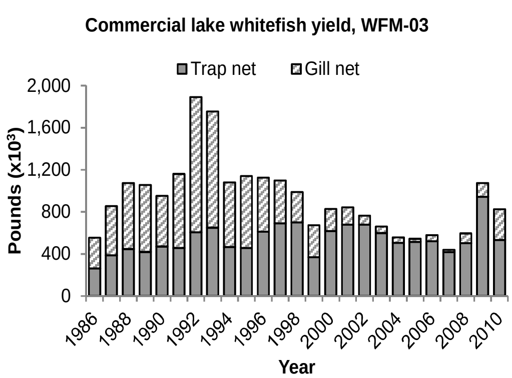
WFM-03 (Naubinway)

Prepared by Ted Treska

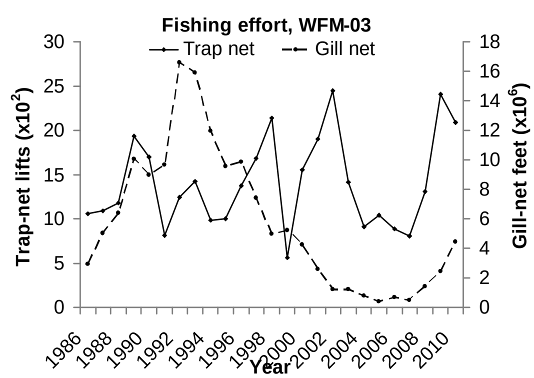
WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinaw west to Seul Choix Point and is bounded on the south by Beaver Island and a complex of shoals and islands surrounding it. Nearly the entire unit is shallow water less than 90 ft deep. There are 483,000 surface acres of water less than 240 ft deep.

WFM-03 has been an exclusive commercial fishing zone for the CORA fishery since 1985. For that matter, WFM-03 has been an important commercial fishing area for the last 150 years. A trap-net and both large- and small-boat gill-net fishery operate throughout WFM-03.

The commercial fishery harvest from WFM-03 averaged 923,000 lb during 1986-2010. The gill-net fishery accounted for an average of 59% of the harvest during 1986-1995. Recently effort has shifted to trap nets, which have harvested a majority (87%) of the fish over the last decade. Peak combined harvests of 1.8 million lb occurred in 1992-1993. The commercial harvest was 858,000 lb in 2010.

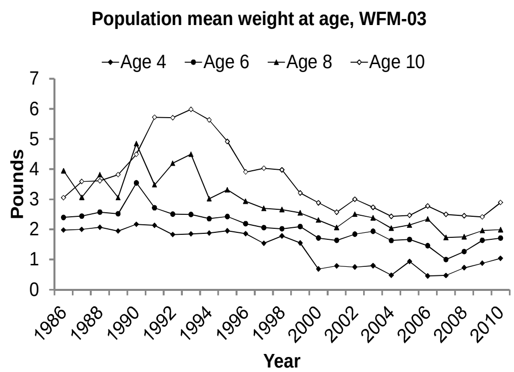


Gill-net effort in WFM-03 has been on a long-term decline since the early 1990s, but surged again in 2010, making up 35% of harvest. Gill-net effort peaked at 16.5 million ft in 1992 and declined until the last few years, when a gradual increase started. Gill-net effort in 2010 was 4.4 million ft. which was substantially greater than during 2002-2008, but still much lower than during much of 1986-2000. Since 1986, trap-net effort has been highly variable, averaging 1,400 lifts per year, but varying from a low of 565 to a high of almost 2,500. 2010 saw a decline in trap-net effort from the recent high of 2,406 in 2009 to just short of 2,100 most recently. The large decline in gill-net effort has been partially due to the conversion program associated with the 2000 Consent Decree, but over the last 10 years, clogging of gill nets with *Cladophora* has been the primary force keeping gill net effort low.



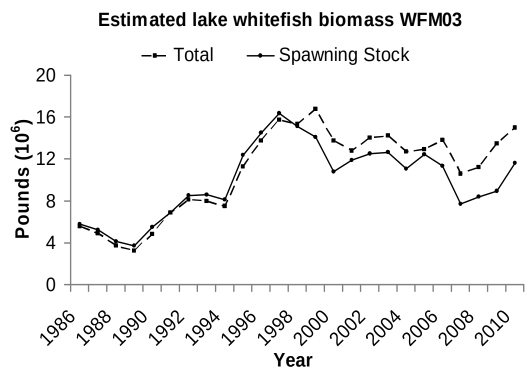
The relationship between fishing effort and harvest in WFM-03 is not as clear as in some other units. Trap-net effort explained only 48% of the variation in trap-net catch and there appeared to be an asymptotic level to harvest for trap nets. On-the-other-hand, gill-net effort explained 93% of the variation in gill-net harvest during 1986-2010 and catch was linearly related to fishing effort. Average trap-net catch rate was 414 lb lift^{-1} and average gill-net catch rate was 67 lb 1000 ft.$^{-1}$ during 1986-2010.

Mean weight at nearly all ages appears to be increasing over the last few years and continued to inch up in 2010. Unfortunately, mean weight at age in 2010 was still lower than during the late 1980s and 1990s.



Estimated recruitment of age-4 whitefish to the fishable population appears to have finally stabilized in WFM-03 in the last decade. Recruitment averaged 3.2 million age-4 whitefish during 1986-2010. The lowest recruitment was 387,000 fish for the 1984 year class in 1988, while the highest recruitment was 4.87 million fish for the 2001 year class in 2005. The 2006 year class was estimated to contain 4.4 million fish when it recruited in 2010.

Biomass of age-4 and older whitefish in WFM-03 trended downward from the late 1990s to 2007, but since has been showing a modest increase. Fishable biomass averaged 10.8 million lb during 1986-2010, while spawning stock biomass averaged 9.9 million lb during the same time period. Fishable biomass peaked at 16.8 million lb in 1999 and spawning biomass peaked at 16.4 million lb in 1997. The gap between spawning biomass and fishable biomass has been increasing over the last decade primarily because of growth declines. Fishable and spawning stock biomasses were estimated at 15.0 and 11.6 million lb, respectively, in 2010.



Von Bertalanffy growth parameters for *L*∞ and *k* and an average water temperature of 6^{o}C were inputted into the stock assessment model in order to produce a natural mortality rate identical to that estimated through mark-recapture of whitefish from WFM-03. A mark-recapture study of adult whitefish was conducted during 2003-2007 in WFM-03 and natural mortality rate was estimated to be 0.40 y^{-1} from the tag recovery information. Von Bertalanffy growth values of 55.0 cm total length for *L*∞ and 0.38 for *k* produced an estimate of 0.402 y^{-1} from the Pauly relationship.

Total instantaneous mortality rate averaged 0.61 y^{-1} in WFM-03 during 1986-2010. Gill-net and trap-net mortality averaged 0.11 y^{-1} and 0.10 y-^{1} in WFM-03 during 1986-2010. Gill net mortality peaked at 0.36 y^{-1} in 1993 then continually declined to only 0.03 y^{-1} in 2007, though increasing over the last 3 years. Trap-net mortality peaked at 0.20 y^{-1} in 1989 and since then has fluctuated between 0.05 y-1 and 0.14 y^{-1}. Trap-net mortality was estimated to be 0.08 y^{-1} in 2010, compared to 0.04 y^{-1} for gill-net mortality in 2010.

The assessment model for WFM-03 was rated as low because Markov Chain Monte Carlo simulations were fair and there were substantial retrospective patterns. Retrospective patterns of biomass and recruitment were not stable and seemed to be influenced by model estimates of year class strength.

Summary Status WFM-03 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.22 lb
Age at first spawning	4 y
Size at 50% maturity	1.60 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.306lb (0.003 SE)
Current SSBR	0.959 lb (0.016 SE)
SSBR at target mortality	0.124 lb (0.000 SE)
Spawning potential reduction	
At target mortality	0.095 (0.0002 SE)
Average yield per recruit	0.235 lb (0.010 SE)
Natural mortality (*M*)	0.402 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	9 y
Fully selected age to trap nets	9 y
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.023 y^{-1} (0.002 SE)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.092 y^{-1} (0.007 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2008-2010)	N/A
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.517 y^{-1} (0.023 SE)
Recruitment (age 4)	
(average 2001-2010)	4,310,000 fish (117,000 SE)
Biomass (age 4+)	
(average 2001-2010)	13,060,000 lb (409,000 SE)
Spawning biomass	
(average 2001-2010)	10,857,000 lb (548,000 SE)
MSC recommended yield limit for 2012	2,219,400 lb
Actual yield limit for 2012	2,219,400 lb

WFM-04 (Beaver Island)

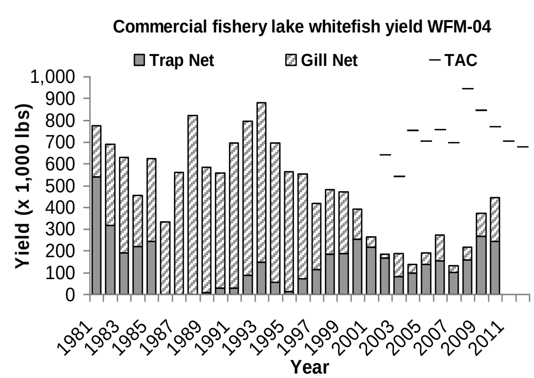
Prepared by Stephen J. Lenart

WFM-04 is located in central northern Lake Michigan and contains a very diverse range of habitat. The Beaver Island archipelago, which consists of eight named islands, is the dominant feature of the unit. These islands, located mainly along the northern edge of the unit, are associated with a large, rocky reef complex that extends about 15 miles west from Waugoshance Point near the northwestern tip of Michigan's Lower Peninsula. This northern reef complex is shallow, ranging from 5 to 30 ft deep. Many smaller submerged reefs extend from the northern reef complex to the south, running along the east and west sides of Beaver Island, a 55 mi^2 landmass that bisects the unit. These latter reefs are surrounded by deep water. WFM-04 contains 577,000 surface acres of water <240 ft deep.

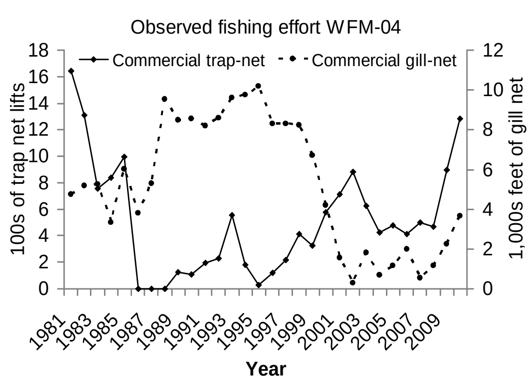
At least several reproductively isolated stocks of whitefish inhabit WFM-04, and most, if not all, of these are associated with the large northern reef complex. One stock spawns in Sturgeon Bay along the northeast side of the unit, while another stock is found at Hog Island.

WFM-04 has been an exclusive commercial fishing zone for the Chippewa-Ottawa Resource Authority (CORA) Tribes since 1985. Much of the western half of the unit is designated as a lake trout refuge where retention of lake trout by recreational or commercial fishers is prohibited. The eastern portion of WFM-04 along the Lower Peninsula of Michigan has been a favorite fishing area for CORA small-boat fisheries, although access along this eastern shore is quite limited. The offshore waters of WFM-04 are fished exclusively by large-boat gill-net and trap-net operations. Only trap-net operations targeting whitefish conduct fisheries within the lake trout refuge. The recreational whitefish fishery is not likely a significant factor in this unit.

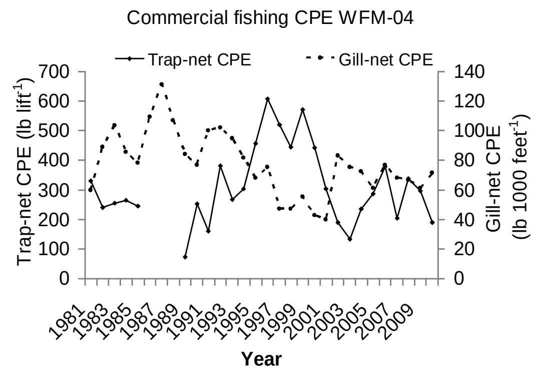
In the four years prior to implementation of the 1985 Agreement between the State and the three COTFMA tribes, the trap-net fishery accounted for a substantial proportion (30–70%) of the total commercial yield. Average commercial yield was 636,000 lb during this period. After 1985, the gill-net fishery dominated, accounting for more than 90% of the total commercial yield during 1986 to 1996 (no trap-net operations were active during 1986 to 1989). Commercial yield, which peaked at 880,000 lb in 1993, declined steadily through the mid to late 2000s, reaching a low of 130,000 lb in 2007. Commercial yield has since rebounded and 2010 yield was 445,000 lb, the highest yield recorded since 2000. Since the inception of the 2000 Decree, yield has ranged between 19-58% of the model-derived yield limit for this unit.



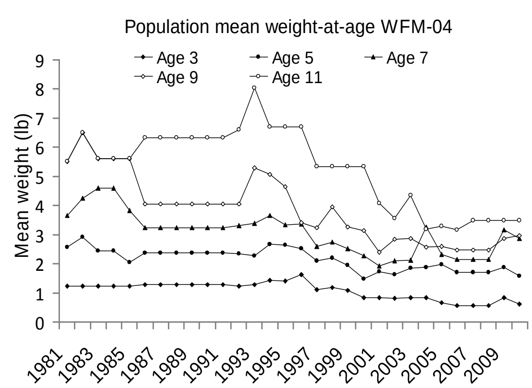
During the late 1980s and throughout the 1990s, the gill-net fishery was the dominant fishery in WFM-04. Average gill-net effort was approximately 6.3 million feet during 1985 to 1999 and gill-net yield routinely exceeded 500,000 lb. Gill-net fishery effort declined substantially with the inception of the 2000 Decree, from 6.3 million feet in 1998 to under 250,000 feet in 2002. Since then gill-net effort has ranged between 0.4 and 2.8 million feet. Trap-net fishery effort has been quite variable over the years, but was generally low when the gill-net fishery was at its peak. After averaging more than 1,100 lifts per year during 1981 to 1985, the trap-net fishery was inactive for a three-year period. Effort remained low through the mid-1990s (average of 200 lifts during 1989 to 1996). During the period 1997 to 2002, trap-net effort steadily increased, reaching 881 lifts in 2002. Effort then stabilized, ranging between 400 and 500 lifts during 2004 and 2008. Trap-net fishery effort nearly doubled from 2008 to 2009 (881 lifts) and then increased by 30% to 1,285 lifts in 2010, an effort level not seen since the early 1980s.



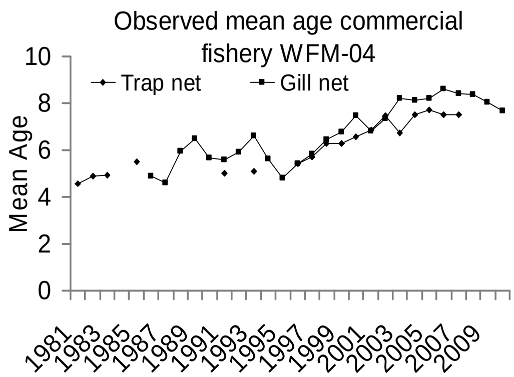
Since rebounding in 2002 after a decade-long decline, catch rates in the gill-net fishery have been quite steady in recent years, averaging 71 lb 1,000 feet^{-1} of effort during 2002 to 2010 (range 61 to 83 lb). In contrast, catch rates in the trap-net fishery showed a marked increase during the 1990s. However, trap-net effort was generally low during this period. Trap-net catch rates have been highly variable throughout the past decade, though a declining pattern has emerged in the past four years.



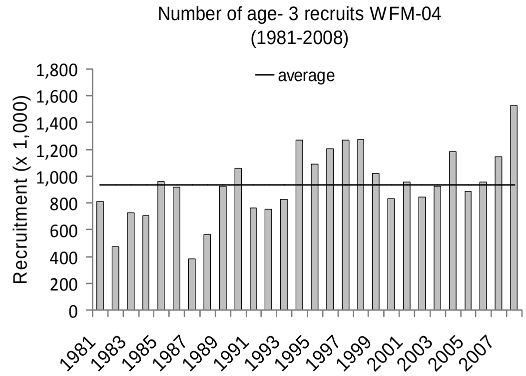
Growth of whitefish in WFM-04 has followed the long-term trend evident across all of northern Lake Michigan- fish are much smaller at a given age than they were during the late 1980s and early 1990s. The decline in growth which began in the early 1990s continued through the early 2000s, at which time growth stabilized across most age classes. After showing a modest increase in 2009 for most age classes, size-at-age declined in 2010 for fish younger than age seven. One should note that weight-at-age in the population is derived from survey and trap-net fish; since fish younger than age 7 contribute only minimally to the harvest, sample sizes tend to be rather small.



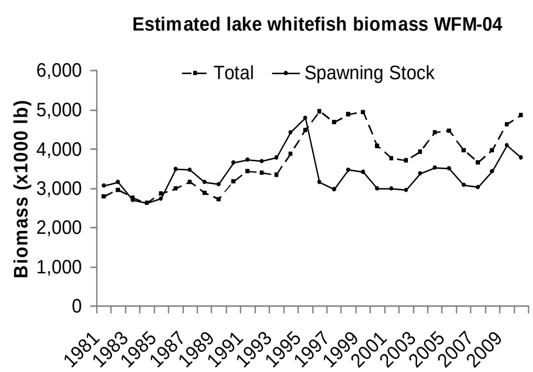
Another indicator of long-term growth patterns can be gleaned from the fishery age composition. During the 1980s, the mean age of a whitefish harvested in the trap-net and gill-net fisheries was approximately five years. By 2005, the mean age in both fisheries had increased to approximately eight years. The recent decline in the gill-net fishery mean age is likely due to a combination of strong year classes from the early 2000s and increased selectivity of younger fish due to a slight uptick in growth in 2009.



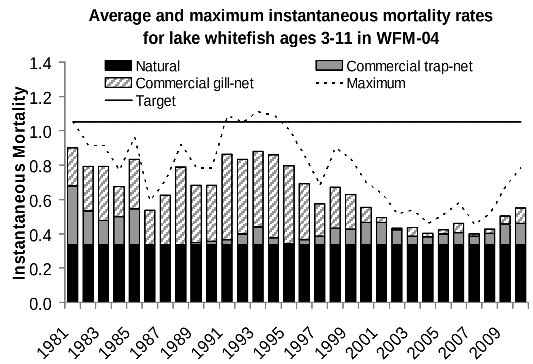
Although estimated recruitment of age-3 whitefish to the population in WFM-04 has been quite stable overall, the late 1990s and 2000s appear to have been favorable periods for recruitment. During 1981 to 1993, average estimated recruitment was approximately 760,000 age-3 fish. During 1994 to 2008, average estimated recruitment was more than 40% higher (1.1 million fish). Although the 2004 and 2005 cohorts (age-3 in 2007 and 2008) appear to be relatively strong, they had yet to fully recruit to the fishery in 2010.



Patterns in total stock biomass have generally mirrored those in recruitment. Total biomass increased markedly during the late 1990s and has remained relatively high (between 4 and 5 million lb) since. Higher mortality rates on adult fish in the mid to late 1990s, coupled with declining growth, helped dampen spawning stock biomass (SSB) during this period of higher recruitment. From 1981 to 1995, estimated spawning stock biomass increased from 3.0 to 4.8 million lb. SSB then declined to just over 3 million lb in 1996 before stabilizing between 3.0 and 3.5 million lb during 1997 to 2008. The most recent estimates suggest that SSB has increased to roughly 4 million lb.



Mortality on lake whitefish in WFM-04 peaked in the middle 1990s, when the gill-net fishery was highest source of mortality. During 1987 to 1996, instantaneous gill-net mortality on age-4+ fish ranged between 0.32 and 0.56 yr^{-1} (average 0.45) and total maximum annual mortality rates exceeded 65% during 1991 to 1994. After 1996, gill-net mortality declined for six consecutive years and has since remained below 0.10 yr^{-1}. During 2008 to 2010, average instantaneous gill-net mortality on age-4+ fish was 0.06 y^{-1}. Trap-net mortality, which was highest in the early part of the time series, was a minor component of the overall mortality during the mid-1980s and most of the 1990s (average 0.032 y^{-1} during 1986 to 1997). Trap-net mortality increased gradually from 1997 to 2001, but then declined and remained below 0.10 y^{-1} through 2008. Trap-net mortality has exceeded 0.13 y^{-1} for the past two years and the average during 2008-2010 on fish aged 4+ was 0.12 y^{-1}. Total mortality (*Z*) of age-4 and older whitefish in WFM-04 has steadily declined since the mid-1990s, when age-specific maximum rates exceeded the current management target maximum of 1.05 y^{-1}. In 2010, the highest estimated mortality experienced by a specific age class was 0.79 y^{-1}. For the first time since 2000, fishing mortality exceeded natural mortality as the largest source of mortality for certain age classes. Natural mortality, as estimated from the Pauley equation, remains the largest source of mortality (0.337 y^{-1}) for fish younger than age 9.



The 2012 model-generated yield limit of 678,000 lb represents a 3% decrease from the 2011 model-generated limit. The abundance of mature fish has remained fairly stable over the past 4 years and thus harvest limits have been stable as well. Total mortality remains below target, though mortality rates for fish 9+ are now estimated to be above 50%. As in all units in which the available whitefish yield is allocated wholly to the CORA tribal fishery, the final harvest regulation guideline (HRG) for WFM-04 is determined by CORA according to the process detailed in the Tribal Management Plan for the 1836 Treaty waters.

Model Changes and Diagnostics – The basic model structure was maintained during the 2012 assessment, with one substantive change relating to the fishery selectivity function. For this assessment, fishery selectivity was modeled as a simple logistic function of mean length-at-age for both the gill-net and trap-net fisheries. In all previous assessments, fishery selectivity was modeled as a function of age. Selectivity was "blocked" through time (i.e. length-at-age was constant within a block) to correspond with major shifts in growth. This change helped smooth retrospective patterns in spawning biomass evident in the base version of the assessment, though further work is needed to determine whether the assumption regarding constancy within the time blocks is reasonable.

After updating the source file to include 2010 data, the new base model was optimized. The model met minimum convergence criteria, provided a reasonable fit to the observed fishery parameters and biomass estimates were insensitive to changes in start values for key parameters. Results of MCMC simulations were mildly problematic, but simulations ran to completion for the first time in recent years. The 2012 WFM-04 model performance was rated as “medium”, primarily due to the issues related to MCMC simulations and assumptions made regarding selectivity time blocks. Nonetheless, this new base model appears to provide a good framework to build upon.

Summary Status WFM-04 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.73 lb
Age at first spawning	3 y
Size at 50% maturity	1.58 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.582 lb (1.577 – 1.588)
Current SSBR	1.054 lb (1.003 – 1.116)
SSBR at target mortality	0.243 lb
Spawning potential reduction	
At target mortality	0.666 (0.633 – 0.706)
Average yield per recruit	0.369 lb (0.332 – 0.399)
Natural mortality (*M*)	0.337 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.062 y^{-1} (0.051 - 0.073)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.117 y^{-1} (0.099 – 0.134)
Sea lamprey mortality (ML)	NA
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.517 y^{-1} (0.488 – 0.544)
Recruitment (age 3)	
(average 2001-2010)	1,008,481 fish (855,303 – 1,201,160)
Biomass (age 3+)	
(average 2001-2010)	4,037,241 lb (3,526,360 – 4,669,270)
Spawning biomass	
(average 2001-2010)	3,312,364 lb (2,898,580 – 3,828,460)
MSC recommended yield limit for 2012	678,000 lb
HRG for 2012	678,000 lb

WFM-05 (Grand Traverse Bay)

Prepared by Erik J. Olsen and Stephen J. Lenart

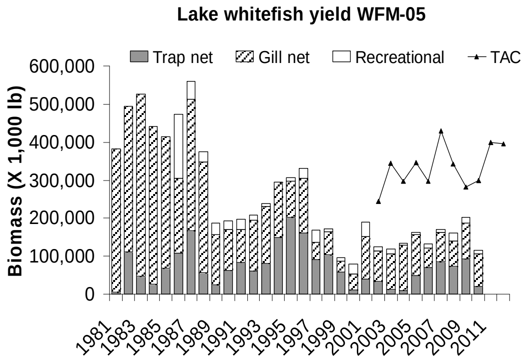
Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including both the east and west arms of Grand Traverse Bay. The deepest parts of WFM-05 exceed 600 ft., both in the offshore waters west of the Leelanau Peninsula, as well as within the east arm of Grand Traverse Bay. Several small shallow reef areas are located in the offshore waters, and there is an extensive shallow water area associated with the Fox Islands. Seventeen statistical grids make up WFM-05, but only 488,000 surface acres, or 46% of the water in these grids, is less <240 ft. deep. Much of the offshore waters of WFM-05 are part of the northern Lake Michigan lake trout refuge.

There are at least four reproductively isolated stocks of lake whitefish that inhabit WFM-05. Discrete spawning stocks of whitefish are found in both the east and west arms of Grand Traverse Bay, and in the outer Bay associated with Northport Bay based on mark-recapture studied conducted by Michigan State University researchers. There probably is another spawning stock of whitefish associated with the Fox Islands based on size and age structure of fish caught at the islands. Another small spawning stock is likely found in Little Traverse Bay.

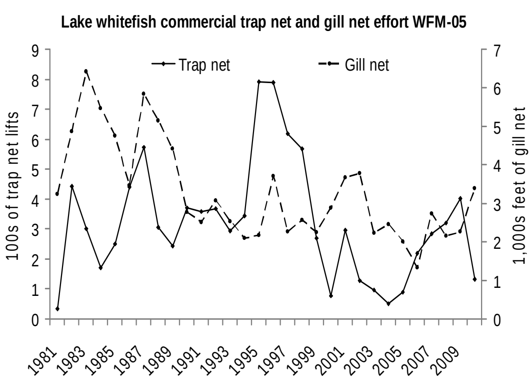
WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. Tribal small-boat fishers relied on Grand Traverse Bay as an important fishing ground because the Bay contains deep water located close to shore, and because it offers small-boat fishers protection from wind and waves. WFM-05 has been an exclusive tribal commercial fishing zone since 1985 and WFM-05 waters of Grand Traverse Bay have been an exclusive commercial fishing area for the Grand Traverse Band since 1985.

Initial tribal fishing activities in WFM-05 were focused on an unexploited population of whitefish. Commercial fishing by State-licensed fisheries had been prohibited in WFM-05 for several decades before tribal small-boat fishers began fishing the area in the late 1970s. Initial yields in 1978 and 1979 were in excess of 400,000 lb, and jumbo (≥ 4 lb) whitefish made up more than 90% of the yield. Harvest increased to >500,000 lb in 1983 and 1984, but by then jumbo whitefish made up only 30% of the yield.

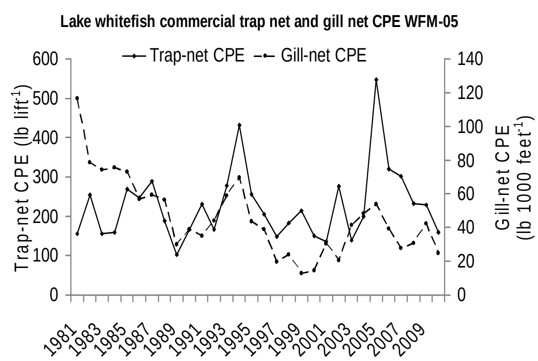
Commercial yields of lake whitefish during the 1990s were substantially less than during the 1980s. The commercial yield averaged 383,000 lb during 1980 to 1989 and 205,000 lb during 1990 to 1999. The fishery declined through the late 1990s, with the lowest recorded yield coming in 2000 at 53,000 lb. The fishery has rebounded slightly through 2009, averaging 141,000 lb during the timeframe. The large-mesh gill-net yield has exceeded the trap-net yield in every year except the period from 1994 to 2000. Increased trap-net effort beginning in 2006 resulted in trap-net yield becoming similar to that of gill net.



Large-mesh gill-net effort in WFM-05 declined from 1984-1989 and has held relatively stable since; whereas trap-net effort has varied widely. Gill-net effort declined from an average of 6.4 million ft. from 1983 through 1990. Since then, the large-mesh gill-net fishery has averaged 2.6 million feet annually, with an all-time low of 1.3 million feet in 2006. Trap-net effort has varied annually between 200 and 800 lifts during 1982-1999. Through the 1990s, trap-net effort averaged 423 lifts per year, peaking at 790 lifts in 1996. Trap-net effort has declined since, averaging 202 lifts since 2000, with an all-time low of 51 lifts in 2004.



The decline in yield of whitefish in WFM-05 has generally mirrored the decline in lake whitefish recruitment within this management unit. CPUE of whitefish in the large-mesh gill-net fishery declined from 153 lb 1,000 ft.$^{-1}$ of gill net in 1979 to a low of 13 lb 1000 ft^{-1} in 1999. Since 2000, gill-net CPUE has generally been trending upward. Except for some relatively high catch rates in 1994 and 2005, from 1981-2010 the CPUE of whitefish in the trap-net fishery was relatively stable, averaging 226 lb lift^{-1}. From 2000-2004, trap-net CPUE averaged 180 lb, but jumped significantly to 546 lb lift^{-1} in 2005, before dropping back to around 249 lb lift^{-1} through 2010. Gill-net fishers in WFM-05 claim the long-term decline in catch rates through 2000 is a result of both increased water clarity due to quagga and zebra mussel activity, along with increased algal growth that makes the net highly visible to whitefish. Catch rates have increased recently with the relatively strong 1999-2002 year-classes entering the fishery. Whatever the cause, it is evident that catch rates of whitefish in the large-mesh gill-net fishery have declined substantially in the unit relative to the early part of the time series.

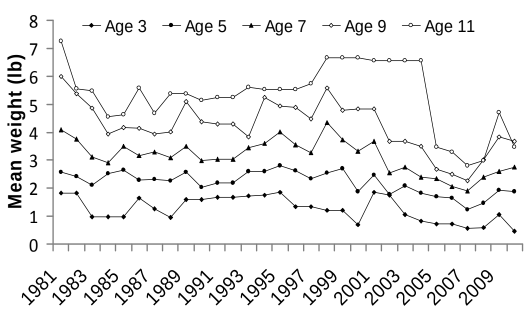


Whitefish from WFM-05 are currently of small to moderate size. Mean weight at age is trending down in recent years. From 2000 to 2009, the proportion of the yield made up of the three size classes of whitefish were 76% No.1 (< 3 lb), 18% mediums (3-4 lb), and 6% jumbos (≥ 4 lb). In comparison, from 1980 to 1989, 65% were classified No.1, 22% mediums, and 13% jumbos and from 1990-1999, 65% No.1, 20% mediums, and 15% jumbos.

As illustrated earlier, size structure of whitefish in the yield from WFM-05 has changed over time, as the proportion of jumbos declined and the proportion of No.1 whitefish increased. Annual mean weight of whitefish sampled from trap-net harvests ranged from 2.0 to 3.6 lb since 1979 and averaged 2.68 lb during the last three years (2008-2010). Annual mean weight of whitefish in the gill-net harvest ranged from 2.4 to 3.5 lb since 1979 and averaged 2.95 lb during the last three years (2008-2010).

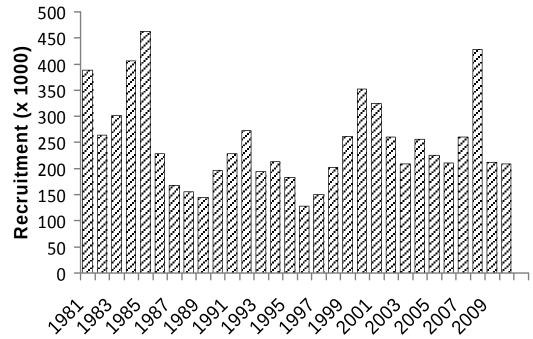
Mean weights of lake whitefish (ages 3-9) from WFM-05 declined from 1981 through the 1990s. This pattern of declining growth is also being observed in other areas of Lakes Michigan and Huron, including substantial declines in areas adjacent to this management unit. In recent years, there has been an observed increase in size at age of older fish in this unit.

Lake whitefish population mean weight-at-age WFM-05



Recruitment of age-3 whitefish to the population in WFM-05 is highly variable and has generally declined since the mid-1980s based on estimates from the stock assessment model. Following relatively high recruitment of age-3 whitefish into the population at the beginning of the time-series, estimated recruitment declined significantly, but has held relatively stable over the past 20+ years.

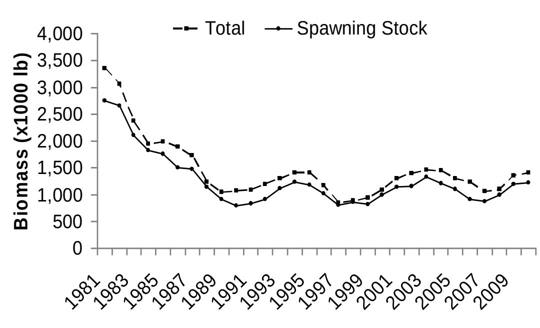
Lake whitefish recruitment (age- 3) WFM-05



During 1981-1985 average estimated recruitment was 364,000 fish (range 264,000 to 463,000). Since then, estimates have ranged between 128,000 and 429,000, with an average of 268,000 age-3 fish entering the fishery annually from 2000-2010.

Biomass of whitefish estimated with the stock assessment model declined through the 1980s. Annual biomass of whitefish age 3 and older (calculated at the beginning of each year) peaked at the beginning of the 1981-2009 timeframe with 3.4 million lb. Biomass steadily declined to 1.05 million lb in 1989 and has ranged from 850,000 to 1.47 million lb from 1990 to 2010. Spawning stock biomass followed the same trend, peaking at 2.8 million lb in 1981 before declining through the remainder of the decade. Since 1990 spawning stock biomass has been relatively steady, between 819,000 and 1.32 million lb.

Estimated lake whitefish biomass WFM-05



From 1981-1998, the combined commercial fishing mortality (*F*) met or exceeded natural mortality in this unit.

Since l998, *F* dropped to an annual level generally less than that of natural mortality. Fishing mortality within this unit has been dominated by gill nets; however during the late 1990s trap net approached or surpassed gill-net mortality. Since then, both gill-net and trap-net mortality have held relatively steady at a reduced level, with an increase in trap net mortality observed since 2006. Instantaneous fishing-induced mortality on whitefish age 4 and older averaged 0.12 for the large-mesh gill-net fishery and 0.09 for the trap-net fishery during 2008-2010. Gill net-induced fishing mortality ranged from 0.34 in 1983 to 0.06 in 2006, while trap-net-induced fishing mortality ranged from 0.01 as recently as 2004 to 0.28 in 1998. The gill-and trap-net mortality level has declined from a combined rate of 0.59 in 1996 to a low of 0.12 in 2000.

Total instantaneous mortality on the fishable stock in WFM-05 during 2008-2010 was substantially less than the target rate of 1.05. Total instantaneous mortality was estimated to be 0.464 during 2008-2010 and the spawning potential reduction value was 0.488.

Model Changes and Diagnostics – To generate the 2012 yield limit, the model data file was updated with biological data through 2010. No structural changes were made to the base model for the 2012 assessment. The model reached convergence and was not sensitive to changes in initial conditions (q and popscaler) and MCMC diagnostics were reasonable. The model fit to harvest and effort was acceptable, but the fit to the fishery age compositions was slightly problematic in the last few years of the assessment. A retrospective analysis of biomass demonstrated improved agreement over recent assessments, most likely due to better resolution of the size of the 2005 year class. The 2012 assessment model was given a medium rating. Incorporation of the recreation yield into the WFM-05 assessment remains an outstanding issue. A modified version that combined recreational fishery yield and commercial gill-net fishery yield was constructed in an attempt to account for recreational extractions in a simplified manner (commercial GN effort was adjusted proportionally). This approach did not result in population rescaling- stock size scaled upward in a predictable manner, resulting in a similar TAC to the base assessment once projected recreational yield was subtracted. Work will continue on this aspect of the assessment.

The 2012 model-generated yield limit of 396,000 lb was largely unchanged from the 2011 model limit of 399,000 lb. Since overall mortality is well below target, the projection model estimated that fishing effort could be increased approximately three-fold during 2012 from the average during 2008-2010.

Summary Status WFM-05 Whitefish	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	0.94 lb
Age at first spawning	4 y
Size at 50% maturity	1.87 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.91 lb (2.90 – 2.92)
Current SSBR	1.42 lb (1.34 – 1.50)
SSBR at target mortality	0.172 lb
Spawning potential reduction	
At target mortality	0.488 (0.462 – 0.516)
Average yield per recruit	0.689 lb (0.660 – 0.715)
Natural mortality (*M*)	0.252 y^{-1}
Fishing mortality rate 2008-2010	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.120 y^{-1} (0.106 – 0.135)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.092 y^{-1} (0.081 – 0.103)
Sea lamprey mortality (ML)	NA
Total mortality (*Z*)	
(average ages 4+, 2008-2010)	0.464 y^{-1} (0.441 – 0.489)
Recruitment (age 3)	
(average 2001-2010)	262,592 fish (227,358 – 304,278)
Biomass (age 3+)	
(average 2001-2010)	1,312,533 lb (1,202,330 – 1,435,630)
Spawning biomass	
(average 2001-2010)	1,118,316 lb (1,028,520 – 1,217,660)
Model Recommended yield limit in 2012	396,000 lb
Actual yield limit in 2012	396,000 lb

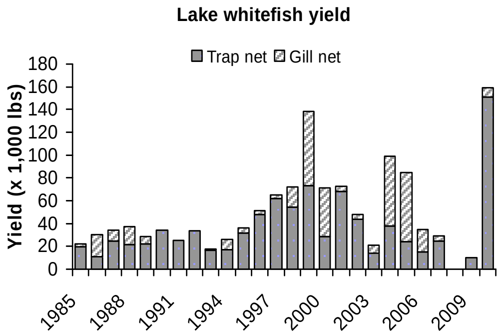
WFM-06 (Leland - Frankfort)

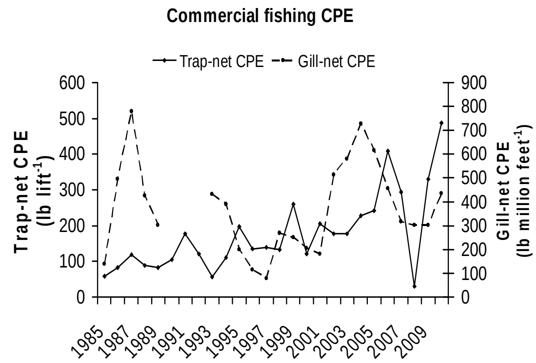
Prepared by Randall M. Claramunt and David C. Caroffino

Lake whitefish management unit WFM-06 is located in 1836 Treaty waters west of the Leelanau Peninsula from about Cathead Point south to Arcadia. Surface area for this unit is 945,156 acres (including part or all of grids 709-714, 808-814, 908-912, and 1008-1011). These waters of Lake Michigan include Good Harbor Bay, Sleeping Bear Bay, and Platte Bay. Two large islands, North Manitou and South Manitou, are contained in this management zone, as are three large shoal areas including North Manitou Shoal, Pyramid Point Shoal, and Sleeping Bear Shoal. Major rivers flowing into WFM-06 include the Platte, and the Betsie. Betsie Lake is a drowned river mouth formed where the Betsie River flows into Lake Michigan. Except for areas near shore or around the islands, most of the waters in WFM-06 are deep (>200 ft). Bays, islands, and shoal areas offer the best habitat for lake whitefish spawning in this management area.

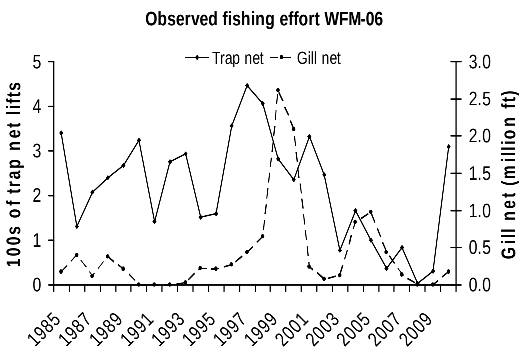
WFM-06 was reserved for state licensed commercial trap-net fishing operations from 1985 through 1999, except that tribal gill netting was allowed in grid 714. Most state-licensed trap-net effort and harvest has been reported from grids 812-814 and 912. Beginning in 2000, all of WFM-06 became a shared zone, and waters were opened to both state and tribal fishers. Between 2000 and 2008, effort by state-licensed fishers declined substantially in this unit, and the majority of yield came from tribal fishers. Effort and harvest by state-licensed fishermen has increased in the last two years and is expected to remain stable in the coming years. An important regulation change in the state fishery occurred in 2005, as the depth restriction was modified to allow state-licensed trap-net fishers to set nets at depths up to 130 feet instead of being restricted to 90 feet. Starting in August of 2010, the regulation was modified again, allowing state fishers to set trap nets in up to 150 feet of water.

Total yield in WFM-06 increased sharply from 9,884 lb in 2009 to 158,531 lb in 2010. This was due to increased effort by state fishers and the completion of a new marina in Leland, which reestablished access for tribal fishers. Tribal yield accounted for 93,290 lb of the total, the remaining 65,241 lb was associated with the state commercial fishery. The state commercial fishery exceeded its total allowable catch in 2010 by 3,241 lb, although the total yield in the unit for all parties was only 77% of the total allowed. The combined level of yield in this unit in 2010 was the highest recorded since the inception of the Consent Decree and the highest since 1981. The proportion of yield by gear type was 95% trap net and only 5% gill net. This represented a higher proportion of trap-yield than the historical average (73%).



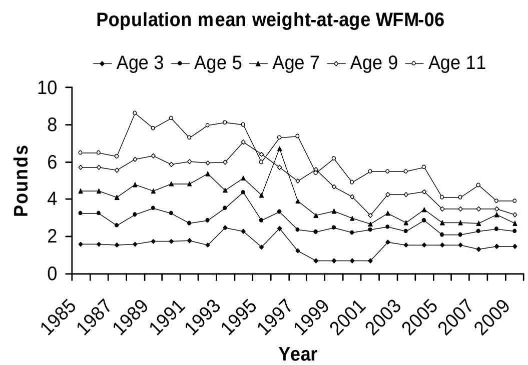


The increase in yield in 2010 was a result of increased effort. In total, 310 trap-net lifts were made by state and tribal commercial fishers, representing a 10-fold increase over 2009 and the most since 2001 (332 lifts). Gill-net effort also increased in 2010 to 176,800 ft, although this was still below the long-term average of 444,200 ft.



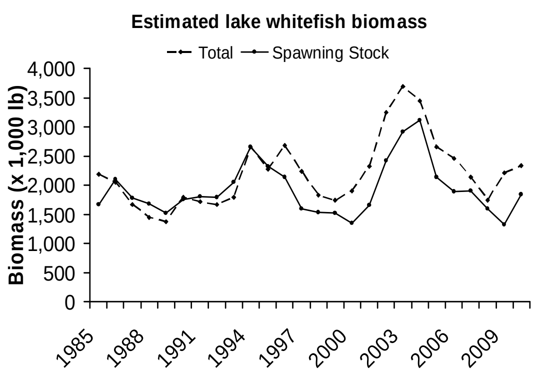
Catch-per-unit-effort (CPUE) is generally variable in this unit. In 2010 the trap-net CPUE was the highest ever recorded (488 lb lift^{-1}), which is what allowed the peak yield to occur, even though trap-net effort was near the long-term average. Gill-net CPUE in 2010 was 434 lb 1000 ft^{-1}, slightly higher than the long-term average of 370 lb 1000 ft^{-1} but much lower than the peak of 780 lb 1000 ft^{-1} set in 1987.

Weight-at-age declined substantially between 1996 and 2005, and although current averages are well below those of the 1980s and early 1990s, the most recent values are increasing. In 2010 weight-at-age was on average approximately 13% higher than 2009 values.

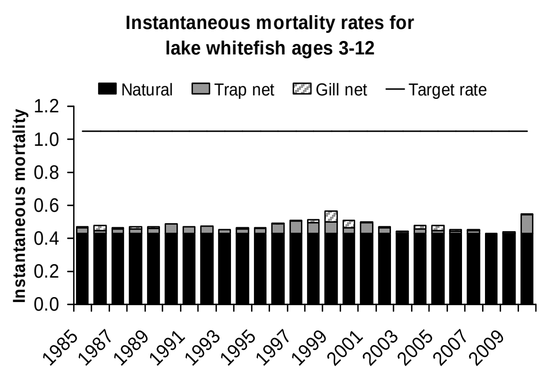


Recruitment, based on estimated numbers of age-3 fish, decreased from 834,000 fish in 2009 to 384,000 fish in 2010. Recruitment in 2010 was lower than the long-term average of 408,000 fish. Periods of high recruitment were observed during 2000-2002, and low recruitment was observed during 1987-88 and 2007-2008.

Estimates of total biomass and spawning stock biomass have roughly paralleled each other throughout the time series, and they largely reflect changes in the estimates of recruitment. In 2010 spawning stock biomass estimates stopped their five-year decline and increased approximately 40% to 1.8 million lb. This increase may have been due to a combination of increasing weight at age and a rescaling of recent recruitment estimates. The total biomass estimate for 2010 also increased from 2009 and was 2.3 million lb, slightly higher than the long-term average of 2.2 million lb.



Total instantaneous mortality rate (*Z*) in 2010 was 0.52 y^{-1}; higher than both the 2009 value (0.43 y^{-1}) and the long-term average (0.47 y^{-1}). Instantaneous fishing mortality rates (*F*) have varied considerably for trap nets and gill nets throughout the time series. During 2010, *F* for the trap-net fishery was higher than that observed at any point of the time series (0.09 y^{-1}). The fishing mortality associated with gill nets was 0.005 y^{-1}. Even though this is an extremely low value, it is the highest observed since 2005. The 2010 estimate for instantaneous natural mortality rate was 0.43 y^{-1}, which is still the largest source of lake whitefish mortality in WFM-06. Natural mortality (*M*) is estimated using the Pauly equation based on growth parameters (K, L∞) for the stock and water temperature of 6º C. The rate is assumed to be constant over time, but is updated annually during each stock assessment. In 2010, the growth parameters were estimated at 57.1 for L∞ and 0.43 for K based on survey data from the entire time series (1985-2010) to represent growth conditions for this stock.



The 2012 model generated limit was 540,600 lb. Because the model performed poorly due to limited data inputs, the TFC continued the harvest policy established for 2011. The 2012 TAC was set at 250,000 lb, with 185,000 lb allocated to the tribal fishery and 65,000 lb allocated to the state commercial fishery. Even with the highest harvest of the time series occurring in 2010, fishing mortality and effort could increase from 2010 levels.

Summary Status WFM-06 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.65 lb
Age at first spawning	3 y
Size at 50% maturity	2.46 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.63 lb (0.003 SE)
Current SSBR	1.48 lb (0.044 SE)
SSBR at target mortality	0.41 lb (0.002 SE)
Spawning potential reduction	
At target mortality	0.25 (0.001 SE)
Average yield per recruit	0.11 lb (0.044 SE)
Natural mortality (*M*)	0.432 y^{-1}
Fishing mortality rates	
Fully selected age to gill nets	6 y
Fully selected age to trap nets	6 y
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.002 y^{-1} (0.001 SE)
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.035 y^{-1} (0.009 SE)
Sea lamprey mortality (ML) (average 2008-2010, ages 4+)	N/A
Total mortality (*Z*) (average 2008-2010 ages 4+)	0.469 y^{-1} (0.01 SE)
Recruitment (age 3) (average 2001-2010)	509,000 fish (102,862 SE)
Biomass (age 3+) (average 2001-2010)	2,620,000 lb (199,641 SE)
Spawning biomass (average 2001-2010)	2,080,000 lb (182,201 SE)
Recommended yield limit in 2012	546,000 lb
Actual yield limit for 2012	250,000 lb

WFM-07 (Ludington)

Prepared by Ken LaHaye and Marty Holtgren

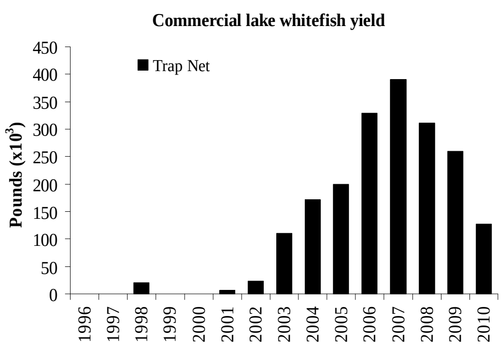
Lake whitefish management unit WFM-07 is located within the 1836 Treaty Ceded Waters of eastern central Lake Michigan from Arcadia in the north to just south of Stony Lake, and west to the Michigan/Wisconsin state line bisecting the middle of the lake. This lake whitefish management unit includes part or all of grids 1107-1111, 1207-1211, 1306-1310, 1406-1410, 1506-1510 and 1606-1609. The surface area for this unit is 1,286,940 acres (2,011 square miles) of which 274,943 acres (430 square miles) have bottom depths of 240 feet or less, with maximum depths up to 900 feet. There are several inflows from the Big Manistee, Little Manistee, Big Sable, Pere Marquette, and Pentwater Rivers, and drowned river mouths at Manistee Lake, Pere Marquette Lake, and Pentwater Lake.

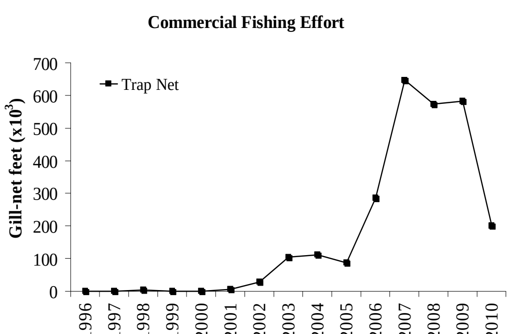
Since 2000, WFM-07 has been a Tribal commercial fishing zone for lake whitefish, part of the Little River Zone with tribal fishing regulated by the Little River Band of Ottawa Indians (LRBOI). From 1985 through 2000, there was no significant State commercial fishing effort and no Tribal commercial effort for lake whitefish within this unit. The current regulations prohibit the use of large-mesh gill nets and allow for use of trap nets for commercial lake whitefish exploitation.

There has been no statistical catch-at-age modeling of the lake whitefish stock in WFM-07 due to a lack of long-term commercial catch-at-age information. Pursuant to the 2000 Consent Decree, the tribes were allowed three years of commercial fishing without harvest limits in this unit during 2001-2003. During this three-year period, commercial fishing was limited by an effort restriction of two trap-net operations with twelve nets each.

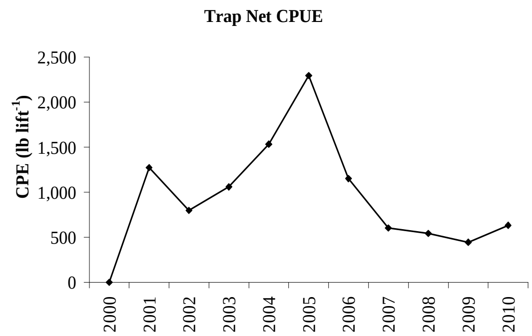
At the conclusion of the 2003 fishing season, three years of commercial trap net fishing activity for lake whitefish was completed by Tribal fishers within this unit. Following the 2000 Consent Decree and the Tribal Management Plan, an annual Harvest Regulation Guideline (HRG) for lake whitefish was developed for this management unit beginning in 2004. Additionally, the Chippewa Ottawa Resource Authority (CORA) adopted additional effort limitations of 4 trap-net permits with a maximum of 12 nets per permit for this unit.

The 2001-2010 average lake whitefish commercial harvest within this unit has been 192,778 lb (Range: 6,361-389,997 lb.). In 2001 Tribal commercial fishing activities began, with effort only occurring in October and November. A total harvest of 6,361 lb from 5 trap-net lifts was reported. In 2002 Tribal commercial harvest was 23,165 lb with 29 trap-net lifts. By 2003, Tribal commercial fishing was distributed across the fishing season and harvest and effort increased to 68,383 lb and 104 trap-net lifts, respectively. Commercial lake whitefish activity continued to increase in 2004 with a harvest of 204,142 lb, from an effort of 112 trap-net lifts. In 2005, harvest was steady (199,570 lb), but effort declined (87 trap-net lifts). In 2006, both harvest (329,270 lb) and effort (286 trap-net lifts) increased. Commercial lake whitefish yield in WFM-07 reached its highest level in recent years, with 389,997 lb of harvest and 647 trap-net lifts reported in 2007. In 2008, lake whitefish yield was 311,413 lb with an effort of 573 trap-net lifts. The 2009 lake whitefish yield was 258,942 lb, with an associated effort of 582 trap-net lifts. This represents a decline from harvest recorded during 2006 to 2008, yet effort increased slightly from 2008 levels. The 2010 lake whitefish yield was 127,229 lb with an associated effort of 201 trap net lifts, both lower than 2009.

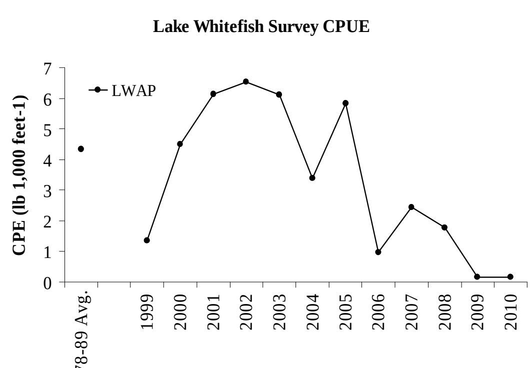




Commercial trap net catch-per-unit-effort (CPUE) for lake whitefish reached a peak of 2,294 lb lift^{-1} in 2005 and showed a declining trend through 2009 to 445 lb lift^{-1}. The 2010 CPUE of 633 lb lift^{-1} was a slight increase when compared to 2007-2009. Trap-net CPUE for lake whitefish was lower during 2006-2010 than it was during 2001-2005. The 2001-2010 average CPUE was 1,033 lb lift^{-1} (Range: 445-2294 lb).

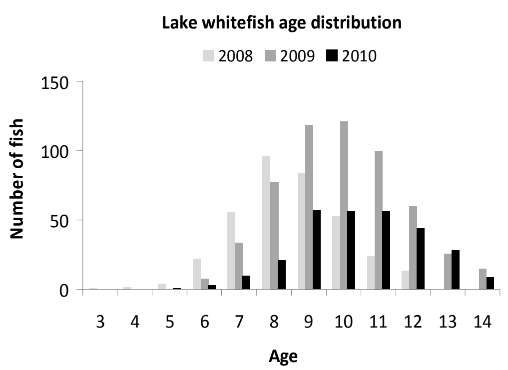


Fishery-independent surveys were conducted during the spring with graded-mesh gill nets (GMGN) following the Lakewide Assessment Plan (LWAP). From 1999 to 2008, GMGN CPUE (number 1000 ft^{-1} of GMGN) for lake whitefish were 1.4, 4.5, 6.1, 6.5, 6.1, 4.3, 5.8, 0.97, 2.45, and 1.77, respectively. In 2009 and 2010 only 2 lake whitefish were caught during the LWAP surveys for each year, resulting in a CPUE near zero. The 2009 and 2010 CPUE for lake whitefish have been the lowest recorded since the GMGN assessments were instituted. From 2000-2005 the average CPUE for lake whitefish in WFM-07 was higher than that reported for similar surveys conducted during the 1980s.

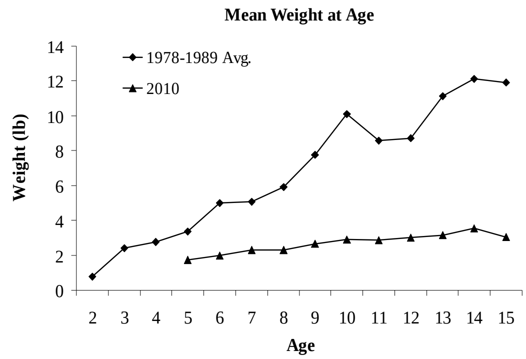


Commercial monitoring during 2004-2010 has shown that whitefish are maintaining a mean total length of over 20”, larger than the 2001-2003 observations. However, the current mean total length in this unit is below the 1978-1989 survey and 1983 commercial samples, which averaged over 23”.

Similar to average total length, the mean weight of lake whitefish from the commercial samples (2.68 lb) in 2010 is currently lower than the 1978-1989 survey average (6.84 lb) and the 1983 commercial samples (5.54 lb). The mean age of lake whitefish from the 2010 commercial samples was 10.5 y. The current data indicate the lake whitefish population has an older mean age compared to the 1978-1989 GMGN survey mean of 4.8 y and the 1983 commercial sample of 7.3 y.



Lake whitefish mean weight-at-age from 2010 survey and commercial samples was lower than the 1978-1989 survey average. This follows a similar trend that has been observed from 2000 to present.



The lake whitefish stocks within WFM-07 have relatively low exploitation rates as compared to other management zones in northern Lake Michigan. Recent survey data indicates the abundance of lake whitefish may be decreasing within this management unit when compared to historical observations of relative abundance. The results from the spring GMGN surveys and the commercial harvest, when compared to historical information, shows signs of decreased weight-at-age and increased mean age of the population. Also the stock is showing indications of relatively stable mean size at age since 2000, though currently below historical averages.

The 2011 WFM-07 lake whitefish HRG of 500,000 lb was developed and recommended by the LRBOI and adopted by CORA. The HRG has been set at this level since 2004 and was established by examining the status of the lake whitefish population (e.g., catch rates, mean size at age) and the harvest limits established for the adjacent whitefish zones (WFM-06 and WFM-08).

Year	Gear	Mean TL (Inch)	Mean Wt (Lb)	Mean Age
1978-1989 Avg.	GMGN	23.34	6.84	4.8
1983	CF	23.32	5.54	7.3
2000	GMGN	18.61	2.22	6.1
2001	GMGN	18.96	2.37	9.9
2001	CF	19.89	2.76	10.9
2002	GMGN	18.44	2.33	8.9
2002	CF	19.34	2.69	9.7
2003	GMGN	19.14	2.38	8.4
2003	CF	19.68	2.52	11.5
2004	GMGN	20.68	3.02	10.6
2004	CF	20.21	2.77	9.2
2005	GMGN	17.99	2.37	7.7
2005	CF	20.31	2.86	10.9
2006	GMGN	19.20	2.70	10.8
2006	CF	20.15	2.58	7.8
2007	GMGN	20.95	3.12	8.8
2007	CF	20.27	2.65	9.0
2008	GMGN	19.89	2.89	8.3
2008	CF	20.53	2.74	8.6
2009	CF	20.30	2.85	9.9
2010	CF	20.48	2.68	10.5

GMGN – Graded mesh gill net survey CF – Commercial fish survey

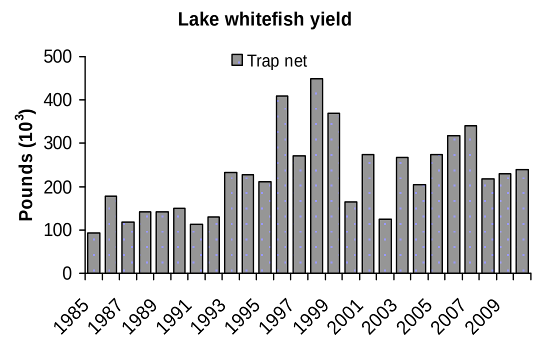
WFM-08 (Muskegon)

Prepared by Randall M. Claramunt and David C. Caroffino

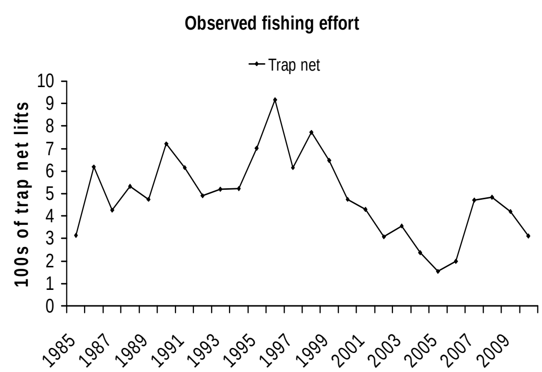
Management unit WFM-08 is the Lake Michigan whitefish zone from about Montague south past Port Sheldon. WFM-08 has a surface area of 1,506,880 acres in Michigan grids 1706-1710, 1806-1810, 1906-1911, and 2006-2011. Apart from the shoreline, inflows from the White, Muskegon, and Grand rivers, and drowned river mouths at White Lake, Muskegon Lake, Mona Lake, and Pigeon Lake, this area has few other distinguishing features relevant to lake whitefish biology. Depth gradients west from shore are relatively gradual, but most of the waters in WFM-08 are 200 ft deep or deeper. More than three quarters of the trap-net effort and over 80% of the trap-net harvest is reported from grid 1810. Although commercial exploitation and monitoring have occurred for many years, little is known about reproductive biology of the WFM-08 lake whitefish stock. Fish in this area are near the southern end of the distribution for lake whitefish.

Two state-licensed trap-net fishers operate in WFM-08, where minimum length for whitefish in commercial catches was 19 inches total length (TL) through 1999 and 17 inches thereafter. Other management zones have had a 17-inch minimum TL size limit throughout the time series. Through 2010 there has been no gill-net harvest of lake whitefish in WFM-08, and this unit is primarily a trap-net fishery. An important regulation change since 2000 was a modification of the depth restriction in 2005, allowing state-licensed trap-net fishers to fish in water depths up to 130 feet instead of being restricted to 90 feet. Starting in August of 2010, state-licensed trap-net fishers were allowed to fish up to depths of 150 feet.

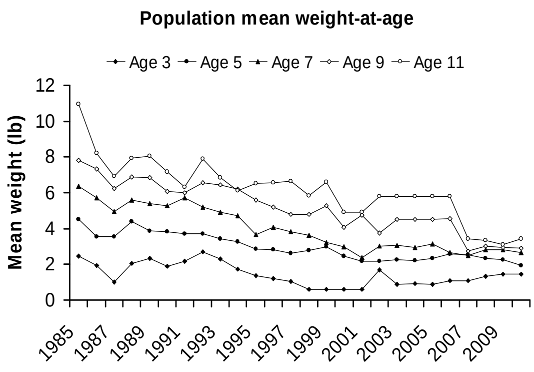
Lake whitefish yield from WFM-08 in 2010 was 238,900 lb. In 2010, yield increased slightly from 2009 (229,000 lb), and was just above the 1985-2010 average of 226,000 lb.



After increasing by more than 200% between 2005 and 2008, trap-net effort has declined and was 311 lifts in 2010. The current level is below the long-term average of 390 lifts.

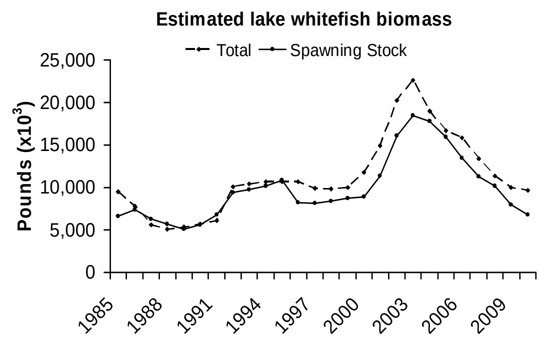


Weight-at-age data trended downward from 1985 through 2003. After 2003, weight-at-age appeared to stabilize for most of the age groups, although biological data for the older age groups is limited and appears to be decreasing during the last three years in the time series. Overall, weight-at-age values in 2010 are relatively unchanged from 2009 and are approximately 25% lower than the long-term average for ages 4-9 from 1985-2009.

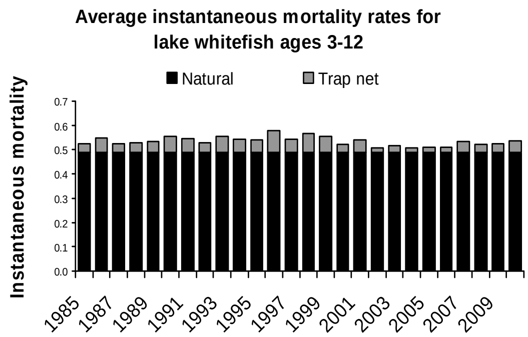


Recruitment, based on the estimated number of age-3 fish, was 2.8 million in 2010. Estimates of recruitment were considerably higher during 1999-2003 (averaged 5.9 million and peaked at 8.9 million), but the estimate for 2010 was slightly above the 1985-2009 average of 2.7 million age-3 fish.

Until 2003, estimates of total fishable biomass and spawning stock biomass continued along increasing trends that had persisted since the early 1990s. The peak of the biomass estimates followed the peak in recruitment. After 2004, both fishable biomass and spawning stock biomass began to decline, as a result of aging strong year classes and fewer recruits entering the population. The stock may have experienced density-dependent controls as total biomass decreased from 22.6 million lb in 2003 to an estimated 9.6 million lb in 2010. Spawning stock biomass followed a similar decline from 18.5 million lb in 2003 to 6.8 million lb in 2010. The ratio of spawning stock biomass to total biomass (age 3+) was 0.70 in 2010, which is lower than the 1985-2009 average ratio of 0.89.

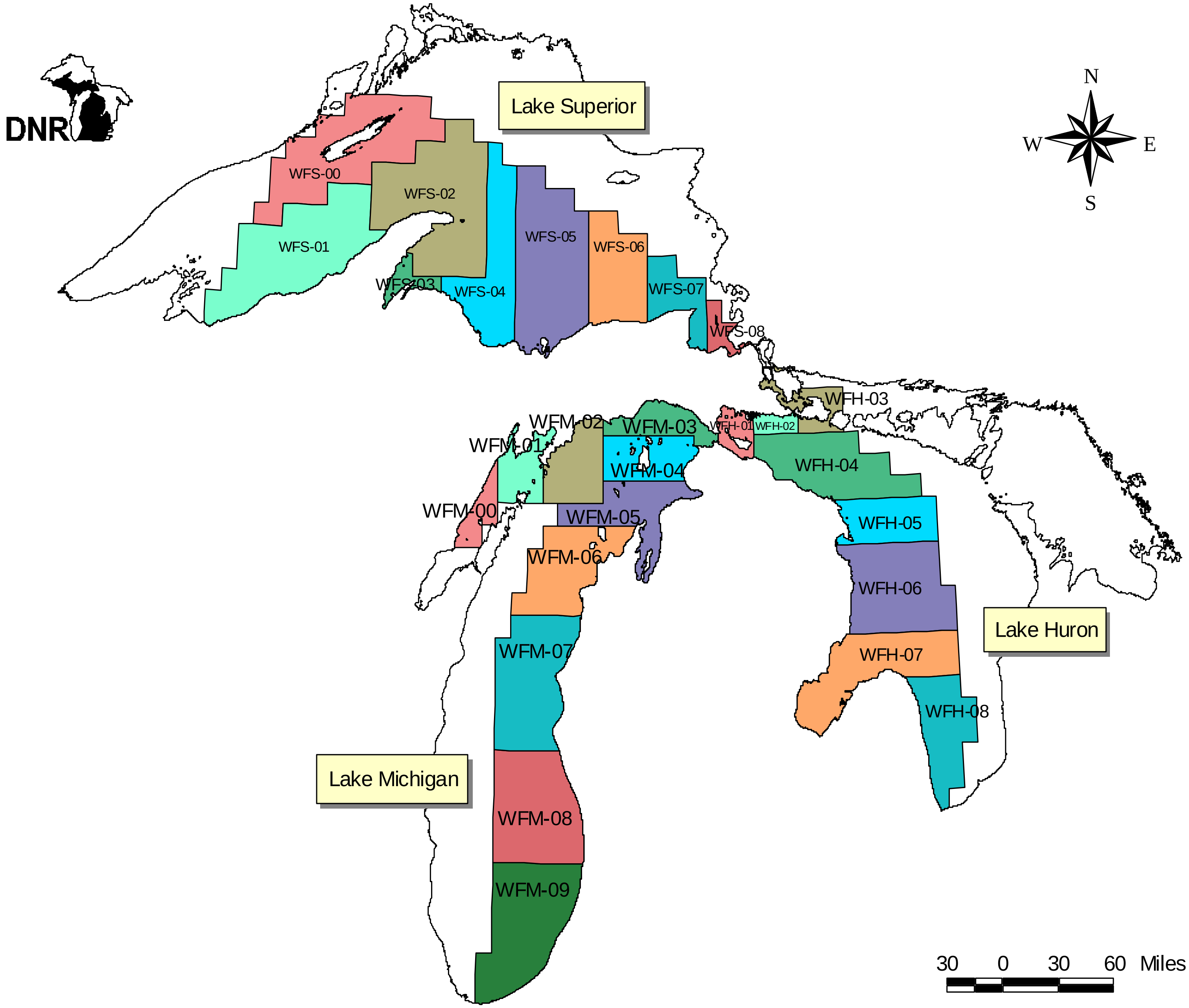


Mortality rates have been relatively stable throughout the time series. Instantaneous total mortality (*Z*) was estimated at 0.536 y^{-1} during 2010, below the target mortality rate of 1.05 y^{-1}. Components of the total rate consisted of 0.046 y^{-1} for instantaneous trap-net fishing mortality (*F*) and 0.490 y^{-1} for instantaneous natural mortality (*M*). Estimates of mortality have been very consistent from 1985-2010 and the ratio of *F* to *Z* averaged 0.089 from 1985 through 2009. Natural mortality (*M*) is a major source of lake whitefish mortality in WFM-08 and *M* is estimated using the Pauly equation based on growth parameters (K, $L\infty$) for the stock and water temperature of 6ºC. The rate is assumed to be constant over time, but is updated annually during each stock assessment. In 2010, the growth parameters were estimated at 54.2 for $L\infty$ and 0.51 for K based on survey and commercial data from the entire time series (1985-2010) to better represent growth conditions for this stock.

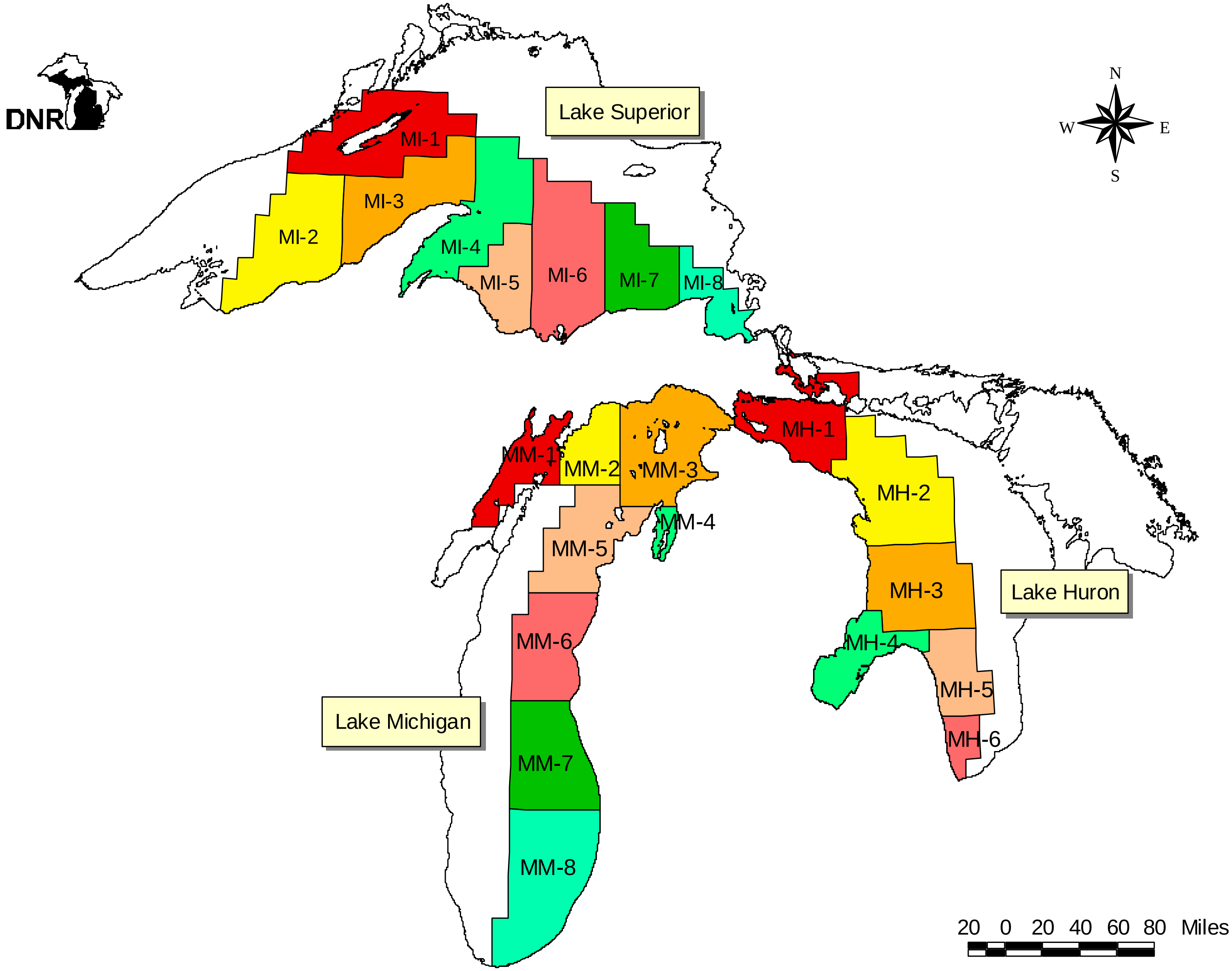


The 2012 yield limit for WFM-08, calculated using the projection model, was 1,628,400 lb (500,000 lb for state-licensed fishers and 1,128,400 lb for tribal fishers).

Summary Status WFM-08 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.57 lb
Age at first spawning	3 y
Size at 50% maturity	1.85 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	0.952 lb (0.002 SE)
Current SSBR	0.87 lb (0.023 SE)
SSBR at target mortality	0.28 lb (0.0002 SE)
Spawning potential reduction	
At target mortality	0.29 (0.001 SE)
Average yield per recruit	0.07 lb (0.019 SE)
Natural mortality (*M*)	0.490 y^{-1}
Fishing mortality rates	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	7 y
Gill net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0 y^{-1}
Trap net fishing mortality (*F*)	
Average 2008-2010, ages 4+	0.041 y^{-1} (0.003 SE)
Sea lamprey mortality (ML)	
(average 2008-2010, ages 4+)	N/A
Total mortality (*Z*)	
(average 2008-2010, ages 4+)	0.532 y^{-1} (0.003 SE)
Recruitment (age 3)	
(average 2001-2010)	3,680,000 fish (746,037 SE)
Biomass (age 3+)	
(average 2001-2010)	15,400,000 lb (1,385,180 SE)
Spawning biomass	
(average 2001-2010)	12,900,000 lb (1,285,878 SE)
Recommended yield limit in 2012	1,628,400 lb
Actual yield limit for 2012	1,628,400 lb



Appendix 1. Lake whitefish management units.



Appendix 2. Lake trout management units.