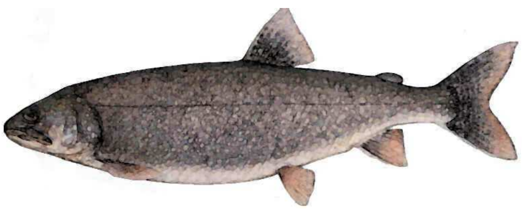
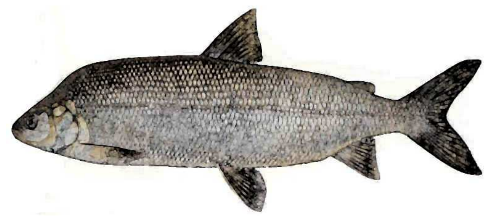
Technical Fisheries Committee Administrative Report 2011: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron, and Michigan, with Recommended Yield and Effort Levels for 2011





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

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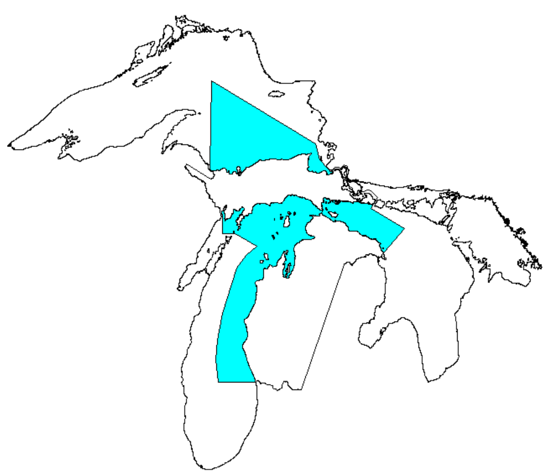
Editors



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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. In management units where the state and tribes share the commercial whitefish harvest, maximum whitefish mortality rates are regulated with yield limits for each party. The Consent Decree provides specific guidelines on how these yield and effort limits are to be calculated. 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 2011, 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 2011 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, 45, or 47%, 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 2011 specified in the Consent Decree.

The 2011 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 harvest regulation guidelines (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	109,646	109,646	NA
		MI-6	118,372	118,372	3,182,000
		MI-7	72,903	80,911	3,112,000
	Huron	MH-1*	436,856	245,000	
		MH-2	94,365	91,804	NA
	Michigan	MM-123*	0	503,000	15,675,000
		MM-4*	73,231	214,626	1,193,000
		MM-5*	119,169	119,169	470,000
		MM-67	362,570	362,570	NA
Lake whitefish	Superior	WFS-04	95,000	95,000	NA
		WFS-05	408,000	408,000	NA
		WFS-06	No model estimate	210,000	NA
		WFS-07	871,500	514,000	NA
		WFS-08	167,700	167,700	NA
	Huron	Northern Combined	719,600	719,600	NA
		WFH-05	1,142,000	758,300	
	Michigan	WFM-01	3,644,000	3,644,000	NA
		WFM-02	1,580,500	558,000	NA
		WFM-03	2,510,000	2,510,000	NA
		WFM-04	702,000	702,000	NA
		WFM-05	399,000	399,000	NA
		WFM-06	604,000	250,000	NA
		WFM-07	No model estimate	500,000	NA
		WFM-08	1,300,200	1,300,200	NA

*Units with stipulated harvest limits

In 2011, the MSC continued the model rotation plan for three lake trout units. Full stock assessments were not completed for MI-7, MH-2, and MM-67. Output from the 2009 full assessment was used along with current harvest and sea lamprey mortality information to project the population forward to the current year. The mortality provisions of the Consent Decree were then applied to the current population to estimate safe harvest limits for 2011. Full stock assessments in these units are next scheduled for 2012.

Lake Superior contains self-sustaining stocks of lean lake trout, 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 0.08 y^{-1} in MI-5 but remains high (above 0.14 y^{-1}) in MI-6 and MI-7 and is generally 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. 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. However, a summary of this unit and its fishery is included in this report.

Evidence for widespread natural reproduction in Lake Huron continues to be found in all data sources. In 2010, unclipped fish represented 13% of the commercial fishery in the U.S. waters of northern Lake Huron and 23% of the recreational lake trout fishery. In the Canadian commercial fishery the proportion of unclipped fish reached 26%. The continued presence of unclipped fish in the population warranted their inclusion into the TAC projection for management unit MH-1. 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. The stipulation agreed to by the parties in 2010 for MH-1 held the total harvest limit at 245,000 lb for 2011, despite the model predicting a higher harvest limit.

In MH-2, lake trout mortality rates remain below target. 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. This unit was again in rotation for 2011, and a full assessment was not completed.

Lamprey mortality is again becoming a concern in Lake Huron, particularly in the northern treaty waters. The estimated lamprey-induced mortality on lake trout nearly doubled in MH-1 to 0.12 y^{-1} but remained near 0.08 y^{-1} in MH-2. Increases in lamprey-induced mortality in Lake Huron will reduce the number of lake trout available for harvest. 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 2011, full assessments were run for all units except MM-67, which remained in rotation. In unit MM-123 lake trout mortality is above target. Substantial rates of sea lamprey-induced mortality (0.26 y^{-1}) continue to cause excessive total mortality rates. 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 450,000 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 2010. Total harvest declined by 25% from 2009 to 2010, and lamprey mortality declined by 14%, yet estimated spawning biomass declined for the third consecutive year. There is a Consent Decree stipulation for MM-4, which set the 2011 harvest limit at 214,626 lb, nearly three times the model recommended harvest limit.

Mortality rates in MM-5 and MM-67 are below target. In 2010 there was 20,000 lb of commercial harvest in MM-5. Although this represented only 30% of the harvest limit, it provided needed data for the model, following two years of no harvest. Lamprey mortality in MM-5 has been below 1998 baseline levels since 2004, but it increased to 0.13 y^{-1} in the most recent calculation. The potential for harvest in this unit is currently more dependent more upon behavior of the fishers rather than availability of the resource. The 2010 commercial harvest of lake trout in MM-67 declined to 4,100 lb, the lowest level since 2006. This represented only 10% of the total TAC available. Overall mortality in this unit remains well below target, as the recreational fishery only harvested 11% of its allowed TAC and lamprey mortality is below 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, and the most recent yield levels are similar to those from the early 1980s. 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 a number of 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. In 2010 the Biological Services Division of CORA still set HRGs for individual units after examination of the combined model output, but in 2011 a single HRG for the entire Northern Lake Huron unit was set.

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 northern Lake Michigan units, commercial effort and yield had generally declined since the 2000 Consent Decree was implemented, but yield has recently rebounded and 2009 yield levels were the highest they have been under the Decree in units WFM-01, WFM-03 and WFM-04. In central and southern units, yield has generally been more stable under the provisions of the Decree, though new fishing opportunities resulted in increased yield in WFM-07, which peaked in 2007 and has since declined.

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 2011, 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. An alternative harvest limit was set by the TFC. The harvest limits exceeded the peak historical harvest from this unit without setting 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 2011 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 2011 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 2011 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2011, 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 2010, but did not in 2010, 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 2011

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-2, MI-5, MI-6, and MI-7. Additionally, MH-1 was considered partially phased-in. 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 was 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 2011 TACs for MH-1, 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 2011 TACs for MI-7 and MH-2 were calculated per the Consent Decree. However, the 2011 TACs for these units changed by more than 15% compared to the 2010 TACs. The TFC agreed to restrict the change in the 2011 Harvest Limits for MI-7 and MH-2 to 15%.

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 each of the most recent three years, 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 suggested 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.

<u>Priority Technical Evaluations</u>

- 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. Nonetheless, a systemic, broad-scale review of the methodologies employed in estimating selectivity and catchability in the Treaty models is warranted and ongoing.

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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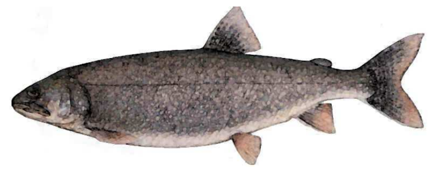
STATUS OF LAKE TROUT POPULATIONS



Lake Superior

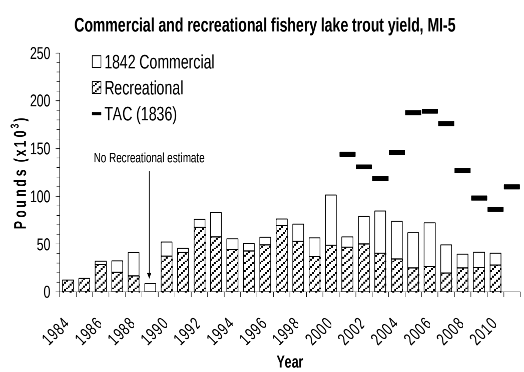
MI-5 (Marquette - Big Bay)

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 2006 to 2010, tribal yield averaged 23,700 lb and tribal large-mesh gill-net effort averaged 566,000 ft y^{-1}.

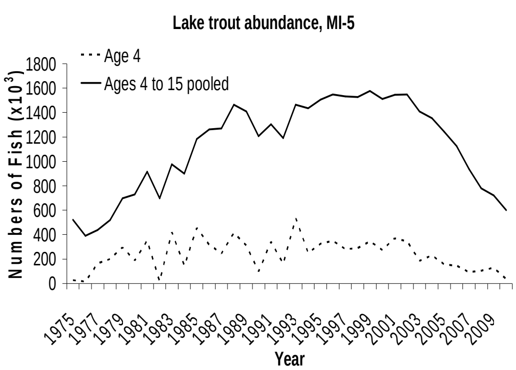
Generally, the commercial fishery is conducted from late winter through early October, with a dome-shaped selectivity with peak age between 7 and 10. The commercial fishery operates in various grids near Marquette, and the overall impacts on the MI-5 population are nominal. However, in 2000 and 2003 through 2009, 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.

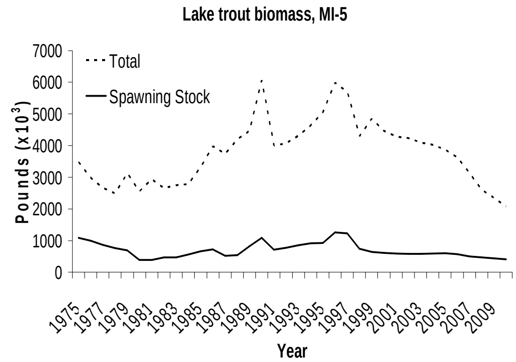


Recreational harvest of lake trout comprises both charter and sport angler fisheries. Most of this activity is centered around the port of Marquette, though some lake trout are harvested at

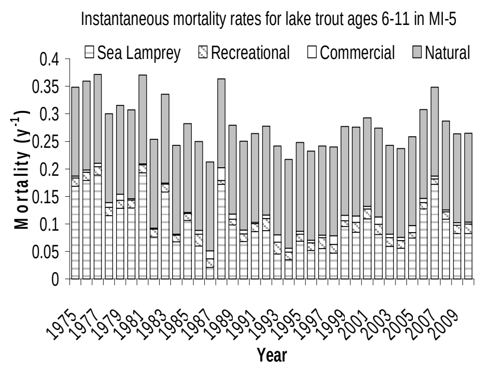
Stannard Rock. There are no seasonal restrictions on the sport fishery, though most of the fishery occurs during the months of May through October. Daily bag limits of lake trout increased from 3 to 5 fish in 2010. Recreational harvest of wild lake trout has increased from 4,400 fish (12,400 round lb) in 1984 to a peak of 15,000 fish (69,200 lb) in 1997 but has been declining since 2003. Average harvest during 2006 to 2010 was 6,200 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 1.12 million fish (age 4 and older) during 2001 to 2010. Total biomass of age-4 and older lake trout averaged 3.4 million lb during 2001-2010. Lake trout biomass declined from 5.9 million lb in 1996 to 2 million lb in 2010. Spawning stock biomass averaged 530,100 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 1981. With the exception 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 25.4% during 2008 to 2010, which has increased since the 1990s due to increases in sea lamprey mortality. Spawning stock biomass produced per recruit during 2008 to 2010 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 2011 in 1836 Treaty waters is 109,646 lb, allocated as 105,004 lb for the state recreational fishery and 4,642 lb for the tribal fishery. The recommended yield limit for 1842 Treaty waters is 152,532 lb. The 2011 TAC is higher than 2010 because of slightly higher abundance estimates in the 2011 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.

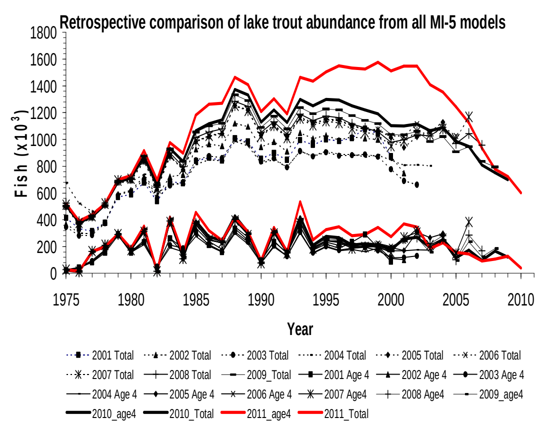
Notable stock dynamics

Commercial yield declined by more than 70% from 2006 to 2010 in MI-5. Summer survey CPUE has declined since 2004. Mean age of fish in surveys has increased in the last 10 years. The recreational fishery was similar with harvest declining by 50% and mean age increasing in the last 10 years.

Model diagnostics

As with recent models, probability intervals were not able to be calculated because of poor results from Markov Chain Monte Carlo (MCMC) simulations. Further work is underway to improve the MCMC results. Summary table quantities are reported with asymptotic standard errors.

The pattern of abundance estimates in the 2011 model was generally higher than the 2010 model. The recent assessment models (2005 through 2011) had higher abundance estimates than earlier assessment models. However, there were no systematic temporal patterns in estimates of abundance across stock assessment models.



Summary Status MI-5 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	2.34 lb
Age at first spawning	6 y
Size at 50% maturity	4.33 lb
Age at 50% maturity	10 y
Spawning biomass per recruit	
Base SSBR	5.323 lb (SE 0.525)
Current SSBR	1.71 lb (SE 0.13)
SSBR at target mortality	0.452 lb (SE 0.011)
Spawning potential reduction	
At target mortality	0.321 (SE 0.011)
Average yield per recruit	0.328 lb (SE 0.039)
Natural mortality (*M*)	0.161 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	15
Sport fishery (2008-2010)	8
Commercial fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.004 y^{-1} (SE 0.001)
Sport fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.015 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
(average ages 6-11, 2007-2009)	0.121 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2008-2010)	0.302 y^{-1} (SE 0.008)
Recruitment (age 4)	
(average 2001-2010)	179,450 fish (SE 23,724)
Biomass (age 4+)	
(average 2001-2010)	3,428,400 lb (SE 381,720)
Spawning biomass	
(average 2001-2010)	530,810 lb (SE 62,170)
MSC recommended yield limit in 2011	109,646 lb
Actual yield limit in 2011	109,646 lb

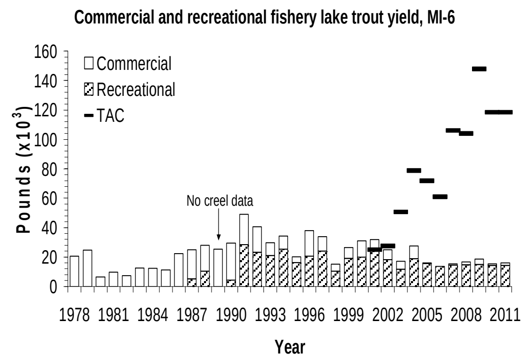
MI-6 (Au Train - Munising)

Prepared by Shawn P. Sitar

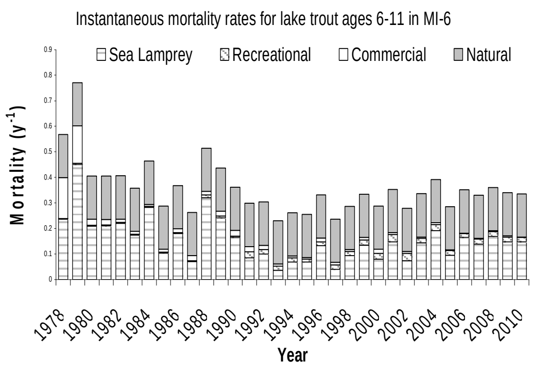
Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 1.8 million acres. This management unit includes Big Reef, an offshore reef complex about 20 miles northeast of Munising. The unit also contains the deepest waters of 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 1,500 lb during 2006 to 2010. Total effort averaged 197,000 ft during the most recent five years.

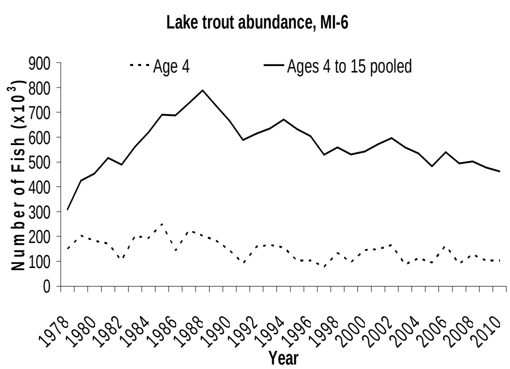
Recreational harvest of lake trout comprises fish caught by both charter and sport angling. Most of the recreational harvest was from the Au Train Bay and Grand Island areas, although some harvest was also from Big Reef. Recreational harvest of wild lake trout increased through the late 1980s and peaked at 6,300 fish (28,500 lb) in 1991. Harvest has steadily declined since 2001 and corresponded to declines in effort. During 2006 to 2010, recreational fishery harvest and effort averaged 3,600 fish (14,400 lb) and 43,100 angler hours, respectively. In the last five years, wild fish composed nearly all (>98%) of the total recreational and commercial harvest of lean lake trout.

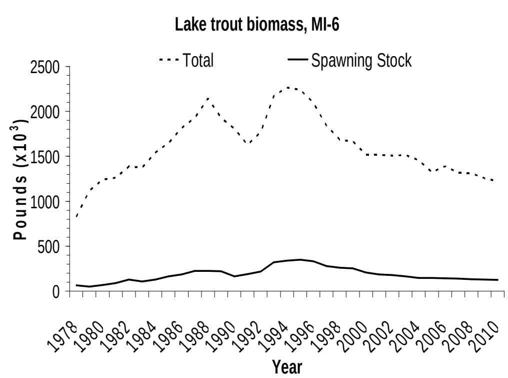


Sea lamprey mortality has been increasing since 1997, and in recent years it has been the highest mortality source for age 6 to 11 lake trout in MI-6. Average sea lamprey mortality during the last five years was nearly four fold higher than in 1997. Recreational fishing mortality has been higher than commercial fishing mortality since 1991. Fishing mortality has been relatively stable since the early 1990s and has shown further decline in recent years. Between 1978 and 2000, total annual mortality (*A*) was highest in 1979 at 56% and declined to 20% in 1993. Subsequently, *A* increased to an average of 29.2% during 2008 to 2010, which is below the target maximum rate of 45%. Total mortality has been increasing in recent years primarily due to sea lamprey mortality.



In the last five years, lake trout abundance averaged 495,000 fish, while population biomass trended downward in this unit due to declines in somatic growth. During 2001-2010, population biomass averaged 1.4 million lb while average annual spawning stock biomass was 150,000 lb. Recruitment of age-4 lake trout in the last 10 years averaged 119,400 fish.





The recommended yield limit for 2011 is 118,372 lb, of which 59,186 lb is allocated to the state recreational fishery and 59,186 lb to the tribal commercial fishery. The 2011 TAC was nearly the same as in 2010.

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 1.2% 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. There appears to be continued unidentified inconsistencies in the observed survey and fishery data sources that causes this model to scale abundance lower than what would be expected given this unit's habitat, ecology, and historical fishery. 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 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. Furthermore, Markov Chain Monte Carlo (MCMC) simulations were able to be run for MI-6 to generate probability intervals for key population quantities.

Summary Status MI-6 Lake Trout	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	2.35 lb
Age at first spawning	6 y
Size at 50% maturity	4.35 lb
Age at 50% maturity	10 y
Spawning biomass per recruit	
Base SSBR	4.616 lb (3.583-5.625)
Current SSBR	0.95 lb (0.791-1.093)
SSBR at target mortality	0.404 lb (0.379-0.423)
Spawning potential reduction	
At target mortality	0.207 (0.191-0.223)
Average yield per recruit	0.122 lb (0.092-0.168)
Natural mortality (*M*)	0.169 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	8
Sport fishery (2008-2010)	9
Commercial fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.003 y^{-1} (0.002-0.004)
Sport fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.017 y^{-1} (0.013-0.025)
Sea lamprey mortality (ML)	
(average ages 6-11, 2007-2009)	0.151 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2008-2010)	0.344 y^{-1} (0.327-0.368)
Recruitment (age 4)	
(average 2001-2010)	119,420 fish (91,229-153,309)
Biomass (age 4+)	
(average 2001-2010)	1,382,100 lb (1,063,090-1,750,770)
Spawning biomass	
(average 2001-2010)	149,740 lb (110,434-194,011)
MSC recommended yield limit in 2011	118,372 lb
Actual yield limit in 2011	118,372 lb

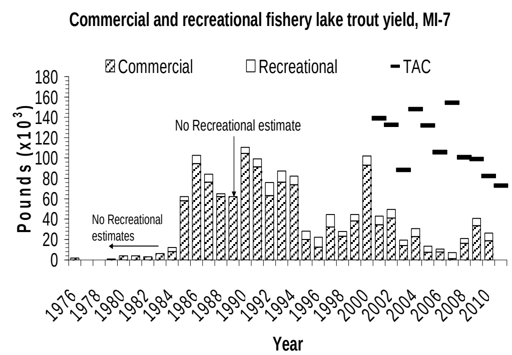
MI-7 (Grand Marais)

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 22,912 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 (3%). 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 2008 to 2010 has averaged 1.3 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 MIDNR 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 harvest of lake trout during 2008 to 2010 was about 1,700 fish (6,400 lb). The average sport effort for the same time period was 19,000 angler hours.



The 2011 TAC was based on forward projection of the 2009 stock assessment model estimates with updated sea lamprey and fishing mortality rates. Mortality rates were based on spring sea lamprey wounding rates and observed commercial and recreational harvest.

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. Commercial fishing mortality declined during 1995 to 1998, and increased between 1999 and 2000. In recent years, commercial fishing has declined to very low levels, but resurged in 2008. The most recent estimate of sea lamprey mortality for this unit is more than triple the 1997 level. 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.

The recommended yield limit for 2011 is 72,903 lb with 21,871 lb allocated to the state recreational fishery and 51,032 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. The recommended total yield limit is higher than observed yields from recent years reflecting mortality rates below target limits.

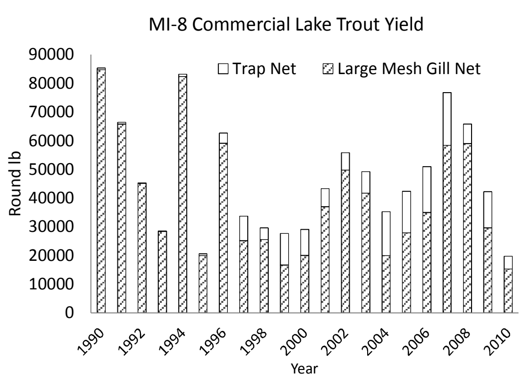
The 2011 TAC is less than the 2010 TAC because stock abundance has been on the decline since 2002, primarily due to declines in recruitment and increases in sea lamprey-induced mortality. The TFC invoked the 15% rule in 2011, which allocated actual TACs of 56,376 lb to the tribal commercial fishery and 24,535 lb to the state recreational fishery.

MI-8 (Whitefish Bay)

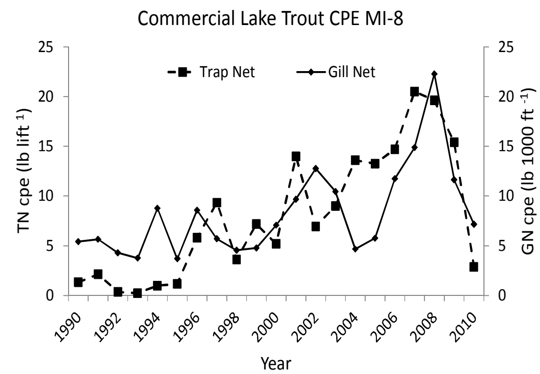
Prepared by Paul Ripple

Lake Trout management unit MI-8 extends from Little Lake harbor east into the upper Saint Marys River. This unit encompasses a total surface area of 1,180 square miles, 763 square miles of which are at depths less than 240 feet. Both tribal commercial trap-net and large-mesh gill-net fisheries operate in the unit. Whitefish is the main target species, with lake trout caught as by-catch. This unit is a deferred zone and is not managed by model-generated harvest limits.

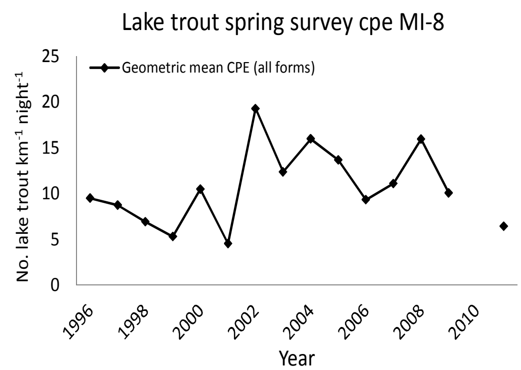
Commercial lake trout yield has fluctuated since 1990. Commercial yield of lake trout (lean and non-lean forms) in 2010 was 20,039 round lb, the lowest during the time series of 1990 to 2010. The highest commercial yield of lake trout in the time series occurred in 1990 at 85,345 round lb. The large-mesh gill-net fishery has accounted for most of the commercial yield over time.



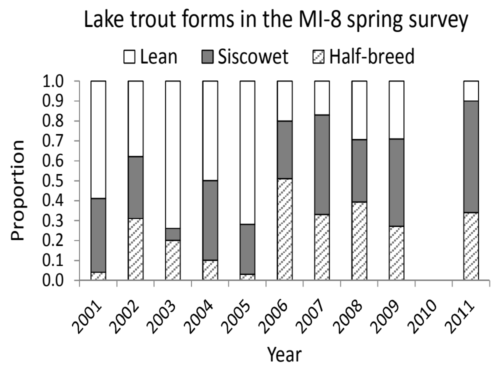
Commercial catch-per-unit-effort for both fisheries has generally increased since 1990, while dropping off in the last two years.



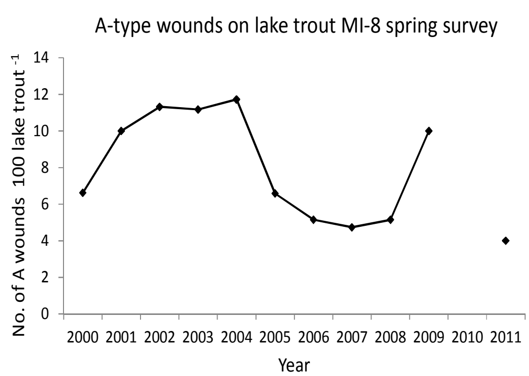
Catch rates of lake trout in the spring survey have varied over time. Catch rates of all lake trout forms peaked in 2002 (19.3 fish km^{-1} $night^{-1}$) and has generally declined since then.



Lake trout stocking ceased in 2000 in this unit and the percentage of non-lean forms in the spring assessment catch has increased since then (15% in 1997 to 90% in 2011). In 2001 Bay Mills personnel began distinguishing half-breed lake trout from other forms in the spring survey. Siscowets accounted for 56% of the total lake trout catch in 2011, the highest contribution of this form for the time series.



Sea lamprey wounding on lake trout in MI-8 was higher in the first half of the decade, peaking in 2004 at 11.7 marks per 100 fish. Wounding has since declined, though a large uptick in observed wounding from 2008 to 2009 (from 5.1 to 10.0 marks per 100 fish) was noted. Wounding declined again to 4 marks per fish in 2011.



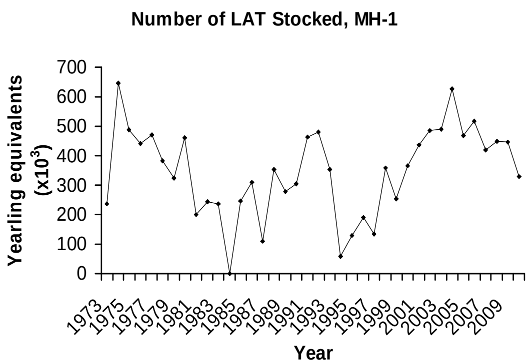
Lake Huron

MH-1 (Northern Lake Huron)

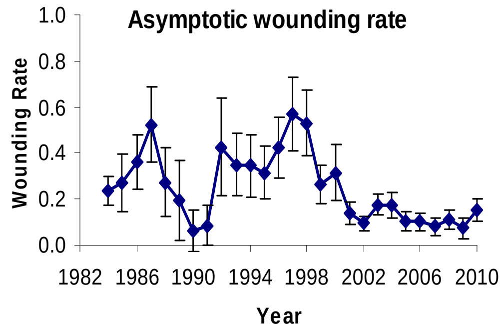
Ji X. He, Mark P. Ebener, and Adam Cottrill

Lake trout management unit MH-1 (northern Lake Huron) covers Michigan statistical district MH-1 and Ontario quota management area (QMA) 4-1, including the Drummond Island Refuge. In 2010, non-clipped lake trout comprised 13% of the tribal harvest, 26% of the Ontario harvest, 23% of the Michigan recreational harvest, 20% of the tribal and USFWS summer survey, 33% of the tribal fall survey, and 10% of the MDNR spring survey.

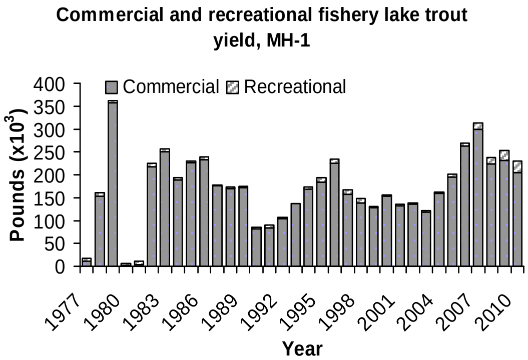
The total number of age-1 lake trout stocked into MH-1 in 2010 was 428,761, including 121,728 planted in the Drummond Island Refuge, and 99,345 planted by MDNR at DeTour. After adjusting for movements among management units within the main basin, the estimated total number of age-1 hatchery lake trout in MH-1 in 2010 was 493,824.



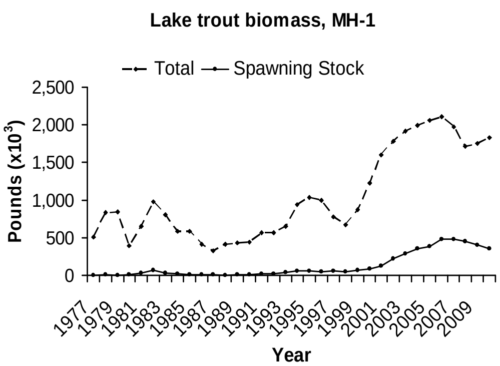
Sea lamprey induced age-specific mortality was based on fitting wounding rate as a logistic function of lake trout body length and the estimated length distribution at age. The wounding rate in a given year was based on spring (April-June) samples in U.S. waters, and reflected sea lamprey induced mortality in the previous year. Asymptotic wounding rate decreased after 1998 and has been substantially lower than the 1998 level since 2001. At age 7, the estimated instantaneous mortality by sea lamprey predation was 0.219 y^{-1} in 1998, and the average was 0.092 y^{-1} during 2007-2009.



Total 2010 commercial harvest of hatchery lake trout in MH-1 and QMA4-1 was 204,116 lb, of which the tribal fishery accounted for 185,906 lb. The total harvest including wild lake trout was 203,617 lb by the tribal fishery and 25,936 lb from the Ontario fishery. The tribal harvest included estimates of throwback mortality from both the trap-net fishery and large-mesh gill-net fishery after 2001. The recreational harvest in 2010 was 26,094 lb. Recreational harvest after 2002 included estimates of hooking mortality. Overall, the recreational harvest still represents a small portion of MH-1 lake trout harvest.



Estimated spawning stock biomass (SSB) was almost negligible until the late 1990s, increased steadily from 1998 to 2006, and then decreased during 2007 through 2010.



The weak year classes after 2000 (stocked yearlings after 2001) might be responsible for the decline in spawning biomass. From 1999 to 2008, however, adding new data from each year always led to increases in the estimates of yearling survival and spawning stock biomass, and such strong retrospective patterns indicated model uncertainty that must be further minimized. Annual fishery harvest during 2007 through 2010 did not exceed the model recommended total allowable harvests (TAC), and estimated age-specific total mortality were in general below the annual mortality limit of 47%.

Uncertainty in the model results led to a stipulation to the Consent Decree agreed to by the Parties, which fixes the 2010 and 2011 TACs for MH-1. The new model structure that has been reviewed and implemented includes: 1) time-varying catchability for both the commercial and recreational fishery, and period-specific catchability for fishery independent surveys; 2) expanded age structures from ages 2-9 to ages 1-15 for both commercial and recreational fishery catch; 3) addition of mature female age structure from fall spawning reef survey; 4) age-specific natural mortality; 5) updated database from 1984 through 2010 for sea lamprey mortality matrix; 6) relative abundance indices based on both summer and spring fishery-independent surveys; 7) explicit separation of hatchery fish and wild fish in the data. With all of those refinements to model structures, the predicted general trends of the stock remained remarkably similar to the last year's model, suggesting the overall model structure is fairly robust.

The current diagnostics suggested three major investigations and potential improvements for future model runs: 1) time-varying selectivity should not trace the changes in age composition, otherwise model predictions may always have retrospective patterns; 2) variance ratios of predicted residuals should be reexamined due to new model structures, otherwise model predictions may continue to be biased; 3) TAC projections should be fully reviewed for two reasons – a) the current model uncertainty is about recruitment, but a large proportion of the TAC is calculated from the age groups prior to the recruitment to the fishery, and b) the further expansion of TAC by the proportion of wild fish is also based on limited data, mostly from those pre-recruitment age groups. We should soon consider estimates of wild recruitment within the model, as it has been observed on a lake-wide basis.

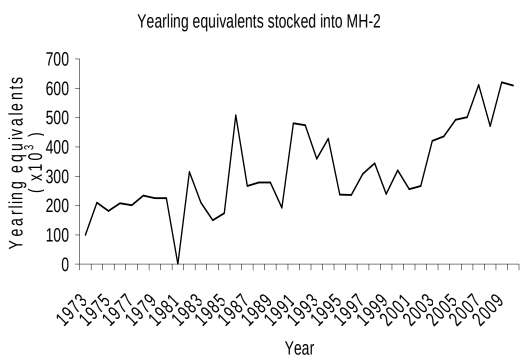
Summary Status MH-1 Lake Trout	Value (Standard Error)
Female maturity	
Size at first spawning	1.05 lb
Age at first spawning	3 y
Size at 50% maturity	3.67 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	6.615 lb (SE 0.615)
Current SSBR	0.981 lb (SE 0.132)
SSBR at target mortality	0.480 lb (SE 0.037)
Spawning potential reduction	
Current SPR	0.148 (SE 0.014)
SPR at target mortality	0.072 (SE 0.004)
Average yield per recruit	0.521 lb (SE 0.042)
Natural mortality (M)	0.121 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	7 y
Sport fishery (2008-2010)	7 y
Commercial fishing mortality (F) (average 2008-2010, ages 6-11)	0.186 y^{-1} (SE 0.023)
Sport fishing mortality (F) (average 2008-2010, ages 6-11)	0.021 y^{-1} (SE 0.004)
Sea lamprey mortality (ML) (average 2007-2009, ages 6-11)	0.092 y^{-1}
Total mortality (Z) (average 2008-2010, ages 6-11)	0.420 y^{-1} (SE 0.025)
Recruitment (age 1) (average 2001-2010)	138,850 fish (SE 7,329)
Biomass (average 2001-2010)	1,871,500 lb (SE 87,554)
Spawning biomass (average 2001-2010)	351,180 lb (SE 21,038)
Model recommended yield limit for 2011	436,857 lb
Actual yield limit for 2011	245,000 lb

MH-2 (North-central Lake Huron)

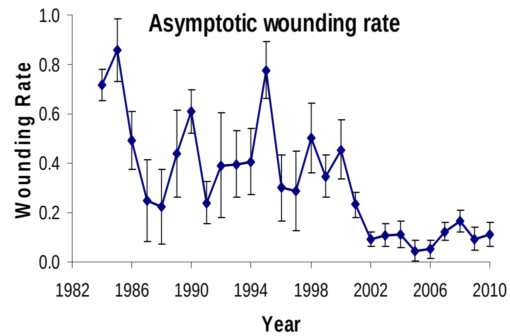
Ji X. He and Adam Cottrill

Lake trout management unit MH-2 (north-central Lake Huron) covers Michigan statistical district MH-2, and Ontario quota management areas (QMA) 4-2, 4-3, and 4-7, including about 50% of the no-fishing zone of Six Fathom Bank Refuge, in which Ontario waters shallower than 40 fathoms are 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. In 2010 non-clipped fish accounted for 32% of lake trout samples from Ontario commercial fisheries, 11% in Michigan recreational fishery and USWFS summer survey, and 8% in MDNR's annual spring survey.

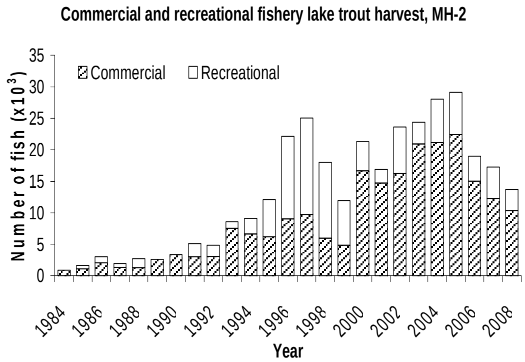
Total age-1 lake trout stocked in 2010 was 596,993. After adjusting for the movement among management units of Lake Huron's main basin, the total number of hatchery lake trout in MH-2 in 2010 was estimated to be 434,697 fish.



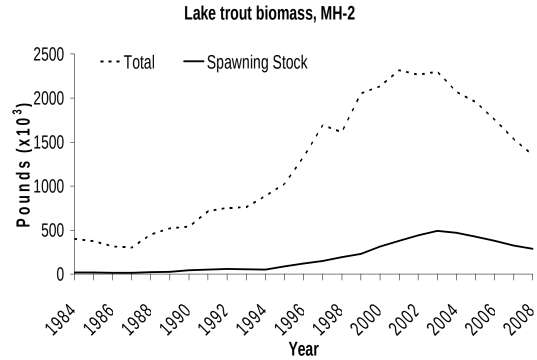
Sea lamprey induced age-specific mortality was based on fitting wounding rate as a logistic function of body length, and length distribution at age. The wounding rate in a given year was based on spring (April-June) lake trout samples of US waters, and reflected sea lamprey induced mortality in the previous year. Asymptotic wounding rate decreased after 2000, and has been substantially lower than the 1998 level since 2001. At age 7, the estimated instantaneous mortality by sea lamprey predation was 0.250 y^{-1} in 1998, and the average was 0.088 y^{-1} during 2007-2009.



Both commercial and recreational harvests were substantial in this region of Lake Huron (Figure 3). The majority of commercial harvest came from Ontario large-mesh gill nets, and there was no commercial fishery in Michigan waters. The reported recreational harvest included both total retention of fish caught and estimates of hooking mortality after 2002.



Spawning stock biomass (SSB) was very low until the late 1990s, and then steadily increased to the highest level of 494,000 lb by 2003 (Figure 4). Although a full assessment was not completed in 2011, in the most recent assessment SSB had decreased to 287,000 lb in 2008, which represented a 40% decline from the 2003 level. Such declines in SSB were inconsistent with the observation that an estimated SSBR was always higher than the target in each of recent eight years and age specific mortality were in general below the limit of 40%. Weak or delayed recruitment might be the major causes of decline in spawning stocks.



The 2011 TACs for MH-2 were based on a projection from the 2009 version of the model. Fishery harvest and sea lamprey mortality values were updated. The recommended harvest limits of 89,647 lb for the state and 4,718 lb for the tribes represented an increase over the 2010 values. The TFC invoked the 15% rule and limited the increase over 2010 TACs to that level. The 2011 TACs were 87,268 lb for the state and 4,536 lb for the tribes.

Lake Michigan

MM-123 (Northern Treaty Waters)

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

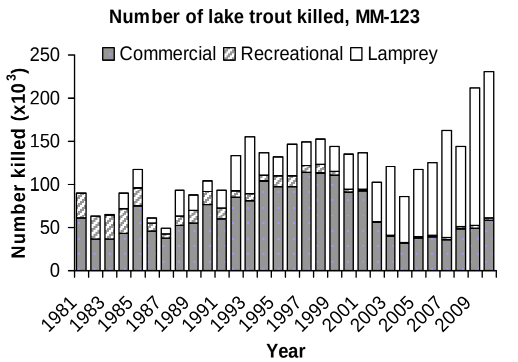
Management unit MM-123 is made up of statistical districts MM-1, MM-2, and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay, covering 5,000 square miles. Water depths in the northern portion of the unit are generally less than 150 feet, and approximately 3,800 square 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.

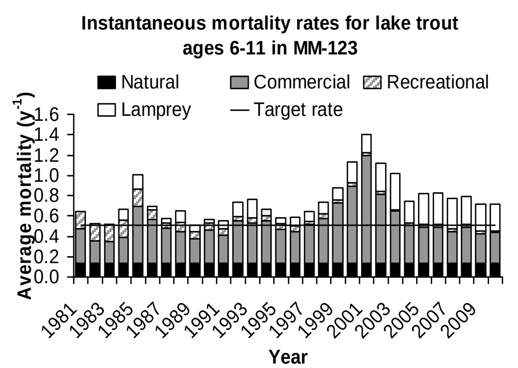
Recruitment of lake trout in MM-123 is currently based entirely on stocking of hatchery-reared fish. Over the last ten years, on average, 1.02 million yearling lake trout have been stocked into MM-123 and approximately 61% of these fish were stocked into the northern refuge. To more accurately estimate 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 621,785 fish from 2001-2010.

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 fisheries primarily target lake whitefish, with lake trout often harvested as by-catch. Commercial fishing mortality peaked in 2001 at 1.06 y^{-1} and in recent years (2004-2010) has been lower and relatively consistent at 0.33 y^{-1}. From 1981 until 2001, commercial fishing accounted for 70% 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 51% of 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 293,069 lb in 2010. 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 9.5 million feet in 2010. The number of lake trout harvested from MM-123 by the commercial fishery increased from 37,484 fish in 1991 to 113,800 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 31,500 fish in 2004, and has increased to 58,500 fish in 2010.

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, and appears to have 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 14,600 lb. The numbers of lake trout harvested fell to just under 400 fish in 2003 and has averaged 2,300 fish from 2005 to 2010. Recreational fishing effort is relatively low in this unit and has been declining. In 2006 124,800 angler hours were spent in the unit and only 59,200 hours were spent in 2010.



Sea lamprey mortality rates in northern Lake Michigan had averaged 0.15 y^{-1} from 1981-2008. With the exception of 1993, lamprey-induced mortality had generally been below the long-term average until the year 2001. After 2001, sea lamprey mortality increased, averaging 0.28 y^{-1} from 2002-2009. The numbers of lake trout killed by sea lamprey peaked at an estimated 170,223 fish in 2010. Prior to the year

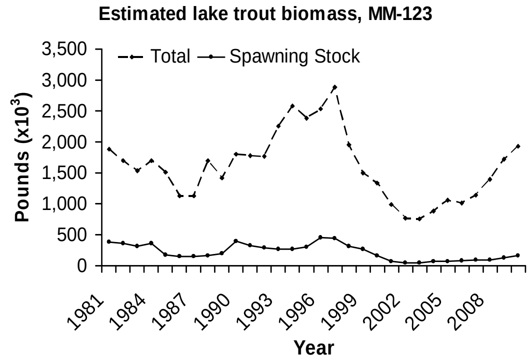
2000, sea lamprey killed an average of 21,500 fish y^{-1}.

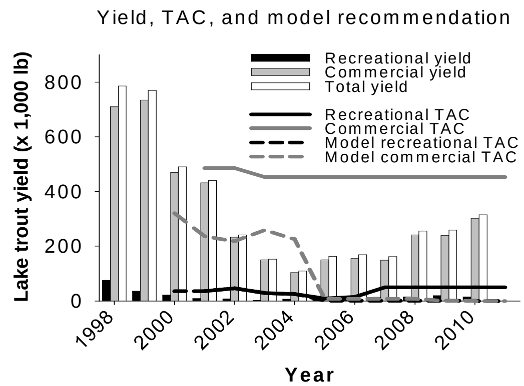
In northern Lake Michigan, 50% of lake trout are spawning by age 6. Lake trout are fully-recruited into commercial and recreational fisheries at age 7.

The biomass of lake trout in northern Lake Michigan nearly tripled, increasing from 1.1 to 2.9 million lb from 1986 to 1997. The biomass of lake trout then steadily declined to 0.7 million lb by 2003. The estimated biomass has since been increasing and was 1.9 million lb in 2010. Most of the biomass is composed of young fish as similar increases were not apparent for the spawning stock.

The spawning stock biomass produced per recruit (including the refuge population) during 2010 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 agreed upon yield limit for 1836 Treaty waters 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 2011 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except the last three ages in the ln-initial (initial population size vector, ages 13-15). The p3 and p4 parameters for commercial gill-net selectivity were not estimated. The MCMC simulations yielded poor results. Residual patterns were average but did show some trends. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, Z, or N.

No major changes were made to the model in 2011. We continue to work on changes to catchability and selectivity, but these were not implemented in this version of the model.

Summary Status MM-123 Lake Trout	**Value (95% probability interval)**
Female maturity	
Size at first spawning	2.22 lb
Age at first spawning	3 y
Size at 50% maturity	6.24 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	7.11 lb (5.98—8.26)
Current SSBR	0.36 lb (0.29—0.44)
SSBR at target mortality	1.09 lb (0.94—1.24)
Spawning potential reduction	
At target mortality	0.155 (0.146—0.164)
Average yield per recruit	0.445 lb (0.394—0.496)
Natural mortality (*M*)	0.135 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	7
Sport fishery (2008-2010)	7
Commercial fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.319 y^{-1} (0.277—0.365)
Sport fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.025 y^{-1} (0.021—0.030)
Sea lamprey mortality (ML)	
(average ages 6-11, 2007-2009)	0.276 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2008-2010)	0.757 y^{-1} (0.714—0.807)
Recruitment (age 4)	
(average 2001-2010)	107,843 fish (SE 11,939)
Biomass (age 3+)	
(average 2001-2010)	1,177,158 lb (1,093,780—1,252,940)
Spawning biomass	
(average 2001-2010)	87,412 lb (77,040—97,933)
MSC recommended yield limit in 2011	0 lb
Actual yield limit in 2011	503,000 lb

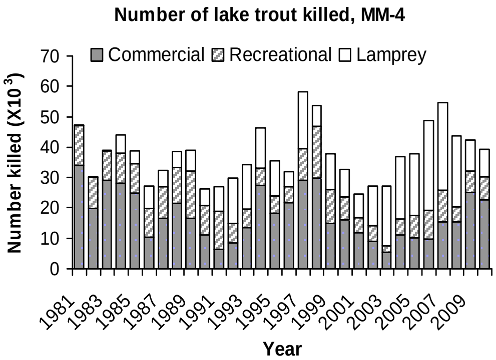
MM-4 (Grand Traverse Bay)

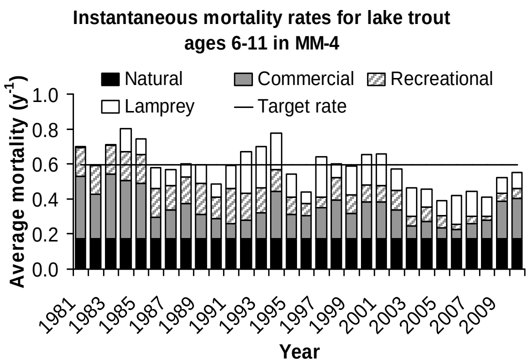
Prepared by Jory L. Jonas, and Erik J. Olsen

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. Over the last ten years, on average, 283,659 yearling lake trout have been stocked into Grand Traverse Bay. 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. After adjustments, the resulting estimates of age-1 recruitment in the Grand Traverse management unit have averaged 322,815 fish from 2001-2010.

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 28,060 fish in 2009 and decreased slightly to 23,466 fish in 2010. Accordingly, the yield of lake trout captured in tribal commercial fisheries peaked in 1998 at 162,951 lb and declined by nearly 86% to 22,921 lb in 2003. Yield had increased to 137,312 lb in 2009 and was 93,381 lb in 2010. 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 has since been increasing and was 1.1 million feet of net in 2010.

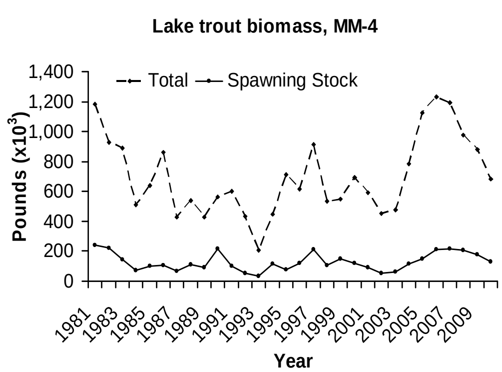




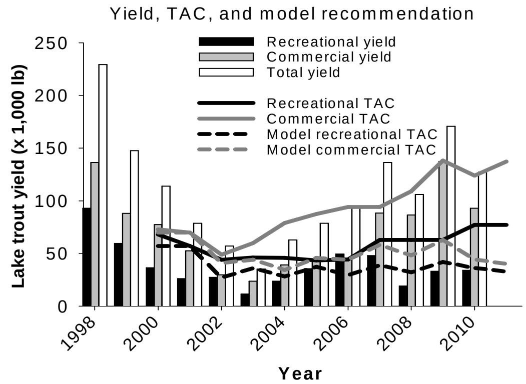
The recreational fisheries for lake trout are comprised of both charter and sport anglers. The sport fishing harvest regulations in the Grand Traverse Bay management unit have changed significantly over the last 15 years, affecting recreational fishing mortality rates and harvest levels. The season for harvesting lake trout is Jan 1 through September 30 and the bag limit is 3 fish. In 2006, size limits were changed and a slot limit was adopted where anglers were only allowed to keep fish between 20 and 25 inches, along with one trophy fish greater than 34 inches. In 2011 the regulations slightly changed. The 20-25 inch slot limit remains, but anglers are allowed to keep one fish of the three fish daily bag that is greater than 25 inches. The mortality rates of lake trout from recreational fishing had been declining from 1991 (0.20 fish y^{-1}) to 1997 (0.06 fish y^{-1}). Recreational fishing mortality was relatively consistent from 1998 to 2002 averaging 0.11 y^{-1}. The lowest recreational fishing mortality rate of the time series occurred in 2008 (0.02 y^{-1}). Recreational fishing mortality increased slightly in 2010 to 0.07 y^{-1}. 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 number of lake trout harvested has been increasing in recent years from 4,697 fish in 2007 to 8,229 fish in 2010. Modifications to size limits may at least partly be responsible for lower yield levels in recent years. Yield has averaged 29,829 lb from 2007-2010.

Sea lamprey mortality rates in Grand Traverse Bay have decreased from 0.16 y^{-1} in 2007 to 0.09 in 2009. The highest lamprey mortality rate was observed in 1992 (0.24 y^{-1}) and the lowest in 1996 (0.07 y^{-1}). An estimated 29,685 fish were killed by lamprey in 2006 and this has since declined to 8,919 fish in 2010.

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 1981 and 2006 at 1.2 million lb. The total biomass of lake trout has been declining since 2006 and was estimated at 682,863 lb in 2010.



Total instantaneous mortality rates in 2010 (0.55 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 2011 in the Grand Traverse Bay management unit is 73,231 lb of which 32,954 lb was allocated to the state recreational fishery and 40,277 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 three 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 for 2011. 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 2010 did not reach the limit of 77,200 lb, the actual Tribal harvest limit in 2011 was determined to be 94,300 lb plus the leftover amount from the State, 43,126 lb, for a total of 137,426 lb.



Model evaluation and changes:

The 2011 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except the last three ages in the ln-initial (initial population size vector, ages 13-15). The p3 and p4 parameters for the recreational fishery selectivity curve were not estimated. To address this, the descending limb selectivity factors rf_p4 and rf_2_p4 were fixed at -0.8. The rf_p3 parameter was fixed at 2.5 for the first recreational fishery. The MCMC simulations yielded poor results. Residual patterns were reasonable, but did show some trending. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, Z or N.

No major changes were made to the model in 2011. We continue to work on changes to catchability and selectivity but these were not implemented in this version of the model.

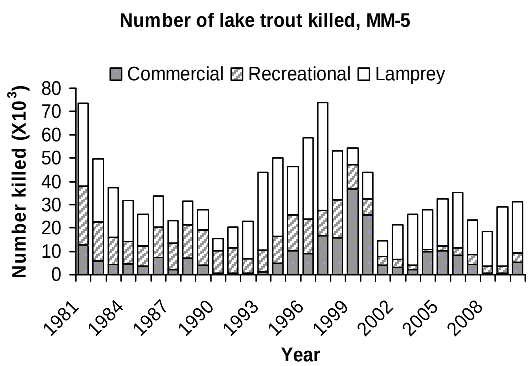
Summary Status MM-4 Lake Trout	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.44 lb
Age at first spawning	3 y
Size at 50% maturity	4.51 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.66 lb (1.16—2.28)
Current SSBR	0.17 lb (0.11—0.25)
SSBR at target mortality	0.21 lb (0.16—0.27)
Spawning potential reduction	
At target mortality	0.127 (0.115—0.139)
Average yield per recruit	0.161 lb (0.123-0.207)
Natural mortality (*M*)	0.175 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	6
Sport fishery (2008-2010)	6
Commercial fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.191 y^{-1} (0.160—0.234)
Sport fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.043 y^{-1} (0.036—0.050)
Sea lamprey mortality (ML)	
(average ages 6-11, 2007-2009)	0.115 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2008-2010)	0.526 y^{-1} (0.488—0.577)
Recruitment (age 4)	
(average 2001-2010)	57,799 fish (SE 9,191)
Biomass (age 3+)	
(average 2001-2010)	832,157 lb (767,647—901,703)
Spawning biomass	
(average 2001-2010)	137,903 lb (120,889—155,569)
MSC recommended yield limit in 2011	73,231 lb
Actual yield limit in 2011	214,626 lb

MM-5 (Leelanau Peninsula to Arcadia)

Prepared by Jory L. Jonas and Erik J. Olsen

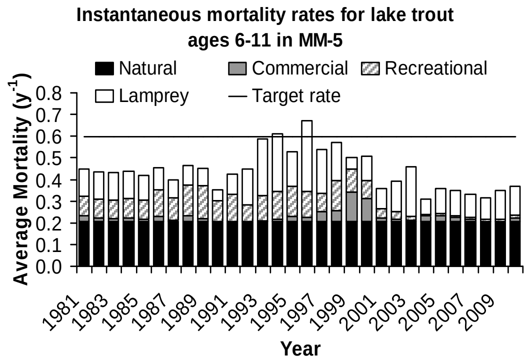
Lake trout management unit MM-5 is located in eastern central Lake Michigan and corresponds to the MM-5 statistical district. This area constitutes an area of high use by both Tribal and State interests. The unit covers 2,100 square miles and encompasses Michigan's waters of Lake Michigan from Arcadia 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. Over the last ten years, on average, 204,120 yearling lake trout were stocked into the MM-5 management unit annually. 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 10 years (2001-2010) the recruitment to age one has averaged 278,215 fish in MM-5.



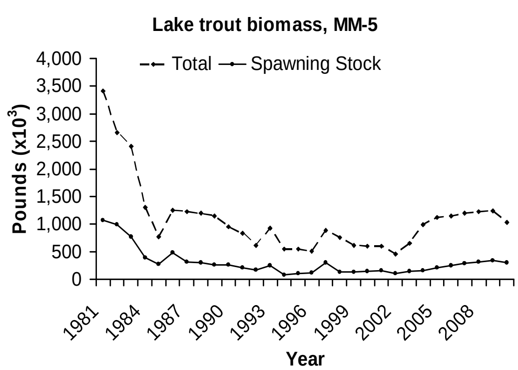
Although both State and Tribal commercial fishermen harvest fish in the management unit, state-licensed commercial fisheries are primarily trap-net operations targeting lake whitefish and are not permitted to harvest lake trout. The Chippewa Ottawa Resource Authority oversees three types of tribal commercial fisheries in this area including large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill-net fishery, while primarily targeting lake whitefish, is generally responsible for the greatest number of harvested lake trout. The 2000 Consent Decree resulted in the conversion of the region's largest gill-net fishers to trap-net operations and recently the market value of lake trout has been low. As a result, commercial harvest and mortality of lake trout have decreased considerably. 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}. The highest commercial mortality rates occurred in 1996 (0.33 y^{-1}) and the lowest occurred in 2008 (0.002 y^{-1}). The commercial harvest of lake trout was highest in 1999 at nearly 25,000 fish and was lowest in 2008 at 500 fish. In 2010, an estimated 3,883 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, <100 feet of gill net were set in the MM-5 management unit. In 2010, 134,000 feet of gill net were set.

Recreational fisheries for lake trout are managed by the State of Michigan and include both charter and sport anglers. The fishing season for lake trout occurs from May 1 - Sept 30 and the bag limit is 3 fish. In 2006, regulations were changed to protect larger spawning lake trout. A maximum size limit was adopted where anglers are only allowed to keep fish below 24 inches and one trophy fish greater than 34 inches. In the MM-5 management unit from 1986 until 1991, recreational fishing mortality (averaged over ages 6-11) exceeded commercial fishing averaging 0.12 y^{-1}. The highest recreational fishing mortality rate occurred in 1989 at 0.15 y^{-1} and the lowest was in 2005 at 0.006 y^{-1}. Since 2003, recreational fishing mortality rates have been extremely low averaging 0.01 y^{-1}. The numbers of lake trout harvested in recreational fisheries is up from 765 fish in 2004 and was estimated at 4,000 fish in 2010. Recreational fishery yield increased from 3,800 lb in 2004 to 23,600 lb in 2010. Angling effort has been generally trending downward in the MM-5 management unit. Effort levels were highest 1987 at 703,739 angler hours and had fallen to 221,633 angler hours in 2010.

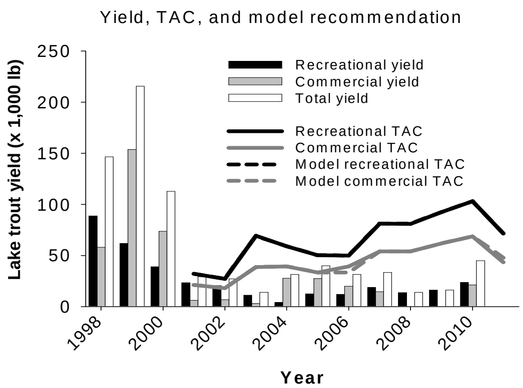


Estimates of lamprey mortality have been relatively consistent since 2005 averaging 0.11 y^{-1}. In 2010 the estimate of lamprey was up slightly at 0.13 y^{-1}. Lampreys have killed more lake trout over the last 10 years than any of the other mortality sources.

Fifty percent of lake trout are spawning by age 6 in MM-5 and are fully recruited into commercial fisheries. Lake trout fully recruit to recreational fisheries by age 5. The biomass of lake trout older than age 3 increased from 458,028 lb in 2002 to 1.2 million lb in 2009. In 2010, the biomass of lake trout was down slightly at 1.0 million lb. The biomass of spawning age lake trout has been increasing from 108,424 lb in 2002 to 296,134 lb in 2010.



The spawning stock biomass produced per recruit is below the target value. Mortality rates (0.37 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 108,152 lb, and is based on a target mortality rate of 45%. Of this yield, 64,894 lb were allocated to the state recreational fishery and 43,258 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 2011 SCAA model reached convergence with acceptable maximum gradient components and reasonable asymptotic standard errors on parameter estimates. All parameters were estimated except the last three ages in the ln-initial (initial population size vector, ages 13-15). The p3 parameter for the commercial fishery was not estimated. Residual patterns were reasonable yet the recreational and commercial fisheries did show some trending. The MCMC simulations yielded poor results. The retrospective analysis of this year's model did not show any systematic temporal patterns in estimates of biomass, *Z*, or N.

No major changes were made to the model in 2011. We continue to work on changes to catchability and selectivity but these were not implemented in this version of the model.

Summary Status MM-5 Lake Trout	**Value (95% probability interval)**
Female maturity	
Size at first spawning	0.78 lb
Age at first spawning	3 y
Size at 50% maturity	3.50 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.23 lb (1.02—1.47)
Current SSBR	0.20 lb (0.17—0.23)
SSBR at target mortality	0.48 lb (0.39—0.58)
Spawning potential reduction	
At target mortality	0.165 (0.158—0.172)
Average yield per recruit	0.031 lb (0.027—0.034)
Natural mortality (*M*)	0.205 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2008-2010)	6
Sport fishery (2008-2010)	5
Commercial fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.007 y^{-1} (0.006—0.008)
Sport fishing mortality (*F*)	
(average 2008-2010, ages 6-11)	0.010 y^{-1} (0.009—0.012)
Sea lamprey mortality (ML)	
(average ages 6-11, 2007-2009)	0.113 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2008-2010)	0.336 y^{-1} (0.328—0.343)
Recruitment (age 4)	
(average 2001-2010)	53,455 fish (SE 5,759)
Biomass (age 3+)	
(average 2001-2010)	947,015 lb (906,626—984,506)
Spawning biomass	
(average 2001-2010)	219,557 lb (206,600—230,692)
MSC recommended yield limit in 2011	108,152 lb
Actual yield limit in 2011	108,152 lb

MM-67 (Southern Treaty Waters)

Prepared by Jory L. Jonas and Archie W. Martell Jr.

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.

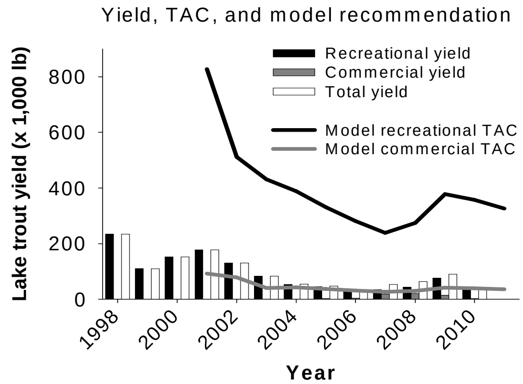
The recruitment of lake trout in the southern treaty waters of Lake Michigan is based entirely on stocking. During the past ten years, an average of 173,143 yearling lake trout have been stocked into non-refuge southern treaty waters, while an additional 364,793 fish were stocked into the mid-lake refuge 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 (2001-2010), the recruitment of lake trout to age one has averaged 361,382 fish in the southern treaty management unit of Lake Michigan.

In 2010, 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 2010 Tribal commercial fishery within this area consisted of five permitted trap nets, 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. The yield of lake trout in commercial fisheries is extremely low and has averaged 17,347 lb over the last 5 years (2006-2010). In 2010 the yield of lake trout was 8,973 lb.

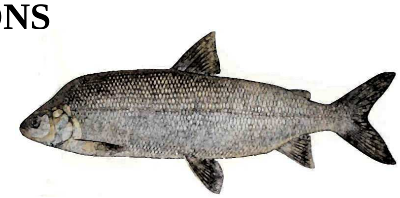
State recreational fisheries for lake trout are comprised of both charter and sport anglers. Size and bag limits did not change from 1981 until 2003. The fishing season had changed twice, once in 1984 which restricted it from the entire year to May 1 through August 15th, and again in 1989 when the season was extended through Labor Day. In 2003, the bag limit was increased from 2 to 3 fish, the size limit increased to 22 inches and the season expanded from May 1 to Sept 30. The harvest of lake trout has declined substantially in the MM-67 management unit from 81,149 fish in 1989 to an estimated 6,894 fish in 2010. Recreational fishing mortality rates have also declined substantially from 0.25 y^{-1} in 1998 to 0.02 y^{-1} in 2010. The average yield of lake trout from 2001-2010 was 43,140 lb and in 2010 was 38,757 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 have declined from 0.11 y^{-1} in 2007 to 0.05 y^{-1} in 2009. Despite the low mortality rates, lamprey have continued to kill more fish than other sources of mortality for the unit. During the last 8 yrs lamprey have killed an average of 23,076 fish y^{-1}.

The harvest limit for 2011 was calculated based on a projection from the last full assessment model. After accounting for harvest and sea lamprey mortality in 2010, it was estimated that 362,570 lb of lake trout were available for harvest. The state recreational fishery is allocated 90 percent or 326,313 lb and the tribal fishery 10 percent of 36,257 lb.



STATUS OF LAKE WHITEFISH POPULATIONS



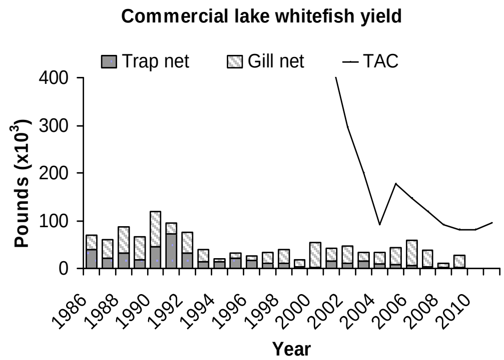
Lake Superior

WFS-04 (Marquette - Big Bay)

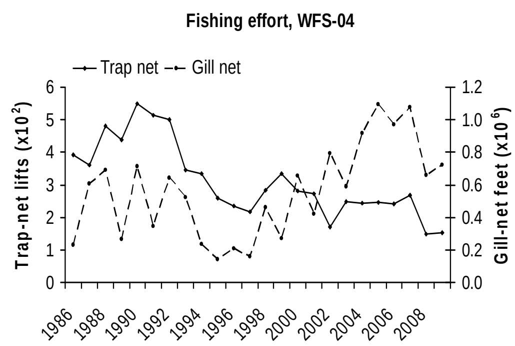
Prepared by Philip J. Schneeberger

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.)

Yield in WFS-04 during 2009 was 48,488 lb, split almost evenly between trap nets (23,761 lb) and gill nets (24,727 lb). Compared to 2008, trap-net yield was virtually unchanged but gill-net yield increased 175% in 2009. In 1836 waters of WFS-04, lake whitefish yield (all from trap nets) was 2,190 lb, representing only 4.5% of the overall yield from the entire management unit in 2009.

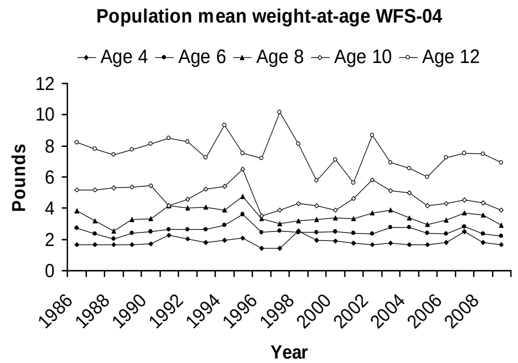


The big jump in gill-net yield occurred with only a 9% increase in effort between 2008 and 2009, from 0.66 to 0.72 million feet. WFS-04 trap-net effort was 153 lifts in 2009, about the same as for 2008. Just 9% of the trap-net effort and none of the gill-net effort took place in 1836 Treaty waters during 2009.



Catch per unit effort (CPUE) increased 151% for gill nets but decreased by 2% for the trap-net fishery in 2009. Values for both gear types were well below averages for the time series.

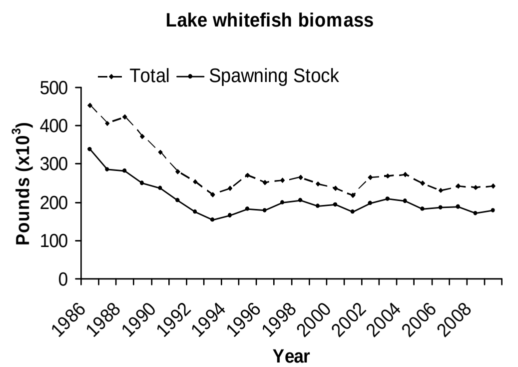
Mean weight-at-age continued a second year of decline in 2009 after trending higher between 2005 and 2007. On average, weight-at-age decreased 4% for ages 4-12+ between 2008 and 2009.



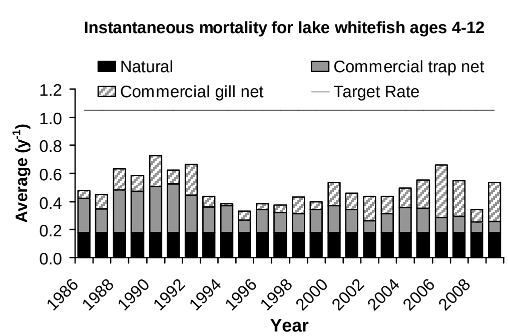
Current von Bertalanffy growth calculations used average length-at-age for all lake whitefish in the state data base (1986-2009), plus one point added for length=25 mm and age=0. Estimates for growth parameters $L\infty$ and k were 771 mm and 0.168. An attempt was made to use length-at-age data for individual fish from the entire time series for the model, but the resulting growth parameters were unrealistic and deemed unacceptable.

Recruitment (number of age-4 lake whitefish from the 2005 year class) was estimated at 55,000 fish in 2009. Recruitment estimates have remained relatively stable since 2003 in WFS-04.

Estimated fishable biomass was 536,000 lb and spawning stock biomass was 395,000 lb in 2009, both values slightly higher than those for 2008 in the current model. Both biomass estimates have remained relatively stable since the mid-1990s. The 2009 ratio of spawning stock biomass to fishable biomass was 0.74, which is also the average ratio for the whole time series.



Based on outputs from the current model, total instantaneous mortality rate (*Z*) for the WFS-04 lake whitefish stock ranged between 0.28 and 0.45 y^{-1} from 1993 through 2009. The 2009 estimate for *Z* was 0.35 y^{-1}, up 25% from the value estimated for 2008 but still well below the target maximum rate. Estimated instantaneous fishing mortality rates (*F*) were 0.11 y^{-1} for gill nets and 0.06 y^{-1} for trap nets in 2009. Instantaneous natural mortality rate was estimated at 0.18 y^{-1}.



The 2011 yield limit calculated for lake whitefish in the entire WFS-04 management unit is 136,000 lb, which is 20,000 lb higher than for 2010. After applying the prescribed reduction to reflect the proportion of this management unit that is outside the Consent Decree, the 2011 yield limit for lake whitefish in 1836 Treaty waters is 95,000 lb.

Summary Status WFS-04 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.98 lb
Age at first spawning	4 y
Size at 50% maturity	2.46 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	8.294 lb (SE 0.014)
Current SSBR	3.18 lb (SE 0.1)
SSBR at target mortality	0.273 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.383 (SE 0.012)
Average yield per recruit	1.345 lb (SE 0.012)
Natural mortality (*M*)	0.178 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	11
Fully selected age to trap nets	8
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.09 y^{-1} (SE 0.006)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.073 y^{-1} (SE 0.004)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.341 y^{-1} (SE 0.009)
Recruitment (age 4)	
(average 2000-2009)	54,827 fish (SE 2,859)
Biomass (age 3+)	
(average 2000-2009)	543,460 lb (SE 20,978)
Spawning biomass	
(average 2000-2009)	415,760 lb (SE 16,283)
MSC recommended yield limit for 2011	95,000 lb
Actual yield limit for 2011	95,000 lb

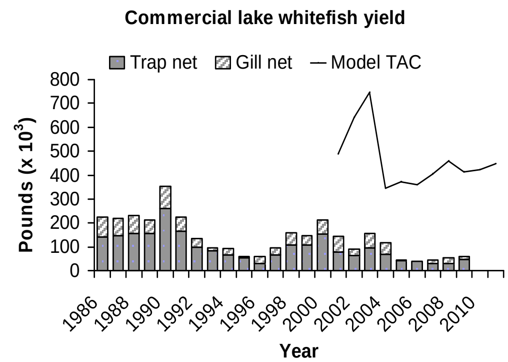
WFS-05 (Munising)

Prepared by Philip J. Schneeberger

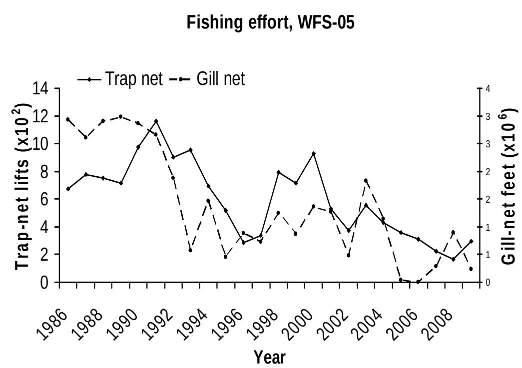
The WFS-05 lake whitefish management unit extends approximately from Laughing Point to Au Sable Point in Michigan waters of Lake Superior. Surface area of the unit is 1,845,495 acres. Several bays (Shelter Bay, Au Train Bay, South Bay, and Trout Bay) and islands (Au Train Island, Wood Island, Williams 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.

Data inputs updated for the current WFS-05 catch-at-age model included not only the 2009 catch and biological statistics, but also additional trap net catch and effort data which were inadvertently left out of models from previous years. Specifically, tribal trap-net catches in 2003 (35,353 lb from 154 lifts) and 2004 (23,592 lb from 134 lifts) were included in the current model.

Lake whitefish yield in WFS-05 was 61,153 lb in 2009, a 15% increase from 2008. Trap nets have accounted for most (average of 71%) of the total yield during 1986-2009. Yields declined between 2000 and 2006 but have trended higher each year since then. Trap-net yield was 48,838 lb and gill-net yield was 12,315 lb in 2009.

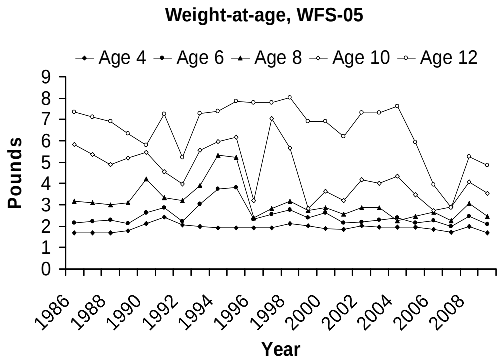


Effort for the trap-net fishery reversed a five-year decline in 2009 measuring 297 lifts and representing a 77% increase from 2008. Gill-net effort went in the other direction, declining 75% to 230,000 ft in 2009. Values for both gear types are well below long-term averages in WFS-05.



Following three years of consistent increases, trap-net catch per unit effort (CPUE) declined slightly in 2009 to 164 lb lift^{-1}. Gill-net CPUE rose sharply from last year to 54 lb 1000 ft^{-1} of net and was the second highest value in the time series.

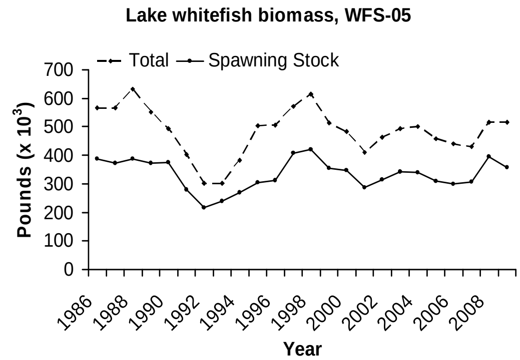
Weight at age decreased for fish of all ages compared to 2008. However, values were higher in 2009 than during 2006-07.



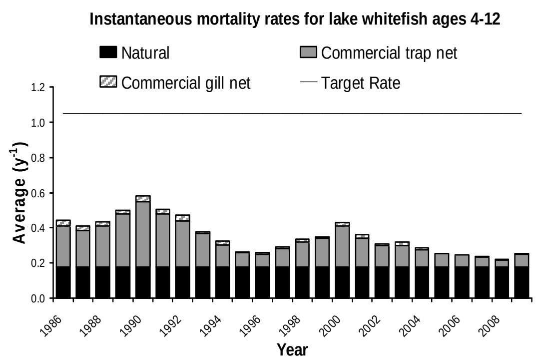
Length-at-age data from individual fish in the entire data set were used to calculate growth with L∞ fixed at 750 mm. The computed von Bertalanffy k value was 0.109.

Estimated recruitment has been relatively stable since 2003. The 2009 estimate of recruitment, reported as number of age-4 lake whitefish in the population (2005 year class), was 78,000 fish. Next year's data will determine whether another recruitment peak is measured in 2011 as has occurred every seven years since 1988.

Biomass estimates in 2009 were 1.07 million lb for the fishable stock (lake whitefish age-4 and older) and 817,000 lb for the spawning stock. The 2009 estimates of biomass using the current model are higher than averages for 1999-2008. The 2009 ratio of spawning stock biomass to fishable biomass was 0.76, which was the same as average for the previous years in the data series.



Estimates for total instantaneous mortality rate (*Z*) have remained consistently below 0.45 y^{-1} during the past 16 years in WFS-05. The 2009 estimate for *Z* was 0.208 y^{-1}. Natural mortality rate (*M*), was estimated at 0.135 y^{-1}, which was 65% of the total mortality estimate. Instantaneous fishing mortality rate (*F*) was 0.013 for gill nets and 0.060 y^{-1} for trap nets for 2009.



The WFS-05 yield limit calculated for 2011 was 408,000 lb. Although this is a 4% decrease from 2010, yield limits for the last three years have been relatively stable.

Summary Status WFS-05 Whitefish	**Value (95% Probability Interval)**
Female maturity	
Size at first spawning	1.79 lb
Age at first spawning	4 y
Size at 50% maturity	2.16 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	9.79 lb (9.76 – 9.82)
Current SSBR	5.38 lb (4.98 – 5.79)
SSBR at target mortality	0.201 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.550 (0.509 – 0.591)
Average yield per recruit	0.934 lb (0.857 – 1.010)
Natural mortality (*M*)	0.135 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	8
Fully selected age to trap nets	7
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.017 y^{-1} (0.014 – 0.019)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.047 y^{-1} (0.040 – 0.054)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.199 y^{-1} (0.190 – 0.208)
Recruitment (age 4)	
(average 2000-2009)	85,900 fish (75,500 – 98,650)
Biomass (age 3+)	
(average 2000-2009)	972,300 lb (862,900 – 1,095,000)
Spawning biomass	
(average 2000-2009)	742,300 lb (654,100 – 839,200)
MSC recommended yield limit for 2011	408,000 lb
Actual yield limit for 2011	408,000 lb

WFS-06 (Grand Marais)

Prepared by Mark P. Ebener

WFS-06 is located in the center of the 1836 treaty-ceded waters of Lake Superior. The unit contains no islands or bays, has 88,600 surface acres of waters less than 240 ft deep and is part of the open water of Lake Superior. There is little habitat for whitefish reproduction in the unit; therefore, it is likely that many of the lake whitefish that inhabit WFS-06 spawn elsewhere.

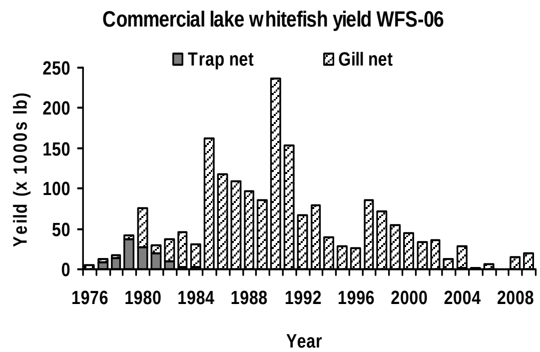
WFS-06 has been an exclusive commercial fishing zone for CORA fishers since 1985. Access to the unit is limited mainly to the Grand Marais area in the west and Little Lake Harbor in the east. A sizeable sport fishery targets whitefish off the pier at Grand Marais, but this yield and effort has not been included in a stock assessment model, as estimates of its magnitude have only existed since 2001. Since that time, recreational yield has averaged 7,400 lb y^{-1} and peaked in 2009 at 11,725 lb.

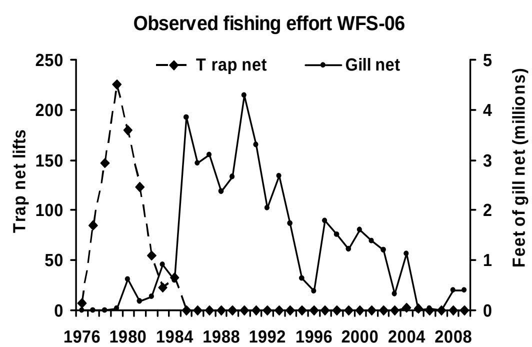
The commercial yield of lake whitefish from WFS-06 has averaged 55,900 lb during 1976-2009. The peak yield was 236,000 lb in 1990 and the yield in 2009 was 19,400 lb.

The large-mesh gill-net fishery has accounted for 99% of the entire yield from WFS-06 during 1976-2009. Peak gill-net effort was 4.2 million ft in 1990 and there was no gill net effort in 2005 or 2007. There was not trap net effort in WFS-06 in 2009 and the gill net effort was 410,000 feet in 2009.

There was a direct linear relationship between gill-net effort and yield of whitefish in WFS-06 during 1981-2008. Gill-net effort explained 88% of the variation in gill-net yield during 1981-2009.

No stock assessment model has been developed for whitefish in WFS-06 since 2003 because the small size of the yield from the area makes it difficult to collect biological data, as such no biological data has been collected from WFS-06 since the early 2000s. The harvest regulating guideline for 2011 was 210,000 lb and represents the SCAA model output from 2004 (i.e. data through 2002).





WFS-07 (Tahquamenon Bay)

Prepared by Mark P. Ebener

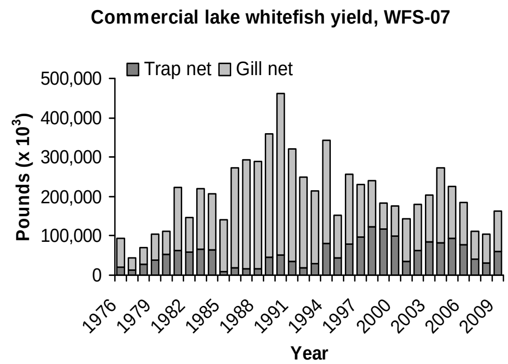
WFS-07 includes the western portion of Whitefish Bay and the main basin of eastern Lake Superior. The unit contains 371,000 surface acres of water less than 240 ft deep. There is also a substantial commercial fishery in adjacent Canadian management units 33 and 34.

WFS-07 contains a single, large stock of whitefish that spawns in the southwest portion of Whitefish Bay. After spawning, many whitefish disperse north to Whitefish Point and then west to areas of the main basin of Lake Superior, but many also remain in Whitefish Bay and some move into Canadian waters.

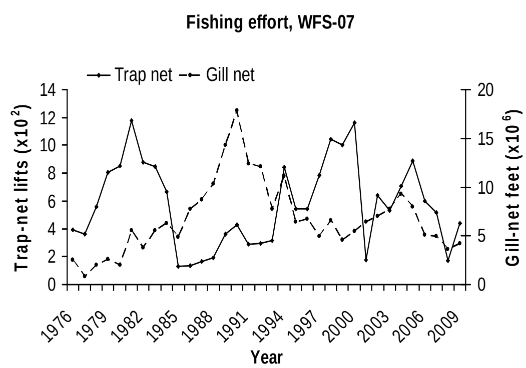
WFS-07 is an important fishing ground for the CORA fishery, and has been an exclusive CORA fishing zone since 1985. Large- and small-boat gill-net fisheries as well as several trap-net fisheries operate in WFS-07. An ice fishery also takes place nearly every winter. There are a large number of relatively good access sites that offer fishermen reasonable protection from wind and waves.

The commercial yield of whitefish from WFS-07 averaged 452,900 lb during 1976-2009. A peak yield of one million lb occurred in 1990 and the lowest reported yield was 98,000 lb in 1977. The 2009 yield was 347,800 lb.

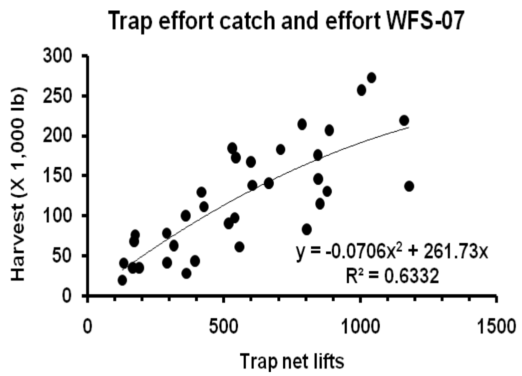
The large-mesh gill-net fishery accounted for 74% of the whitefish yield from WFS-07 during 1976-2009. The trap-net fishery harvested more whitefish from the unit than the gill-net fishery only during 1998-2000. The yield in 2009 was 218,200 lb from the gill-net fishery and 129,600 lb from the trap-net fishery.

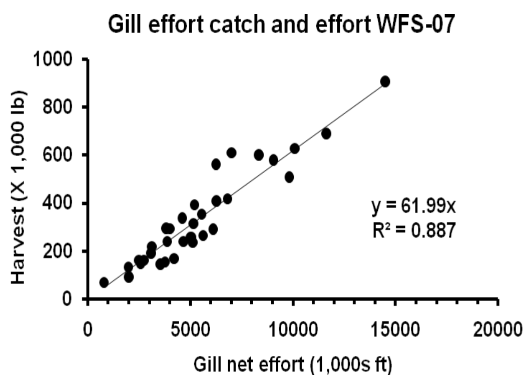


Yield of whitefish from WFS-07 has mirrored changes in fishing effort during 1976-2009. After peaking at 14.5 million ft in 1990, large-mesh gill-net effort declined to between 2.7 and 6.8 million ft during 1997-2009. Gill-net effort was 3.1 million ft in 2009. Trap-net effort increased from 128 lifts in 1985 to 1,161 lifts in 2000 before declining to 171 lifts in 2008. Trap net effort in 2009 was 418 lifts.

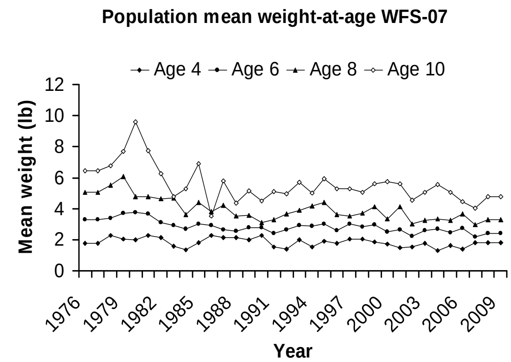


Harvest of whitefish was directly proportional to fishing effort in WFS-07 during 1976-2009. Gill net and trap net effort explained 63% and 89%, respectively, of the variation in harvest by each gear during 1976-2009. The average catch-per-unit-effort was 62 lb 1,000 ft^{-1} in the gill net fishery and 261 lb $lift^{-1}$ in the trap net fishery. The relationship between gill net catch and effort was linear. The relationship for the trap-net fishery was non-linear and asymptotic suggesting that at high levels of fishing effort some factor such as gear inference or habitat is limiting the ability of trap nets to capture whitefish in WFS-07.

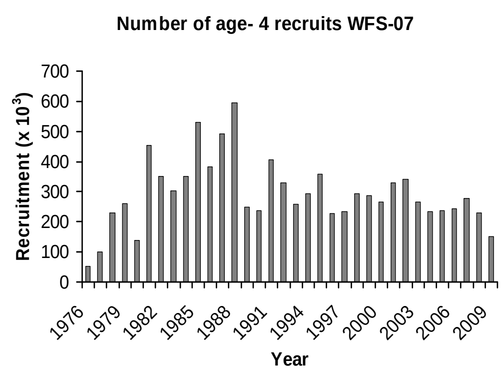




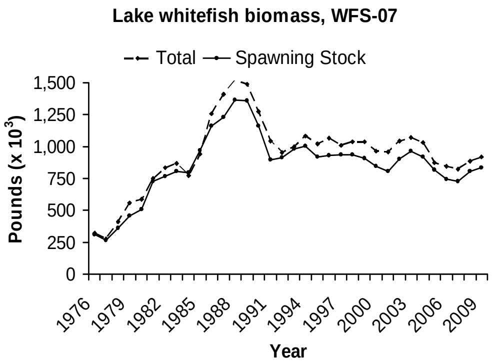
There has been a long-term decline in mean weight at age of whitefish in WFS-07 with older fish experiencing greater declines than younger fish. Mean weight of age 4-11+ whitefish declined by 0.01 to 0.07 lb $year^{-1}$ from 1976 to 2009 with age-9 fish experiencing the greatest decline. Most of the decline in mean weight at age occurred from 1976 to 1990. After 1990 mean weight of most age classes increased through about 2004 then declined to 1990-1992 levels. During 1976-1980 age-11+ whitefish in WFS-07 weighed over 8 lb, but in 2008 they weighed only 5.5 lb. During 1976-1983 ages 4-11+ whitefish weighed between 1 and 8 lb, in 2005-2009 the same ages weighed between 1 and 6 lb.



Estimated recruitment of age-4 whitefish to the fishable population peaked in 1988 and has declined continually since then. The stock assessment model estimated that an average of 294,000 age-4 whitefish recruited to the fishable population each year during 1976-2009. Recruitment varied from 52,000 fish in 1976 to 529,000 fish in 1988. Recruitment was estimated to be 228,000 and 150,000 whitefish in 2008 and 2009, respectively.

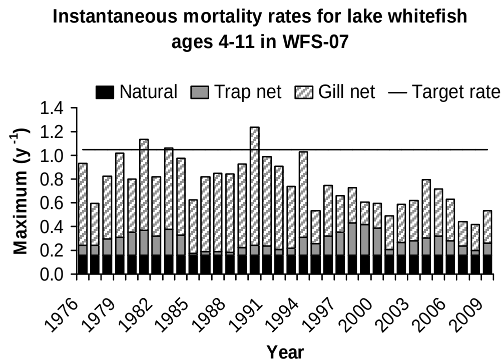


Biomass of age-4 and older whitefish has been declining in WFS-07 since the late 1980s. Total biomass peaked at 3.4 million lb in 1988 and since then has declined by nearly 45,000 lb $year^{-1}$. Spawning biomass has declined by 43,000 lb $year^{-1}$ from 1988 to 2009. Total biomass was 2.0 million lb in 2009 and spawning biomass was 1.8 million lb. Total biomass of whitefish in 2009 was nearly equal to the long-term average of 2.1 million lb.

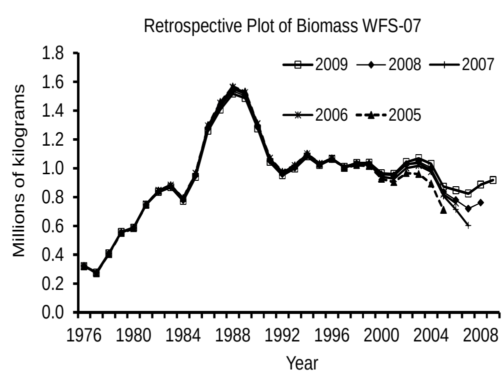


Using Pauly's relationship between average water temperature occupied by a fish (4^{o}C) and von Bertalanffy growth parameters L∞ (78.5 cm) and k (0.1404), natural mortality was estimated to be 0.157 y^{-1} in the stock assessment model. The von Bertalanffy growth model was updated with mean length at 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 1980-2008.

Instantaneous total annual mortality of age-4 and older whitefish was fairly stable from 1976 through 1994, but since 1994 mortality rate has generally declined. The variations in total mortality were largely driven by changes in gill-net effort. Instantaneous total annual mortality averaged 0.49 y^{-1} during 1976-2009 and ranged from a low of 0.30 y^{-1} in 2008 to a high of 0.71 y^{-1} in 1990. Fishing mortality averaged 0.33 y^{-1} during 1976-2009. Gill-net mortality averaged 0.24 y^{-1} and trap-net mortality 0.10 y^{-1} during 1976-2009. Gill net fishing mortality in 2009 was 0.13 y^{-1}, and trap-net mortality was 0.09 y^{-1}.



Because total mortality is declining in WFS-07 and moving further from the maximum target rate, the projection model estimated that fishing mortality could be increased by 3.4 times in 2011 above levels estimated for 2007-2009. As a consequence, the recommended yield limit was estimated to be 871,500 lb in 2011. Convergence criteria were not met for the WFS-07 stock assessment model. Probability distributions and trace and autocorrelation plots from the Markov Chain Monte Carlo simulations were not acceptable, so the stock assessment model was rated as low. However, retrospective pattern of biomass were good, suggesting that problems with the model were not insurmountable.



Summary Status WFS-07 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.97 lb
Age at first spawning	4 y
Size at 50% maturity	2.33 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	7.84 lb (0.001 SE)
Current SSBR	2.51 lb (0.134 SE)
SSBR at target mortality	0.28 lb (0.00 SE)
Spawning potential reduction	
At target mortality	0.322 (0.017 SE)
Average yield per recruit	1.52 lb (0.025 SE)
Natural mortality (*M*)	0.157 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	6
Fully selected age to trap nets	6
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.116 y^{-1} (0.072 SE)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.066 y^{-1} (0.027 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.339 y^{-1} (0.090 SE)
Recruitment (age 4)	
(average 2000-2009)	257,248 fish (54,175 SE)
Biomass (age 4+)	
(average 2000-2009)	2,075,849 lb (189,373 SE)
Spawning biomass	
(average 2000-2009)	1,845,442 lb (163,733 SE)
MSC recommended yield limit for 2011	871,500 lb
Actual yield limit for 2011	514,000 lb

WFS-08 (Brimley)

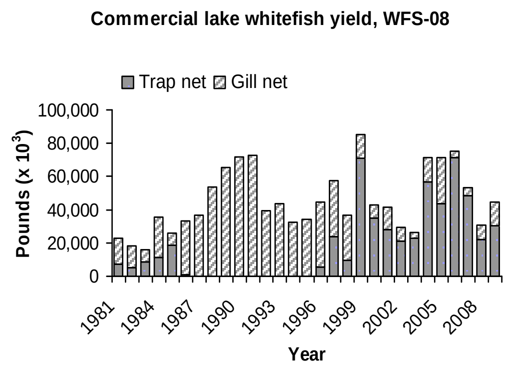
Prepared by Mark P. Ebener

WFS-08 is located in the very southeast portion of Whitefish Bay, Lake Superior. Although WFS-08 is spatially the smallest of the management units in the 1836 ceded waters of Lake Superior the unit 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.

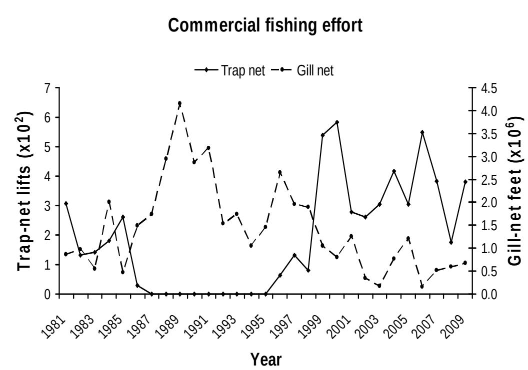
There are probably four reproductively isolated stocks of whitefish that contribute to the commercial fishery in WFS-08. Whitefish that spawn in WFS-07, two areas of WFS-08, and a fourth population that spawns in Canadian waters of management unit 34 all contribute to the fishery.

WFS-08 continues to be a traditional commercial fishing area for the CORA small-boat and gill-net ice fishery. WFS-08 has been an exclusive fishing zone for the CORA fishery since 1985. There are multiple undeveloped landing sites that are commonly used by the small-boat fishery during the open-water fishing season. A commercial trap-net fishery and a sport fishery for whitefish also occur in the unit.

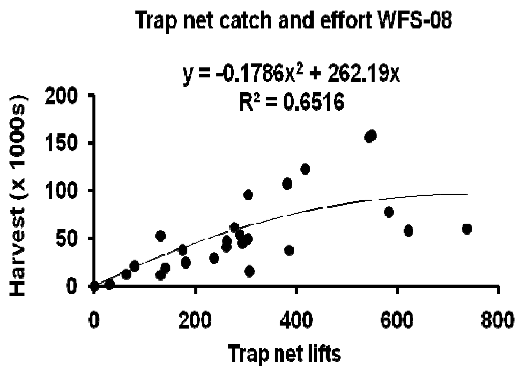
The commercial yield of whitefish from WFS-08 has averaged 99,100 lb during 1981-2009. Annual yields ranged from 35,000 lb in 1983 to 188,000 lb in 1999. The peak yield of 195,000 lb occurred in 1979, just prior to the creation of CORA. The large-mesh gill-net fishery accounted for 59% of the yield from WFS-08 during 1981-2009. There was no trap-net yield from WFS-08 during 1987-1995. The trap-net yield in 2009 was 67,000 lb, while the gill-net yield was 31,300 lb.

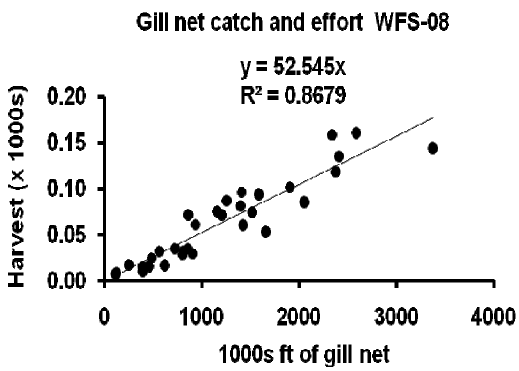


Gill-net effort has been declining in WFS-08 while trap-net effort has increased tremendously. Peak gill-net effort was 3.4 million ft in 1989, but it had declined to 0.12 million ft by 2006. Trap-net effort peaked at 738 lifts in 1979, declined to zero during 1987-1995, then increased thereafter to 583 lifts in 2000, then declined somewhat before increasing again to 549 lifts in 2006. Fishing effort in 2009 was 0.51 million ft of gill net and 381 trap net lifts.

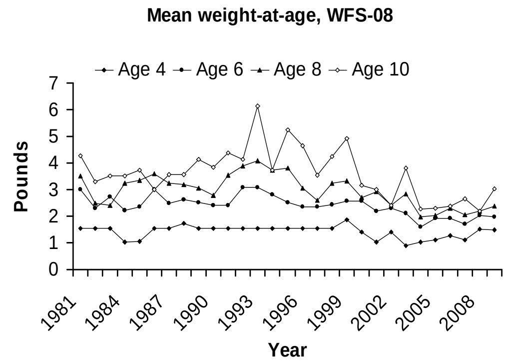


Both gill net and trap net harvest was directly related to their respective fishing efforts. Fishing effort explained 87% of the variation in gill net harvest and 65% of the variation in trap net harvest in WFS-08 during 1981-2009. Average gill net CPUE was 52 lb 1000 ft^{-1} and average trap net CPUE was 262 lb $lift^{-1}$ during 1981-2008. Gill net harvest was linearly related to fishing effort, whereas trap net harvest was a non-linear function of trap net effort, suggesting as in WFS-07, that either gear competition or habitat limitation was affecting trap net catch.

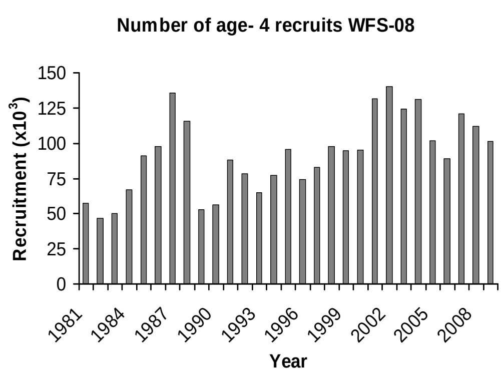




While growth of whitefish in WFS-08 appears to have remained fairly stable during 1981-2009, there has been a slow long-term decline in mean weight at age of most age classes. Mean weight at-age generally declined from 1981 through about 2004 and has since stabilized and increased slightly over the last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

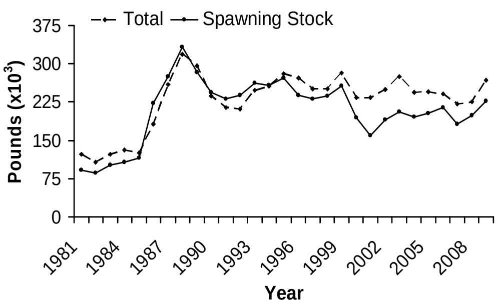


Recruitment of age-4 whitefish in WFS-08 has been less variable than in adjacent unit WFS-07 and on a long-term increase during 1981-2009. Recruitment increased continually from 1989 through 2001, then stabilized at a higher level than any other time during 1981-2009. The stock assessment model estimated that an average of 92,000 age-4 whitefish recruited to the population each year during 1981-2009. Recruitment peaked at 140,000 age-4 whitefish in 2002, and an estimated 101,000 age-4 whitefish recruited to the fishery in 2009. Recruitment in WFS-08 has been increasing at 1,900 fish y^{-1} from 1981 to 2009.



Total fishable biomass has remained relatively stable in WFS-08 since the late 1980s, whereas spawning biomass has declined somewhat possibly because of declines in growth that occurred after 1993. Total biomass of whitefish averaged 502,000 lb during 1981-2009 and spawning biomass averaged 460,000 lb during the same time. Total biomass was 591,000 lb in 2009 and spawning biomass was 501,000 lb.

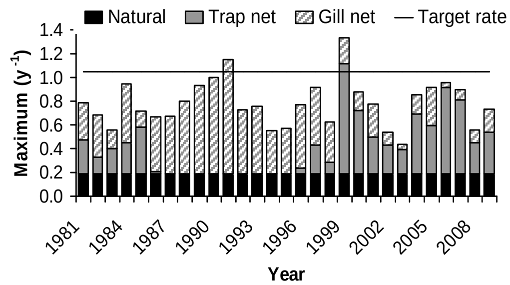
Lake whitefish biomass, WFS-08



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 1981-2009. Annual instantaneous total annual mortality of age-4 and older whitefish averaged 0.58 y^{-1} during 1981-2009 and was 0.54 y^{-1} in 2009. Fishing mortality averaged 0.39 y^{-1} during 1981-2009 and was 0.35 y^{-1} in 2009. Trap-net mortality was 0.24 y^{-1} and gill-net mortality 0.11 y^{-1} in 2009.

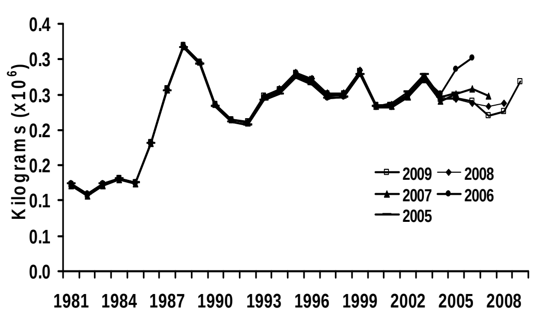
Maximum instantaneous mortality rates for lake whitefish ages 4-11 in WFS-08



Total annual mortality on age-4 and older whitefish was slightly less than the target rate of 1.05 y^{-1} during 2007- 2009. Thus the projection model estimated that fishing mortality rate in 2011 could be increased 1.59 times from levels experienced during 2007-2009. The recommended yield limit at this rate of fishing was estimated to be 167,700 lb in 2011.

Convergence criteria were not met for the WFS-08 stock assessment model, but the Markov Chain Monte Carlo simulations were acceptable and retrospective patterns of biomass were reasonable reflecting reliability of the assessment model. Consequently the stock assessment model was given a high level of reliability.

Retrospective Plot of Biomass, WFS-08



Summary Status WFS-08 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.56 lb
Age at first spawning	4 y
Size at 50% maturity	1.79 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	4.27 lb (0.007 SE)
Current SSBR	1.18 lb (0.042 SE)
SSBR at target mortality	0.201 lb (0.000 SE)
Spawning potential reduction	
At target mortality	0.276 (0.010 SE)
Average yield per recruit	1.10 lb (0.007 SE)
Natural mortality (*M*)	0.187 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	7 y
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.073 y^{-1} (0.058 SE)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.285 y^{-1} (0.197 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.546 y^{-1} (0.241 SE)
Recruitment (age 4)	
(average 2000-2009)	114,896 fish (17,326 SE)
Biomass (age 3+)	
(average 2000-2009)	537,131 lb (37,716 SE)
Spawning biomass	
(average 2000-2009)	434,811 lb (40,644 SE)
MSC recommended yield limit for 2011	167,000 lb
Actual yield limit for 2011	167,000 lb

Lake Huron

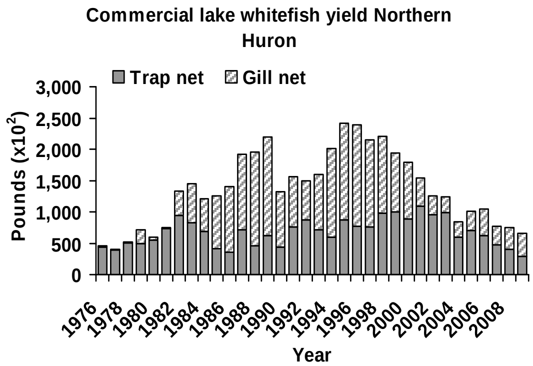
Northern Huron (WFH-01 to WFH-04)

Prepared by Mark P. Ebener

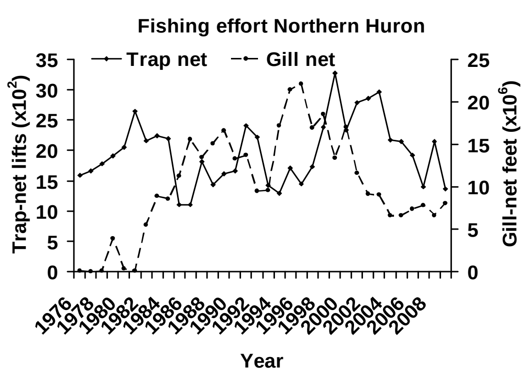
The Northern Huron stock represents the area in Michigan waters of northwest Lake Huron from the Straits of Mackinac east to Drummond Island and south to Presque Isle. Biological and commercial catch information from whitefish management units WFH-01 to WFH-04 were combined to create the Northern Huron model.

Tag-recoveries of adult lake whitefish from the Cedarville (WFH-02) and Cheboygan (WFH-01 and WFH-04) spawning stocks during 2003-2008 indicated that there was substantial movement between management units during the non-spawning season. Roughly 50% of adult lake whitefish tagged in WFH-02 remained in the unit, whereas 19% moved into WFH-01, 30% moved into WFH-03, and 1% moved into WFH-04. Of the fish tagged at Cheboygan (WFH-01/WFH-04) 77% were recovered in the unit of tagging, 11% moved into WFH-02, 4% moved into Ontario waters, and 4% moved into WFH-05 to WFH-07 (see Ebener et al. 2010). Because the fisheries in WFH-01 to WFH-04 were exploiting multiple stocks from adjacent units, the Modeling Subcommittee agreed to develop a single catch-at-age model for northern Lake Huron that included biological and commercial fishery data from WFH-01 to WFH-04.

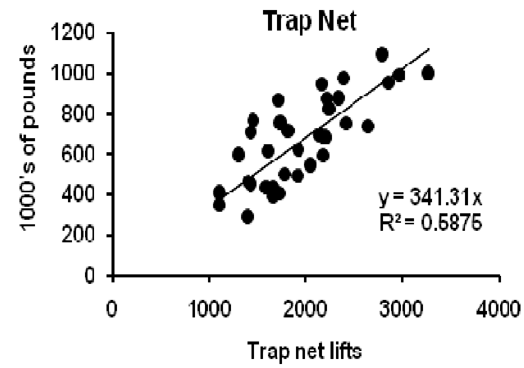
The Northern Huron unit includes the Drummond Island Lake Trout Refuge, the Bay Mills Small Boat Zone, and the Southern Lake Huron Trap Net Zone, all of which were created by the 2000 Consent Decree. Areas north of 40 Mile Point have been an exclusive CORA commercial fishing zone since 1985 and after the 2000 Consent Decree the entire ceded waters of Lake Huron became an exclusive CORA commercial fishing zone. Areas north of the Hammond Bay Refuge Harbor are open to inter-tribal gill-net fishing. Hammond Bay itself encompasses the Bay Mills Small Boat Zone, which is open to gill-net fishing only during October through December. Gill-net fishing in the Small Boat Zone is limited to 10 operations and each operation can fish no more than 6,000 ft. of gill net daily. The area from 40 Mile Point south to Presque Isle encompasses the reminder of Northern Huron and only trap-net fisheries can operate here. The commercial fishery harvest from Northern Huron averaged 1.36 million lb during 1976-2009. Peak harvests of 2.4 million lb occurred in 1995-1996, whereas the lowest harvests were 402,000 to 516,000 lb in 1976-1978. The commercial harvest from Northern Huron was 657,000 lb in 2009. The long-term average harvest during 1976-2009 was evenly split between the gill-net and trap-net fishery, but the trap-net fishery has been harvesting more whitefish than the gill-net fishery since the 2000 Consent Decree was implemented. In 2009 the gill-net fishery harvested 367,000 lb, while the trap-net fishery harvested 291,000 lb.

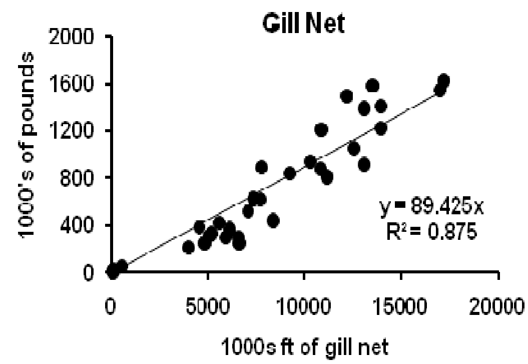


Gill-net effort has declined substantially since the implementation of the Consent Decree, but trap-net effort has not. Large-mesh gill-net effort ranged from a low of 85,000 ft. in 1978 to a high of 17.2 million ft. in 1996 and averaged 8.0 million ft during 1976-2009. Gill-net effort was 13.1 million feet in 2000, after which it declined almost annually to 4.8 million ft. in 2004. Since 2004 gill-net effort has ranged from 5.0 to 6.1 million ft. Gill-net effort was 6.1 million ft. in 2009. Trap-net effort was variable yet stable ranging from 1,100 lifts during 1984-1985 to 3,271 lifts during 1996 and averaged 1,941 lifts during 1976-2009. After 2000 trap-net effort ranged from 1,400 to 2,900 lifts and was 1,394 lifts in 2009.

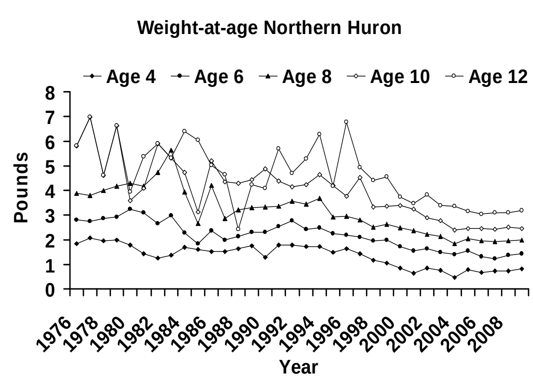


Harvest of whitefish in Northern Huron is directly related to fishing effort. Trap net effort explained 59% of the variation in trap-net harvest and gill-net effort explained 88% of the variation in gill net harvest during 1976-2009. Average trap-net catch rate was 341 lb lift^{-1} and average gill-net catch rate was 89 lb 1000 ft^{-1} during 1976-2009.

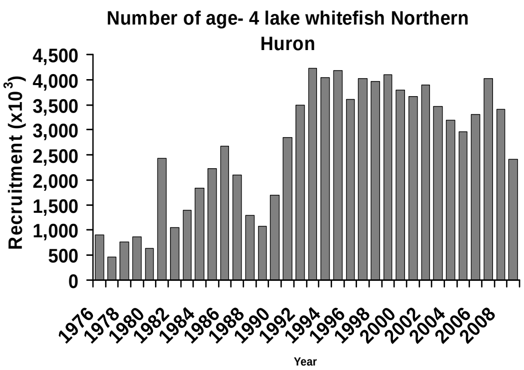




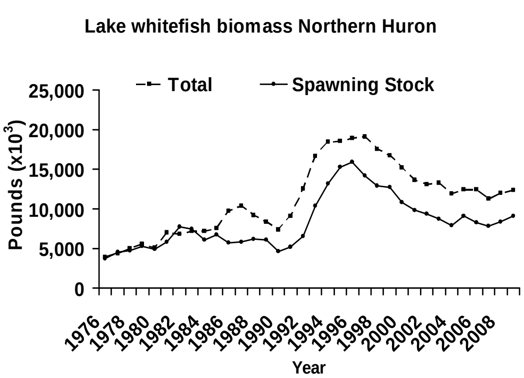
After declining for the better part 15 years, mean weight at age of whitefish in Northern Huron stabilized over the past five years. Mean weight of all ages remained constant from 2004-2009 unlike during the previous 12 years when there was almost an annual decline in mean weight at age.



Recruitment at age 4 increased from the late 1970s to 1992 and has declined slowly since then, although estimated recruitment remains at a high level. From 1976 through 1989 recruitment to the population averaged about 1.4 million fish, thereafter recruitment peaked at 4.0 million fish in 1993 and declined slowly to 2.4 million fish in 2009. Recruitment has been remarkably stable and high in Northern Huron since the late 1980s.

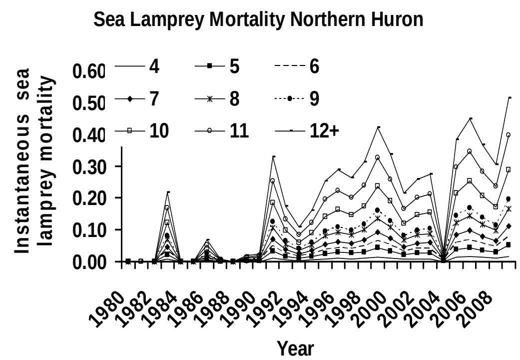


Trends in biomass of whitefish from Northern Huron closely follow trends in recruitment. Biomass of whitefish peaked at 19.0 million lb in 1997, one year later than peak recruitment, and since then fishable biomass has been declining and was 12.4 million lb in 2009. Spawning biomass was estimated to be 9.1 million lb in 2009.



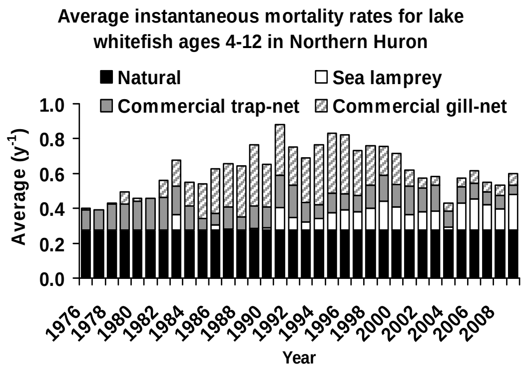
Using Pauly's relationship between average water temperature occupied by a fish (6^{o}C) and von Bertalanffy growth parameters L∞ (58.9 cm) and k (0.223), natural mortality was estimated to be 0.28 y^{-1} in the stock assessment model. The von Bertalanffy growth model was updated with mean length-at-age 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 1980-2008.

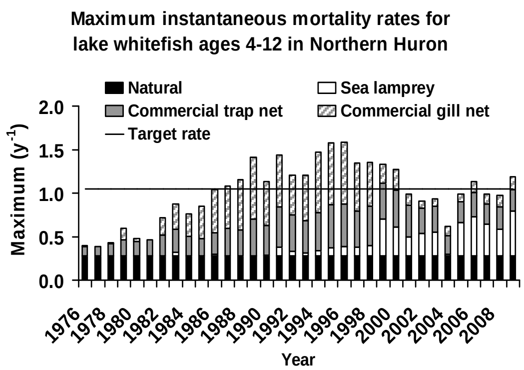
Sea lamprey-induced mortality was estimated from age-specific marking rates and an age-specific probability of survival of 0.25 (see Ebener et al. 2005). Sea lamprey-induced mortality has been slowly increasing across all ages of whitefish in Northern Huron since the early 1990s. Sea lamprey mortality has been equal to or greater than natural mortality for age 10 and older fish in most years since 1996.



Total annual mortality of lake whitefish in Northern Huron averaged 0.62 y^{-1} for ages 4+ during 1976-2009. Gill-net mortality averaged 0.15 y^{-1}, trap-net mortality averaged 0.12 y^{-1}, and sea lamprey mortality averaged 0.07 y^{-1} during 1976-2009. Total mortality peaked at 0.88 y^{-1} in 1989. Peak gill-net mortality averaged 0.35 y^{-1} in 1989, and trap-net mortality peaked at 0.19 y^{-1} in 1991 and 1992. Sea lamprey mortality equaled or exceeded fishing mortality during 2004-2009.

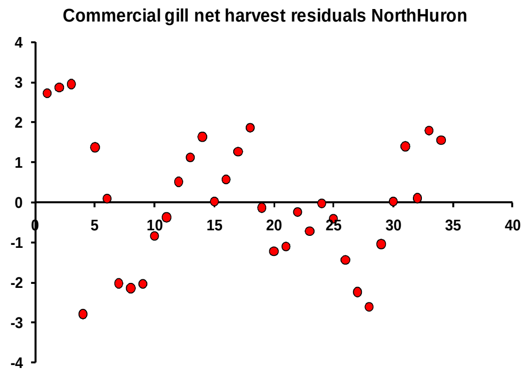
Total annual mortality on the most fully vulnerable age-class was less than the target rate during 2007-2009 and the spawning potential reduction was greater than 0.20. However, peak mortality was greater than the target in 2009, thus the projection model estimated that fishing mortality should not increase in 2011 as the estimated fishing multiplier was only 1.045.

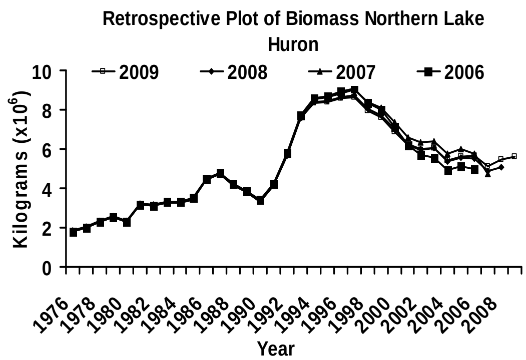




The subsequent estimated harvest limit for Northern Huron was estimated to be 719,600 lb in 2011, which was only a slight increase over the actual 2010 harvest.

Model fit for the Northern Lake Huron SCAA was reasonable. Predicted values for harvest, effort, and mean age in the harvest were similar to observed values, and residuals of trap-net harvest and effort were normally distributed and small. There were, however, patterns to the residuals of gill-net harvest and effort although the residuals were not excessively large (-3 to +3). Retrospective patterns of estimated biomass were very good. The SCAA model of Northern Huron was rated as medium.





Summary Status Northern Huron	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.00 lb
Age at first spawning	4 y
Size at 50% maturity	1.56 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	1.60 lb (0.003 SE)
Current SSBR	0.693 lb (0.011 SE)
SSBR at target mortality	0.156 lb (0.00 SE)
Spawning potential reduction	
At target mortality	0.433 (0.015 SE)
Average yield per recruit	0.238 lb (0.010 SE)
Natural mortality (*M*)	0.278 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	12 y
Fully selected age to trap nets	10 y
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.061 y^{-1} (0.058 SE)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.068 y^{-1} (0.052 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	0.155 y^{-1} (0.131 SE)
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.562 y^{-1} (0.231 SE)
Recruitment (age 4)	
(average 2000-2009)	3,412,000 fish (482,581 SE)
Biomass (age 3+)	
(average 2000-2009)	5,790,000 lb (498,576 SE)
Spawning biomass	
(average 2000-2009)	4,050,000 lb (420,233 SE)
MSC recommended yield limit for 2011	719,600 lb
Actual yield limit for 2011	719,600 lb

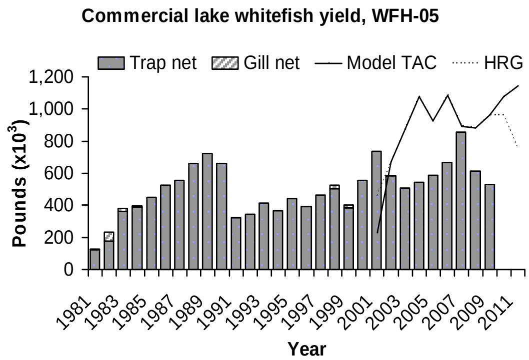
Ji X. He and Mark P. Ebener

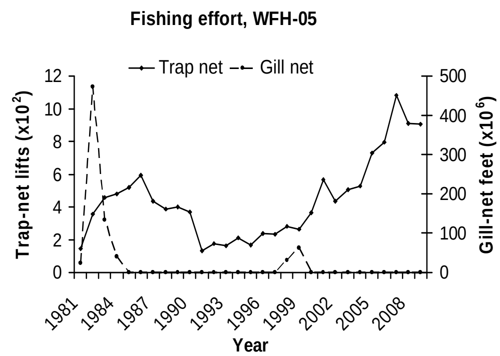
WFH-05 runs from Presque Isle south to the southern end of grids 809-815 in US waters. Before August 2000 WFH-05 was an exclusive unit for the state trap-net fishery. The 2000 Consent Decree has converted this unit into an exclusive unit for the tribal trap-net fishery.

WFH-05 includes two subareas. One is the Southern Lake Huron Trap Net Zone (SLHTNZ), which is the southern end of 1836 Treaty Water. Only four trap-net operations from two tribes can fish in SLHTNZ, and each operation cannot fish more than twelve trap nets. The CORA fishery has a minimum length limit of 17 inches, and there is no limit on depth where trap nets can be set. The second subarea is between SLHTNZ and a straight line running northeast from the tip of North Point of Thunder Bay to the international border. This subarea is a so called “grey” zone. The four tribal fishers in SLHTNZ can apply for state permits to fish in the “grey” zone, with total number of trap nets not to exceed sixteen. In this “grey” zone, the state sets a minimum length limit of 19 inches, and a maximum depth limit of 130 feet.

Annual trap-net harvest ranged from 123,651 lb in 1981 to a high of 858,857 lb in 2007. The first peak (723,735 lb) was at the end of 1980s. The second peak (736,215 lb) was at the beginning of 2000s. The 2009 harvest was 528,350 lb, a decline from the 2008 harvest of 614,370 lb, but above the average annual harvest during 1983-2006 (505,590 lb).

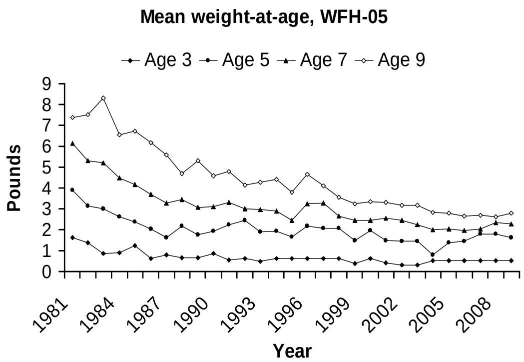
The relationships between annual harvest and fishing effort differed among three periods. The first was 1981-1986; the second was 1987-2002, and the third was 2003-2008. Catch rates were higher during 1987-2002 than the early and recent periods.



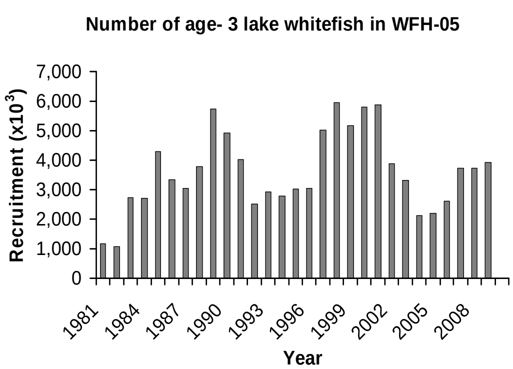


Based on monitoring of the trap-net fishery, lake whitefish averaged 4.1 lb during 1981-1986, 3.1 lb during 1987-2002, and 2.6 lb during 2003-2009. There were dynamic variations between 2.2-3.7 lb during 1986-1990, and a sharp decline in mean weight of a harvested fish from 3.5 lb in 1998 to 2.6 lb in 2001. The mean weight of a harvested lake whitefish was 2.8 lb in 2008-2009. There was an inverse relation between total number of fish harvested and the annual average weight of harvested fish.

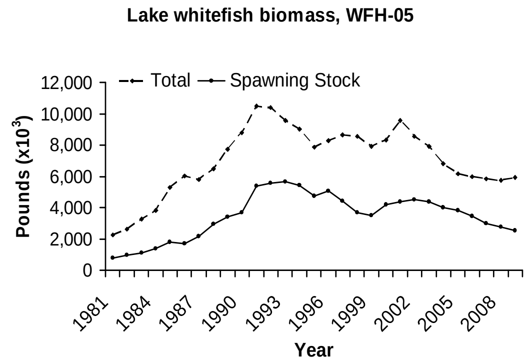
Weight-at-age declined sharply during 1981-1986, followed by dynamic variations and decline during 1987-2002, but the recent trends differed among age groups. For example, age-7 lake whitefish weighted 6.1 lb in 1981, decreased to 3.7 lb by 1986, and 2.5 lb by 2002. The average weight of an age-7 whitefish was 2.0 lb during 2004-2007, but increased back to 2.3 lb by 2008.



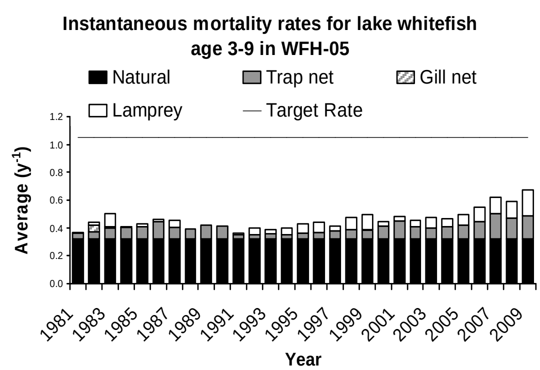
The estimates of recruitment at age 3 averaged 3.8 million during 1983-2009. The first peak was 5.7 million in 1989, followed by a low period of 1992-1996 with an average of 2.9 million, and a high period of 1997-2001 averaged 5.6 million. The recent lowest was 2.1 million in 2004, which was still in the normal range of this time series. The estimated recruitment for 2007-2009 was 3.7-3.9 million, about the average of this time series.



Spawning stock biomass increased rapidly from 1.7 million lb in 1981 to 12.5 million lb in 1993, followed by declines to 7.7 million lb by 1999, the second peak of 10 million lb in 2002, and further declines to 5.6 million lb by 2009. Total biomass of age 3 and older fish had similar patterns over years as spawning stock biomass. Using either spawning-stock or total biomass as examples, a peak biomass was after a period of high recruitment, and was influenced also by the average weight of individual fish.



Natural mortality was the largest source of total mortality, followed by trap-net fishing mortality and sea lamprey-induced mortality. Gill-net fishing mortality was significant only in 1982, although there were gill-net effort and harvest in 1981, 1983-1984, and 1998-1999. The estimated natural mortality was 0.319 y^{-1}. The estimated trap-net fishing mortality was relatively high during 1981-1990 with an average of 0.062 y^{-1}, followed by a low point of 0.019 y^{-1} in 1992, and then increases to 0.067 y^{-1} by 2009. The overall pattern was similar to that of trap-net fishing effort. Sea lamprey-induced mortality increased cyclically over the years, peaking at 0.059 y^{-1} in 1999, and peaking again at the all-time high of 0.10 y^{-1} in 2009.



The estimated average total mortality among ages 4-9 was 0.487 y^{-1} in 2009, with a three-year average of 0.463 y^{-1} during 2007-2009. These were much lower than the limit of 1.05 y^{-1}, so the projection model suggested that the trap-net fishing effort could be more than three times higher than the 2007-2009 average. The model recommended yield limit for 2011 was 1,142,750 lb, which was higher than the recommended limit of 1,075,160 lb for 2010. The harvest of 614,921 lb in 2008 was much lower than the recommended yield limit of 883,000 lb for 2008, and the harvest of 528,350 lb in 2009 was much lower than the recommended yield limit of 962,000 lb.

The assessment model converged to a unique solution but the maximum gradient of 0.0057 was high. MCMC chains for the objective function and model estimates were good. The continuous increases in TAC were due to retrospective patterns in the estimated recruitment and biomass. The model always estimated declines in spawning stock biomass over the recent years, but the estimated level of recruitment and biomass was much higher in the current assessment year than the estimates from previous years. The current age structure in the model (age 2-9) was insufficient to reflect substantial harvest of older fish in recent years.

Summary: The recommended TAC for 2011 was 6% higher than the TAC for 2010. In both 2008 and 2009, harvest was much lower than TAC, and catch per unit effort further declined. Sea lamprey mortality increased in the most recent two years. The estimated recruitment for the most recent three years was much higher than the previous three years, yet was near the average for 1983-2009. The total annual mortality for age 4 and older fish averaged at 36% during 2007-2009. The model continued to indicate a decline in spawning biomass over the recent years. Improvement of the assessment model should start with the use of a wide and realistic age structure based on the recent observations from the fishery.

Summary Status WFH-05 Whitefish	Value (95% probability interval)
Female maturity	
Size at first spawning	0.52 lb
Age at first spawning	3 y
Size at 50% maturity	1.67 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.135 lb
Current SSBR	0.681 lb (0.645 – 0.718)
SSBR at target mortality	0.220 lb
Spawning potential reduction	
Current SPR	0.600(0.568 – 0.632)
SPR at target mortality	0.194
Average yield per recruit	0.176 lb (0.128 – 0.224)
Natural Mortality (M)	0.319 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	8
Fully selected age to trap nets	8
Average gill-net F, ages 4+	N/A
Average trap-net F, ages 4+	0.058 y^{-1} (0.036 – 0.080)
Sea lamprey mortality (ML)	
Average ages 4+, 2007-2009	0.076 y^{-1}
Total mortality (Z)	
Average ages 4+, 2007-2009	0.442 y^{-1} (0.420 – 0.465)
Recruitment (age-3)	
Average 2000-2009	3,720,500 fish (2,529,663 – 4,911,337)
Biomass (age 3+)	
Average 2000-2009	15,617,000 lb (10,694,460 – 20,539,540)
Spawning biomass	
Average 2000-2009	8,160,100 lb (5,402,772 – 10,917,428)
Model recommended yield limit for 2011	1,142,750 lb
Actual yield limit for 2011	758,300 lb

Lake Michigan

WFM-01 (Bays de Noc)

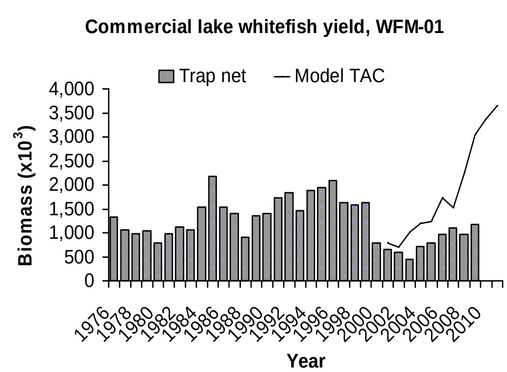
Prepared by Philip J. Schneeberger

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 bays 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.

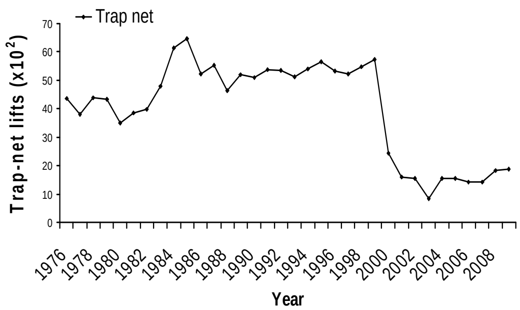
Trap netting has accounted for 98.4% of the WFM-01 commercial lake whitefish yield since 1986. Commercial gill netting in this management zone ceased after 1985. Trawl yield was basically negligible through 2000 and non-existent thereafter. Biological data were lacking from both the gill-net and trawl 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 this year's WFM-01 catch-at-age model. Yield, effort, and fishing mortality figures below reflect these conversions.

Trap-net yield for lake whitefish in WFM-01 was 1,172,000 lb during 2009, up 20% from 2008, and the highest since 1999. Yields in this management unit have generally increased between 2003 and 2009.



Fishing effort was 1,874 trap-net lifts in 2009, up 3% compared to 2008. The current level of effort is roughly only one third the average for years prior to the 2000 Consent Decree (1976-1999).

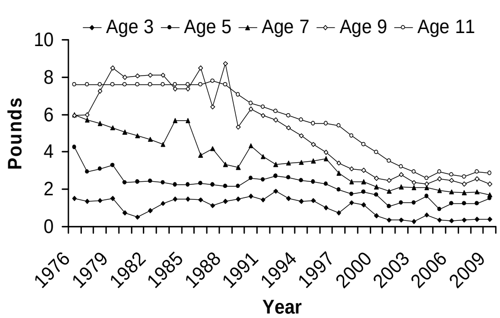
Fishing effort, WFM-01



Catch-per-unit effort (CPUE) has ranged from 197 lb lift^{-1} in 1988 to 780 lb lift^{-1} in 2007. CPUE was 626 lb lift^{-1} in 2009.

Weight-at-age values have been relatively stable during the last 4-5 years following declines, especially for older fish, in the 1990s and early 2000s. Changes in weight-at-age between 2008 and 2009 were less than 10% for all ages except age 5 (19% increase) and age 9 (11% decrease).

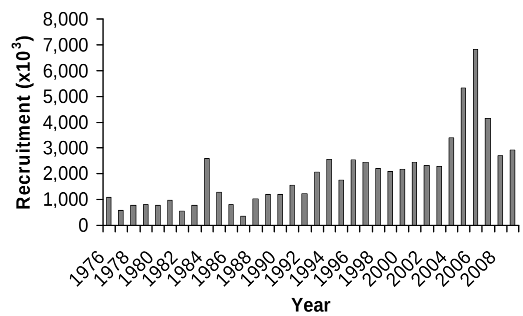
Population mean weight-at-age, WFM-01



A von Bertalanffy growth model was developed using length-at-age data for individual lake whitefish in the combined state and tribal fisheries dataset over the entire time series. Model estimates for growth parameters $L\infty$ and k were 549 mm and 0.15.

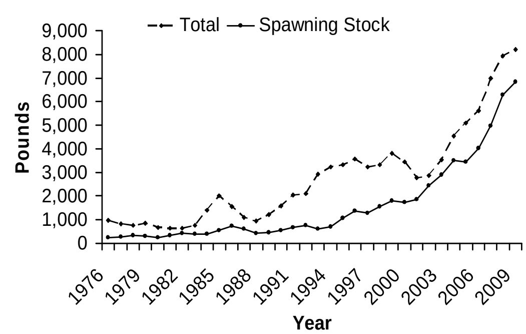
Estimated recruitment (numbers of age-3 fish) increased 7.6% in 2009 compared to 2008. The 2009 recruitment estimate for 3-yr old fish, representing the 2006 year class, was 2.92 million. Recruitment estimates have been higher than 1 million fish every year since 1988 in WFM-01.

Number of age- 3 recruits



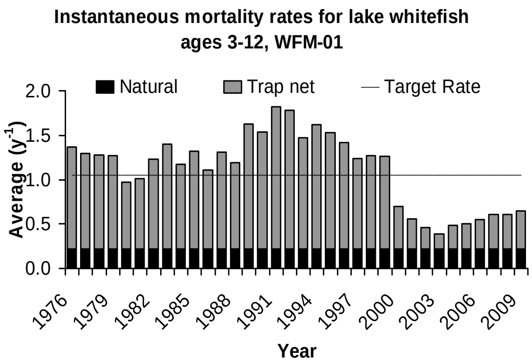
Based on the latest model estimates, fishable biomass was 8.2 million lb in 2009, up for the eighth year in a row. Estimated spawning stock biomass (6.8 million lb) represented 83% of the total biomass estimate. Considering the entire data set, both fishable biomass and spawning stock estimates have generally trended upward, especially since the late 1980s.

Lake whitefish biomass



Estimates of total instantaneous mortality rate (*Z*) declined between 1999 and 2000 and have consistently remained well below the target maximum rate ever since. The 2009 estimate was 0.40 y^{-1} with 0.22 y^{-1}

attributable to instantaneous natural mortality (*M*) and 0.18 y^{-1} due to instantaneous fishing mortality (*F*).



The projected 2011 yield limit for WFM-01 is 3.644 million lb. This value is an 8% increase from the 2010 yield limit of 3.376 million lb. The 2011 yield limit is higher due to favorable estimates for biomass, recruitment, mortality, and CPUE.

Summary Status WFM-01 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.88 lb
Age at first spawning	4 y
Size at 50% maturity	1.33 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.578 lb (2.569 - 2.588)
Current SSBR	1.35 lb (1.28 - 1.43)
SSBR at target mortality	0.1120 lb (0.1119 - 0.1121)
Spawning potential reduction	
At target mortality	0.524 (0.495 - 0.554)
Average yield per recruit	0.505 lb (0.484 - 0.524)
Natural mortality (*M*)	0.219 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to trap nets	8
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.178 y^{-1} (0.153 - 0.206)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.397 y^{-1} (0.372 - 0.425)
Recruitment (age 4)	
(average 2000-2009)	3,620,372 fish (2,444,630 – 5,354,640)
Biomass (age 3+)	
(average 2000-2009)	11,470,195 lb (9,186,750 – 14,537,500)
Spawning biomass	
(average 2000-2009)	8,507,823 lb (7,063,380 – 10,404,800)
MSC recommended yield limit for 2011	3,644,000 lb
Actual yield limit for 2011	3,644,000 lb

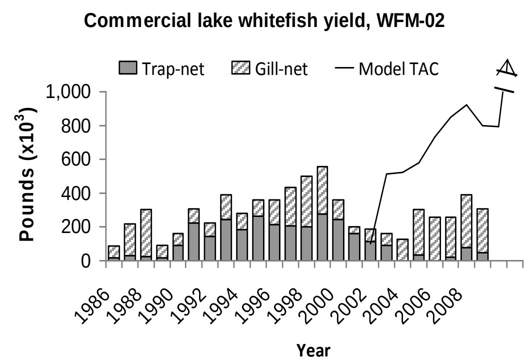
WFM-02 (Manistique)

Prepared by Ted Treska and Mark P. Ebener

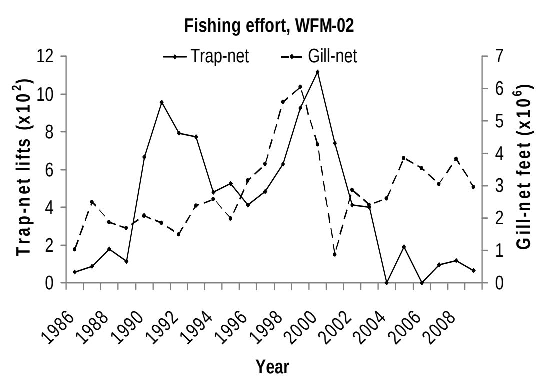
WFM-02 is located in the northwest portion of Lake Michigan. There are 387,000 surface acres of water less than 240 feet deep in the unit. The only known spawning population of whitefish in the management unit is located in Portage Bay; this population is not as abundant as other stocks in Lake Michigan.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

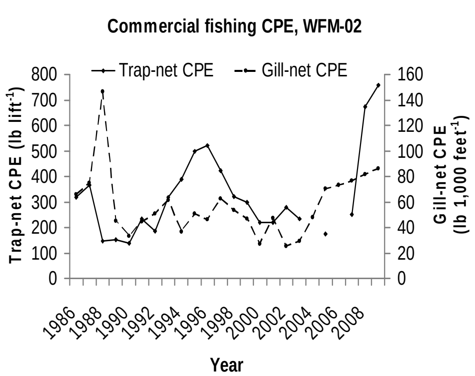
Commercial fishery yield from WFM-02 has averaged 285,000 lb y^{-1} during 1986-2009. As is the case in many Lake Michigan units, yield peaked in the mid to late 1990s with an average yield during 1990 to 1999 of 386,000 lb, with peak yield in 1999 at 558,000 lb. Since 2000, the commercial yield has averaged 250,000 lb and the 2008 yield was the highest recorded since 1999 at nearly 400,000 lb. During the 1990s 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 31,000 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 2009, average effort declined to less than 250 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 2009.



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. 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, all trap net effort in the unit is concentrated near the western border with WFM-01, thus targeting fish moving into the bay, which may not be representative of the entire unit. However, gill-net catch rates have increased substantially in the past five years and the 2009 gill-net CPUE of 86 lb 1000ft^{-1} is the second highest since 1986. 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 73% of the variation in trap-net catch during 1986-2008 in WFM-02. Gill-net effort explained only 51% of the variation in gill-net harvest during 1986-2008.



The stock assessment model projected a total allowable catch of 1.58 million lb from WFM-02 for 2011, but given that the peak historic harvest was 558,000 lb, a harvest regulating guideline (HRG) of 558,000 lb was established by CORA in 2011. This is the fourth 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 2011 assessment. The main reason for low model performance was thought to be the limited number of age classes used in the model, which relied only ages 3 to the 9+ group. In 2005 and 2006, approximately 40% of the fish in the gill-net fishery were age 9+, leading to substantial ambiguity in the model. This proportion increased to 65% and then 79% in 2007 and 2008, with a slight decline to 51% in 2009. To remedy this issue, the plus group was moved to 12+, incorporating 3 more age classes into the model to more accurately represent older fish in the population. 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 samples from being obtained in the past six years. In addition, the biological sample representing the gill-net fishery was very low this year, comprising of only 35 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).

While the 2011 assessment indicates that the population level has declined from the peak in 2006 to levels similar to 2002, and the biomass at levels similar to that of 2004, the model TAC is higher than it has ever been historically. The 2000 and 2001 year classes have comprised between 43 and 58% of the biomass in the past 3 years and seem to be driving the system.

The 2011 assessment model did not meet minimum convergence criteria and 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	0.38 lb
Age at first spawning	3 y
Size at 50% maturity	1.65 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	0.915 lb (SE 0.02)
Current SSBR	0.762 lb (SE 0.02)
SSBR at target mortality	0.113 lb (SE 0.00)
Spawning potential reduction	
At target mortality	0.833 (SE 0.021)
Average yield per recruit	0.121 lb (SE 0.007)
Natural mortality (*M*)	0.377 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	8
Fully selected age to trap nets	8
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.123 y^{-1} (SE 0.012)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.013 y^{-1} (SE 0.001)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.513 y^{-1} (SE 0.012)
Recruitment (age 4)	
(average 1999-2008)	4,013,800 fish (SE 637,030)
Biomass (age 3+)	
(average 1999-2008)	10,746,000 lb (SE 1,294,400)
Spawning biomass	
(average 1999-2008)	7,737,800 lb (SE 863,490)
MSC recommended yield limit for 2011	1,580,490 lb
Actual yield limit for 2011	558,000 lb

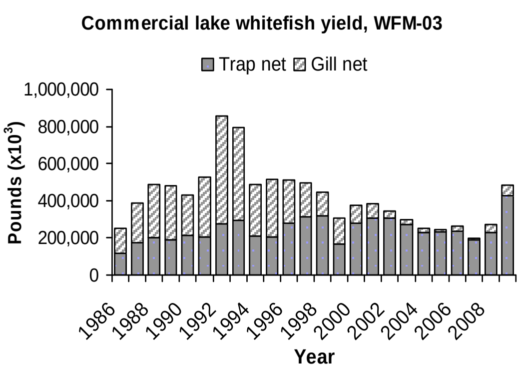
WFM-03 (Naubinway)

Prepared by Mark P. Ebener

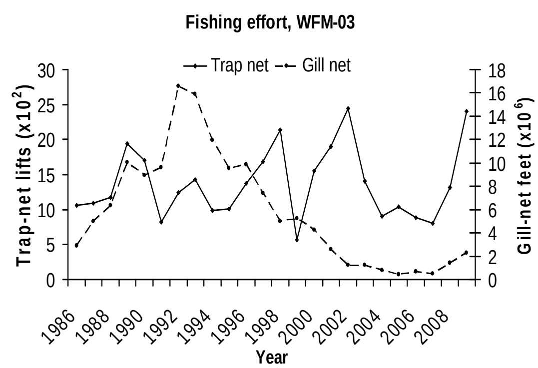
WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinaw west to Seul Choix Point and is bounded on the south by Beaver Island and complex of shoals and islands that surround the island. Nearly the entire unit is shallow water less than 90 ft deep. There are 483,000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

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

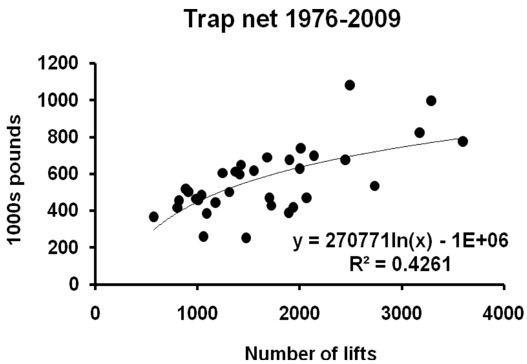
The commercial fishery harvest from WFM-03 averaged 943,000 lb during 1976-2009. The trap-net fishery accounted for 60% of the harvest during 1976-2009. Peak harvests of 1.5-1.8 million lb occurred in 1981-1982 and 1.8-1.9 million lb in 1992-1993. The commercial harvest was 858,000 lb in 2009.

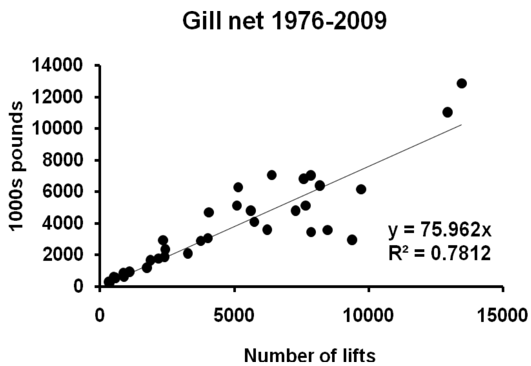


Gill-net effort in WFM-03 has been on a long-term decline during 1976-2009, whereas trap-net effort has been highly variable with no clear trend during the same time period. Gill-net effort peaked at 13.5 million ft in 1992 and declined thereafter. Gill-net effort in 2009 was 1.7 million ft., which was substantially greater than during 2002-2008, but still much lower than during much of 1976-2009. Trap-net effort declined from a peak of 3,597 lifts in 1984 to only 571 lifts in 1999 and was 2,009 lifts in 2009. Trap-net effort has been highly variable but stable at around 1,300 lifts since 1986. 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.

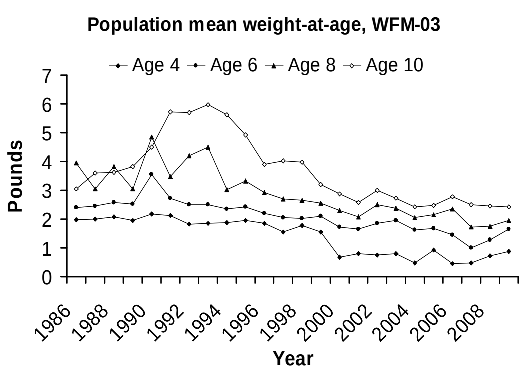


The relationship between fishing effort and harvest in WFM-03 is not as clear as in some other units. Trap-net effort explained only 43% of the variation in trap-net catch and there appeared to be an asymptotic level to harvest for trap nets. On-the-other-hand, gill-net effort explained 78% of the variation in gill-net harvest during 1976-2008 and catch was linearly related to fishing effort. The average trap-net catch rate was 336 lb lift^{-1} and the average gill-net catch rate was 76 lb 1000 ft^{-1} during 1976-2009.





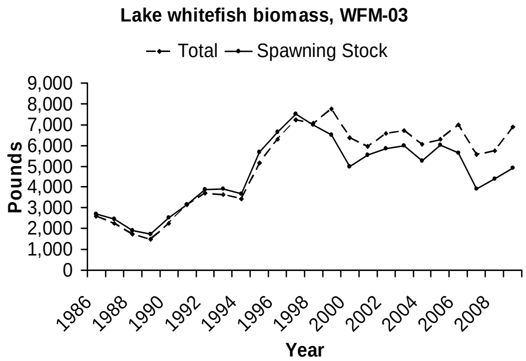
Mean weight at nearly all ages appeared to stabilize and increase slightly in 2009 since the decline began in the mid 1990s. Mean weight at age increased from 2007 to 2009 at all ages except age 4. Unfortunately, mean weight at age in 2009 was still substantially lower than during the 1980s.

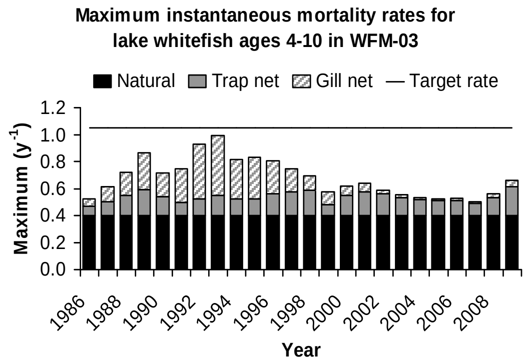


Estimated recruitment of age-4 whitefish to the fishable populations appears to have finally stabilized in WFM-03 in 2008 and 2009. Recruitment averaged 3.4 million age-4 whitefish during 1986-2009. The lowest recruitment was 392,000 fish for the 1984 year class in 1988, while the highest recruitment was 5.8 million fish for the 2002 year class in 2006. The 2005 year class was estimated to contain 4.5 million fish when it recruited in 2009.

Biomass of age-4 and older whitefish in WFM-03 has been on a slow decline since the late 1990s, with a more rapid decline in spawning biomass than total biomass during 1986-2009. Fishable biomass averaged 11.2 million lb during 1986-2009, while spawning stock biomass averaged 10.2 million lb during the same time period. Fishable biomass peaked at 17.1 million lb in 1999 and spawning biomass peaked at 16.6 million lb in 1997. Spawning biomass has been declining much quicker than total biomass since the late 1990s primarily because of growth declines. Fishable biomass and spawning stock biomass were 15.2 and 10.9 million lb, respectively, in 2009.

I input von Bertalanffy growth parameters for $L\infty$ and k and an average water temperature of 6^{o}C 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 59.2 cm total length for $L\infty$ and 0.165 for k produced an estimate of 0.402 y^{-1} from the Pauly relationship.

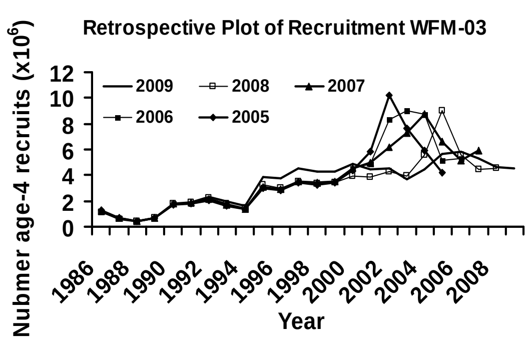
Total instantaneous mortality rate averaged 0.61 y^{-1} in WFM-03 during 1986-2009. Gill-net and trap-net mortality averaged 0.11 y^{-1} and 0.10 $y\text{-}^{1}$ in WFM-03 during 1986-2009. Gill-net mortality peaked at 0.34 y^{-1} in 1993 then continually declined to only 0.03 y^{-1} in 2007. Trap-net mortality peaked at 0.13 y^{-1} in 1997 and since then has fluctuated between 0.05 y-1 and 0.10 y^{-1}. Trap-net mortality was estimated to be 0.11 y^{-1} in 2009, compared to 0.02 $y\text{-}^{1}$ for gill-net mortality in 2009.

Total annual mortality on fully vulnerable age-classes was less than the target rate during 2007-2009 and the spawning potential reduction at current mortality rates and at the target mortality rate was greater than 0.20. The maximum mortality rate did increase in 2009, but was still substantially less than the target rate of 1.05.

The projection model estimated that fishing mortality could be increased 3.8 times. The projected harvest limit for 2011 under this increased fishing rate was estimated to be 2.51 million lb, which is lower than recent years but higher than the early years of the Consent Decree.

Year	Total Allowable Catch
2001	0.95 million
2002	1.31 million
2003	1.46 million
2004	1.94 million
2005	1.97 million
2006	3.4 million
2007	4.16 million
2008	4.83 million
2009	2.82 million
2010	3.4 million

The assessment model for WFM-03 was rated as low because Markov Chain Monte Carlo simulations were poor 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	1.018 lb
Age at first spawning	4 y
Size at 50% maturity	1.837 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	0.924 lb (0.002 SE)
Current SSBR	0.716 lb (0.012 SE)
SSBR at target mortality	0.084 lb (0.000 SE)
Spawning potential reduction	
At target mortality	0.775 (0.013 SE)
Average yield per recruit	0.170 lb (0.009 SE)
Natural mortality (*M*)	0.402 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	9 y
Fully selected age to trap nets	9 y
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.01 y^{-1} (0.015 SE)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.071 y^{-1} (0.073 SE)
Sea lamprey mortality (ML)	
(average ages 4+, 2007-2009)	N/A
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.484 y^{-1} (0.086 SE)
Recruitment (age 4)	
(average 2000-2009)	4,780,000 fish (651,392 SE)
Biomass (age 4+)	
(average 2000-2009)	6,320,000 lb (487,763 SE)
Spawning biomass	
(average 2000-2009)	5,250,000 lb (699,950 SE)
MSC recommended yield limit for 2011	2,510,000 lb
Actual yield limit for 2011	2,510,000 lb

WFM-04 (Beaver Island)

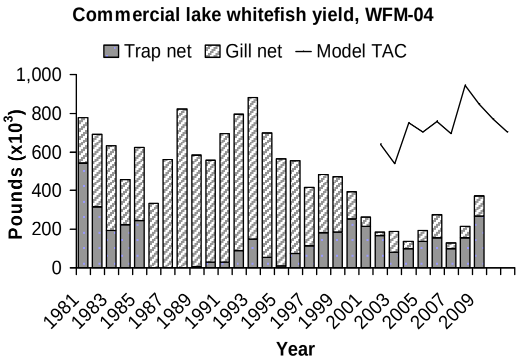
Prepared by Stephen J. Lenart

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.

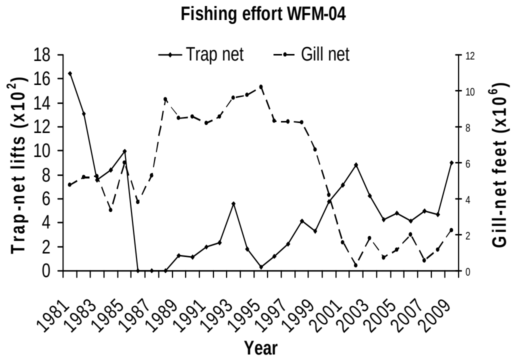
At least several reproductively isolated stocks of whitefish inhabit WFM-04, and most, if not all, of these are associated with the large northern reef complex. One stock spawns in Sturgeon Bay along the northeast side of the unit, while another stock is found at Hog Island.

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.

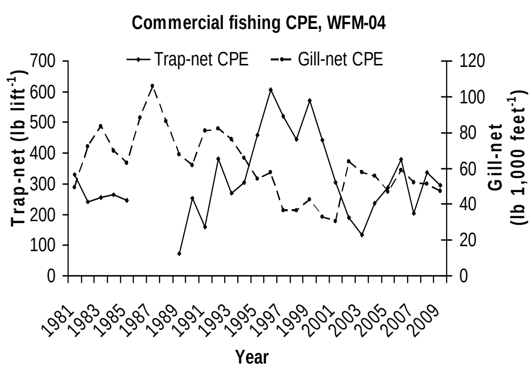
In the four years prior to implementation of the 1985 Agreement between the State and the three COTFMA tribes, the trap-net fishery accounted for a substantial proportion (30–70%) of the total commercial yield. Average commercial yield was 636,000 lb during this period. After 1985, the gill-net fishery 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 2000's, reaching a low of 130,000 lb in 2007. Total yield increased to approximately 217,000 lb in 2008 and then to 373,000 lb in 2009, the highest recorded since 2000. These trends in yield can largely be explained by a steady decline in the gill-net fishery, which has harvested, on average, 72,000 lb y^{-1} during 2000 to 2009. By comparison, average gill-net harvest was 524,000 lb during 1985 to 1999. Since the inception of the 2000 Decree, yield has ranged between 19-44% 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 8 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 8.2 million feet in 1998 to just under 300,000 feet in 2003. Since then gill-net effort has ranged between 0.7 and 2.3 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 y^{-1} 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. In 2009, the trap-net fishery reported 899 lifts, the highest since 1985. This marked increase in effort suggests a spatial redistribution of effort, either from other areas of northern Lake Michigan or Lake Huron.

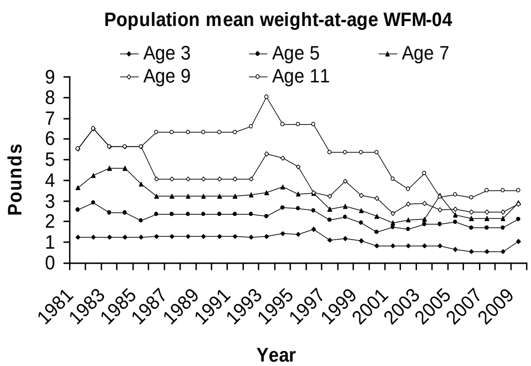


Since rebounding in 2002 after a decade-long decline, catch rates in the gill-net fishery have been quite steady in recent years, averaging 54 lb 1,000 $feet^{-1}$ of effort during 2002 to 2009 (range 47 to 64 lb). In contrast, catch rates in the trap-net fishery showed a marked increase during the 1990s. However, trap-net effort was generally low during this period. Trap-net catch rates have been quite variable throughout the past decade, though a declining pattern has emerged in the past four years, a trend that is generally mirrored in the gill-net fishery.



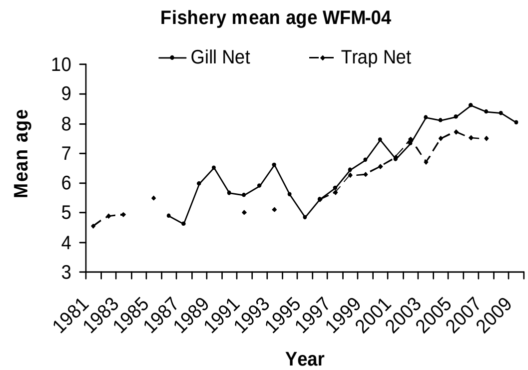
Growth of whitefish in WFM-04 has followed the long-term trend evident across all of northern Lake Michigan-fish are much smaller at a given age than they were during the late 1980s and early 1990s. The decline in growth which began in the early 1990s continued through the early 2000s, at which time growth stabilized across most age classes. Monitoring data from

2009 shows a marked increase in size across most age classes, a somewhat unusual, though encouraging development. The increase was most pronounced for fish aged 5-7. A review of growth patterns in adjacent management units WFM03 and WFM05 show similar increases in size-at-age, suggesting a regional mechanism. 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. Furthermore, the trap-net fishery has not been sampled in the past two years, so gear effects may have influenced the estimates.



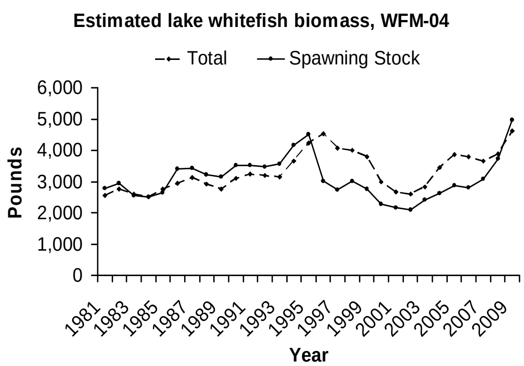
The annual mean weight of a whitefish harvested in the trap-net fishery ranged from 2.0 to 3.3 lb during 1981 to 2009, but recent values have been fairly uniform, in the 2.0 to 2.5 lb range. The mean weight of a whitefish harvested in the gill-net fishery ranged from 2.6 to 3.5 lb during 1981 to 2009. Compared with gill-net fisheries in adjacent management units, mean weight has been highest in WFM-04 since 2004. Mean weight of a fish harvested in the 2009 gill-net fishery was 2.9 lb.

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 tied to a strong 2001 cohort that entered the fishery in 2007 as well as higher selectivity of fish aged 5 and 6 due to increased growth.

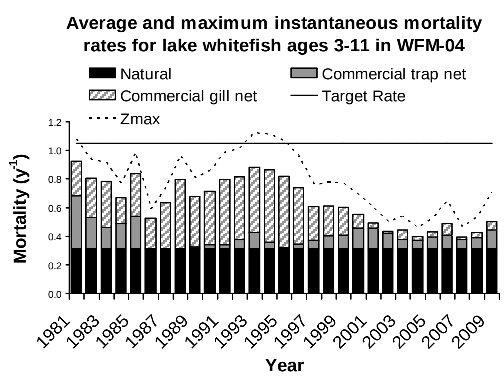


Estimated recruitment of age-3 whitefish to the population in WFM-04 has been markedly stable over time. During the period 1981 to 2005, average estimated recruitment of age-3 whitefish was 783,000 fish (range 357,000 to 1,216,000). Estimates from the catch-at-age model suggest that two of the largest recruitment events occurred in successive years (2004 and 2005), corresponding to the 2001 and 2002 year classes (estimated recruitment of cohorts beyond 2002 not shown due to the high level of uncertainty in the estimates). These recruitment events followed a relatively low period of recruitment during 1999 to 2003.

Spawning stock biomass (SSB) has been fairly stable in WFM-04, a consequence of the consistent recruitment. From 1981 to 1995, estimated spawning stock biomass increased from 2.8 to 4.5 million lb. Relatively high overall mortality rates in the early 1990s, coupled with declining growth, resulted in declining SSB estimates during 1996 to 2002, when estimated SSB fell to a low of 2.1 million lb, less than half that of the 1995 peak. Declining mortality rates helped contribute to a recovery in SSB beginning in 2003. The most recent estimates suggest that SSB has increased to nearly 5 million lb.



A significant factor in this increase in spawning stock biomass was the general decline in fishing mortality rates since the mid-1990s, particularly in the gill-net fishery. During 1987 to 1996, instantaneous gill-net mortality on ages-4+ ranged between 0.36 and 0.57 yr^{-1} (average 0.48). After 1996, gill-net mortality declined for six consecutive years, reaching its lowest point in the time series in 2002 (0.014 y^{-1}). During 2007 to 2009, average instantaneous gill-net mortality was 0.043 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 0.035 y^{-1} during 1986 to 1997). Trap-net mortality increased gradually from 1997 to 2001, but has leveled off in recent years. Average instantaneous trap-net mortality was 0.099 y^{-1} during 2007 to 2009. 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 target maximum of 1.05 y^{-1}. In 2009, the highest estimated mortality experienced by a specific age class (Zmax) was 0.70 y^{-1}. Natural mortality, as estimated from the Pauley equation, remains the largest source of mortality in this unit at 0.314 y^{-1}. Sea lamprey mortality is not estimated separately in this unit, although the high abundance of sea lamprey in northern Lake Michigan may precipitate an evaluation of this mortality component for whitefish. Since 2004, gross wounding (A1-A3) rates on age-6+ whitefish have ranged between 0.7 and 3.5% (average 2.2%).



The 2011 model-generated yield limit of 702,000 lb represents an 8% decrease over the 2010 model-generated limit, despite the model's estimate of increased spawning stock biomass in the last year of assessment. This apparent inconsistency is explained by considering that the 2011 model predicts that fewer fish age 7+ (those most vulnerable to fishing) were present in the population compared to last year.

Younger mature fish not yet fully vulnerable to fishing contributed to the increased spawning-stock estimate as there was a marked increase in weight-at age across all ages, but particularly for ages 4 to 7. One should note that weight-at-age in the fishery is based upon a 3-year average, so the limit for this year is not influenced as much as the biomass estimates by a large annual change in growth. 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. The 2011 HRG was established by CORA at the model-generated limit.

Model Changes and Diagnostics

The basic model structure was maintained during the 2011 assessment. The only major structural change was that fishery catchability was modeled with a random walk, which represents a change from prior assessments (this change resulted in less than a 2% change in the TAC versus the base model). This methodology is more appropriate if catchability is thought to change over time, as we believe to be the case in most of the Treaty water units. After updating the source file to include 2009 data, the new base model was optimized. The model met minimum convergence criteria, provided a reasonable fit to the observed fishery parameters (though with less than optimal fit to gill-net fishery age composition) and biomass estimates were insensitive to changes in start values for key parameters. Gill-net fishery selectivity estimation using the double-logistic function remains problematic. MCMC simulations could not be run to completion (bounding issues). Nonetheless, the WFM-04 model has been quite stable over the years and, in general, biomass estimates show little variation when making modest changes to model structure (bounds, etc). Retrospective analyses of recruitment and SSB do show some fairly strong temporal patterns. A preliminary version of the WFM04 model incorporating length-based fishery selectivity demonstrated improved MCMC diagnostics, reduced retrospective patterns for SSB and slightly improved fit to the age composition data. Additional work and review will be necessary before implementation, but the estimates of stock size obtained from the new model are markedly similar to the base assessment, demonstrating that current estimates of stock size from the base model are likely reasonable, despite the technical inadequacies.

The 2011 WFM-04 model performance was rated as “low”, primarily due to the issues related to MCMC simulations, the lack of fit to the gill-net age composition, and retrospective patterns in SSB.

Summary Status WFM-04 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.03 lb
Age at first spawning	3 y
Size at 50% maturity	1.59 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.237 lb (0.004)
Current SSBR	1.679 lb (0.024)
SSBR at target mortality	0.388 lb (0.000)
Spawning potential reduction	
At target mortality	0.751 (0.000)
Average yield per recruit	0.368 lb (0.015)
Natural mortality (*M*)	0.314 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	10
Fully selected age to trap nets	10
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.043 y^{-1} (0.003)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.099 y^{-1} (0.007)
Sea lamprey mortality (ML)	NA
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.456 y^{-1} (0.009)
Recruitment (age 3)	
(average 2000-2009)	890,563 fish (72,336)
Biomass (age 3+)	
(average 2000-2009)	3,434,068 lb (200,150)
Spawning biomass	
(average 2000-2009)	2,907,010 lb (172,210)
MSC recommended yield limit for 2010	702,000 lb
Actual yield limit for 2011	702,000 lb

WFM-05 (Grand Traverse Bay)

Prepared by Erik J. Olsen and Stephen J. Lenart

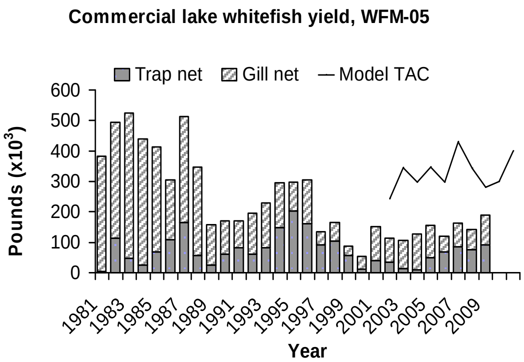
Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including the both the east and west arms of Grand Traverse Bay. The deepest parts 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.

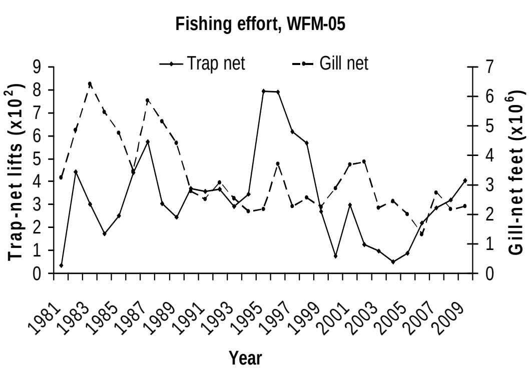
WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. Tribal small-boat fishers relied on Grand Traverse Bay as an important 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.

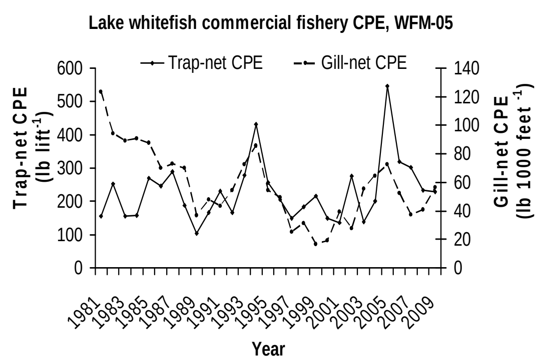
Commercial yields of lake whitefish during the 1990s were substantially less than during the 1980s. The commercial yield averaged 383,000 lb from 1980 to 1989 and 205,000 lb during 1990 to 1999. The fishery declined through the late 1990s, with the lowest recorded yield coming in 2000 at 53,000 lb. The fishery has rebounded slightly through 2009, averaging 140,598 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 1999. 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, but with a downward trend since 1996. 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 y^{-1}, peaking at 790 lifts in 1996. Trap-net effort has declined since, averaging 166 lifts since 2000, with an all-time low of 51 lifts in 2004.



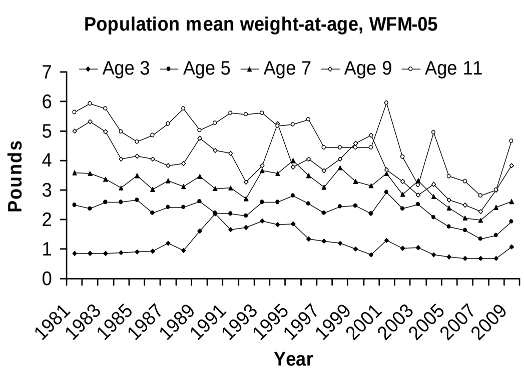
The decline in yield of whitefish in WFM-05 has generally mirrored the decline in lake whitefish recruitment within this management unit. CPUE of whitefish in the large-mesh gill-net fishery declined from 153 lb 1,000 ft^{-1} of gill net in 1979 to a low of 13 lb $1000ft^{-1}$ in 1999. Since 2000, gill-net CPUE has generally been trending upward. Except for some relatively high catch rates in 1994 and 2006, from 1981-2009 the CPUE of whitefish in the trap-net fishery was relatively stable, averaging 228 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 271 lb through 2009. Gill-net fishers in WFM-05 claim the long-term decline in catch rates through 2000 was a result of both increased water clarity due to 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 1997-1999 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.



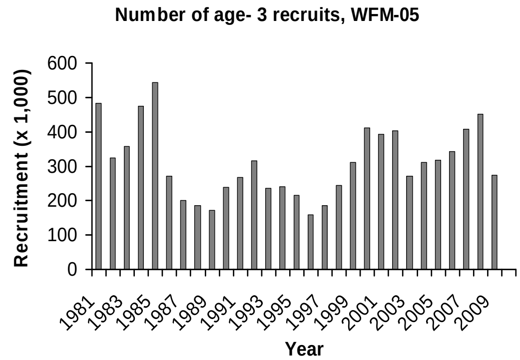
Whitefish from WFM-05 are currently of small to moderate size. Mean weight-at-age is trending down in recent years. From 2000 to 2009, the proportion of the yield made up of the three size classes of whitefish were 76% No.1 (< 3 lb), 18% mediums (3-4 lb), and 6% jumbos (≥ 4 lb). In comparison, from 1980 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 2.4 lb during the last three years (2007-2009). Annual mean weight of whitefish in the gill-net harvest ranged from 2.4 to 3.5 lb since 1979 and averaged 2.8 lb during the last three years (2007-2009).

Mean weights of lake whitefish (ages 3-9) from WFM-05 have been slowly declining since 1981, though substantial increases were noted for most age classes in the last year of the assessment. While the long-term pattern of declining growth has also been observed in other areas of Lakes Michigan and Huron, adjacent units to the north also showed increases in size-at-age during 2009.

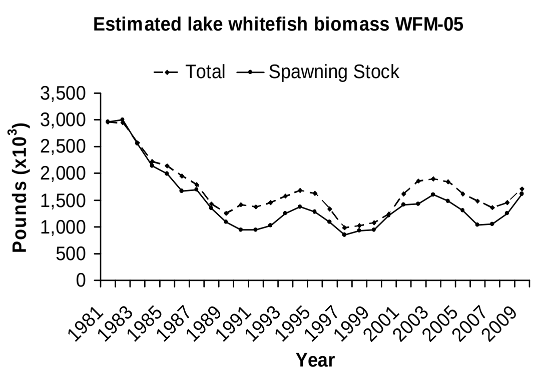


Recruitment of age-3 whitefish to the population in WFM-05 is highly variable and has generally declined since the mid-1980s based on estimates from the stock assessment model. Following relatively high recruitment of age-3 whitefish into the population at the beginning of the time-series, estimated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



During 1981-1985 average estimated recruitment was 437,000 fish (range 324,000 to 544,000). Since then, estimates have ranged between 159,000 and 451,000, with an average of 359,000 age-3 fish entering the fishery annually from 2000-2009.

Biomass of whitefish estimated with the stock assessment model declined through the 1980s. Annual biomass of whitefish ≥ age 3 (calculated at the beginning of each year) peaked at the beginning of the 1981-2009 timeframe with 3.0 million lb. Biomass steadily declined to 1.3 million lb in 1989 and has ranged from 985,000 to 1.9 million lb from 1990 to 2009. Spawning stock biomass followed the same trend, peaking at 3.0 million lb in 1981 before declining through the remainder of the decade. Since 1990 spawning stock biomass has been relatively steady, between 853,000 and 1.6 million lb.



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 averaged 0.10 for the large-mesh gill-net fishery and 0.10 for the trap-net fishery during 2007-2009. Gill net induced fishing mortality ranged from 0.31 in 1983 to 0.05 in 2006, while trap-net induced fishing mortality ranged from 0.01 as recently as 2004 to 0.25 in 1995. The gill-and trap-net mortality level has declined from a combined rate of 0.52 in 1996 to a low of 0.10 in 2000.

Total instantaneous mortality on the fishable stock in WFM-05 during 2007-2009 was substantially less than the target rate of 1.05. Total instantaneous mortality was estimated to be 0.485 during 2007-2009 and the spawning potential reduction value in 2009 was 0.53.

<u>Stock Assessment Model</u>

To generate the 2011 yield limit, the model .dat file was updated with biological data through 2009. Due to low sample size, weight-at-age for age-three fish was calculated from a three-year average. Sample sizes for other fishery parameters were sufficient. No structural changes were made to the base model for the 2011 assessment. The model reached convergence and was not sensitive to changes in initial conditions (q and popscaler), but MCMC simulations were plagued by selectivity bounding issues. The model provided a reasonable fit to harvest and effort, 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 a minor temporal pattern, with good agreement for the last three data years, which is an improvement over prior assessments. A retrospective analysis of recruitment showed a similar pattern, while a retrospective analysis of *F* revealed good agreement. Due to bounding issues, MCMC simulations could not be run to completion. The 2011 assessment model was given a medium rating. A recent analysis of recreational creel data suggests that sufficient harvest and adequate biological samples exist for WFM-05, warranting inclusion of the recreational fishery into the 2012 assessment model. A preliminary model will be evaluated by the MSC in the fall of 2011.

The 2011 model-generated yield limit of 399,000 lb represents a 33% increase from the 2009 limit and was accepted as the HRG for this unit. Estimated spawning biomass increased by 30% from the 2010 assessment. The increase can be almost wholly attributed to increased growth over the past two years, across all age classes. Since overall mortality is well below target, the projection model estimated that fishing effort could be increased approximately three-fold during 2011 from the average during 2007-2009.

Summary Status WFM-05 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	1.06 lb
Age at first spawning	4 y
Size at 50% maturity	1.40 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.51 lb (0.005)
Current SSBR	1.33 lb (0.037)
SSBR at target mortality	0.195 lb
Spawning potential reduction	
At target mortality	0.08 (0.001)
Average yield per recruit	0.561 lb (0.013)
Natural mortality (*M*)	0.289 y^{-1}
Fishing mortality rate 2007-2009	
Fully selected age to gill nets	11
Fully selected age to trap nets	11
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.096 y^{-1} (0.006)
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.10 y^{-1} (0.007)
Sea lamprey mortality (ML)	NA
Total mortality (*Z*)	
(average ages 4+, 2007-2009)	0.485 y^{-1} (0.012)
Recruitment (age 3)	
(average 2000-2009)	358,920 fish (26,131)
Biomass (age 3+)	
(average 2000-2009)	1,607,200 lb (75,348)
Spawning biomass	
(average 2000-2009)	1,339,900 lb (60,267)
Model Recommended yield limit in 2011	399,000 lb
Actual yield limit for 2011	399,000 lb

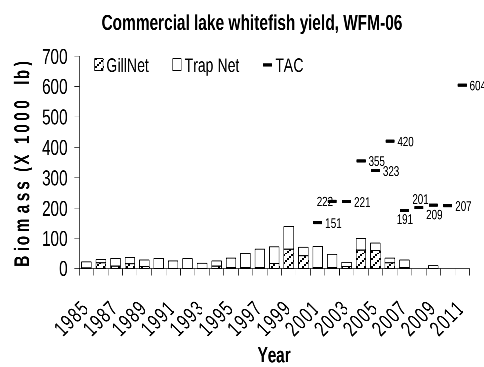
WFM-06 (Leland - Frankfort)

Prepared by Randall M. Claramunt

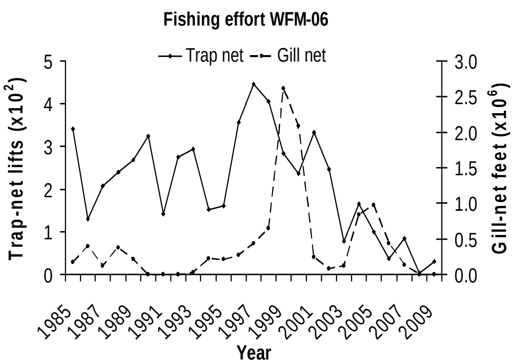
Lake whitefish management unit WFM-06 is located in 1836 Treaty waters west of the Leelanau Peninsula from about Cathead Point south to Arcadia. Surface area for this unit is 945,156 acres (including part or all of grids 709-714, 808-814, 908-912, and 1008-1011). These waters of Lake Michigan include 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 is reported from grids 812-814 and 912. Beginning in 2000, WFM-06 became a shared zone in a truer sense of the term, and waters were opened to both state and tribal fishers. Since 2000, state-licensed effort has declined and the majority of yield is from tribal effort (trap and gill nets). 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.

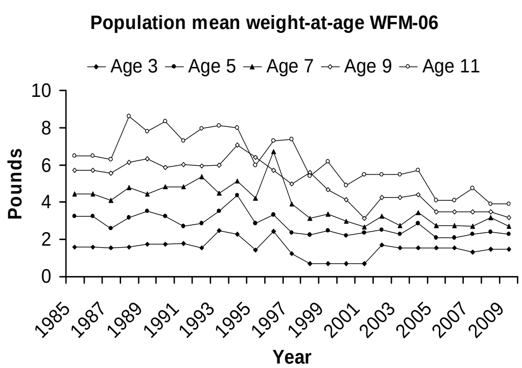
There was a moderate increase in harvest in 2009 of 9,900 lb, up from only 130 lb of harvest in 2008, but still substantially down from 29,000 lb in 2007. Harvest remains well below the 1985-2008 average of 46,000 lb for this unit. Of the total yield in 2009, trap-net yield was 9,860 lb (99.6%) and gill-net yield was 40 lb (0.4%). Proportions of yield by gear type have varied considerably from year to year with an average split of 73.0% from trap nets and 27.0% from gill nets between 1985 and 2008.



Trap-net effort was low (30 lifts) in 2009; effort had increased from 38 lifts in 2006 to 84 lifts in 2007. However, trap-net effort in 2008 (3 lifts) was the lowest recorded level for the 1985-2008 series (average of 221 lifts). Gill-net effort in 2009 (1,300 ft) was unchanged from 2008, and was substantially lower than the 1985-2008 average of 444,200 ft.

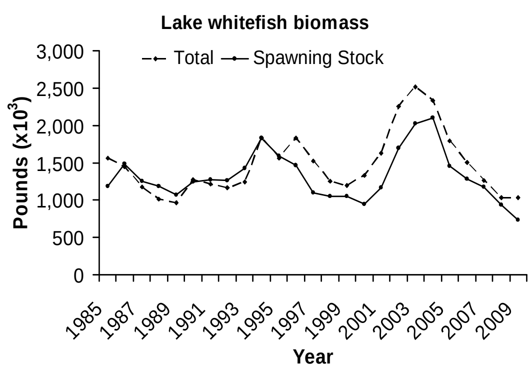


Lake whitefish weight-at-age in 2009 was relatively unchanged for most age groups from the 2008 values. Weight-at-age during 2004 and 2005 appeared to have stabilized from observed declines during 1996 to 2001 for most ages. Based on samples for fish aged 5-12+, weight-at-age values were still 25% lower than the 1985-2008 averages.



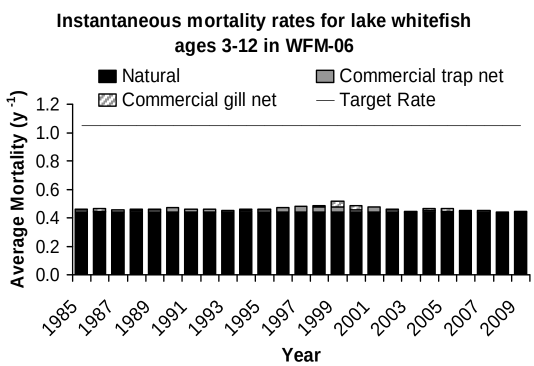
Recruitment, based on estimated numbers of age-3 fish, increased from 212,000 fish in 2008 to 557,000 fish in 2009. Recruitment in 2009 was lower than the long-term average of 576,000 fish. Periods of high recruitment were observed during 2000-2002, and low recruitment was observed during 1987-88 and 2004-2005.

Estimates of total biomass and spawning stock biomass have roughly paralleled each other from 1985 through 2009, and reflect changes in recruitment estimates. Biomass values estimated for 2009 were 1.03 million lb for total and 729,000 lb for spawning stock biomass. The ratio of spawning stock biomass to total biomass was 0.71 in 2009, which was lower than the ratio in 2008 of 0.91.



Total instantaneous mortality rate (*Z*) in 2009 was 0.443 y^{-1}, showing a moderate increase in the rate from 0.33 y^{-1} in 2007 (mortality was not estimated in 2008). Based on current estimates, the 2009 rate for *Z* is similar to the average of 0.41 y^{-1} for 1985-2007. Instantaneous fishing mortality rates (*F*) have varied considerably for trap nets and gill nets throughout the time series. During 2009, *F* was higher for the trap-net fishery because it was the only major source of fishing mortality. Estimates for F were 0.005 y^{-1} for trap nets and <0.0001 y^{-1} for gill nets.

The 2009 estimate for instantaneous natural mortality rate was 0.438 y^{-1}, 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 6ºC. The rate is assumed to be constant over time, but is updated annually during each stock assessment. In 2009, the growth parameters were estimated at 57.2 for L∞ and 0.44 for K based on survey data from the entire time series (1985-2009) to represent growth conditions for this stock.



The 2011 model generated limit was 604,000 lb. Due to the low performance of the model because of limited data inputs and concerns about the estimates generated from the assessment, the TFC has agreed to adopt an alternative total harvest limit of 250,000 lb. Even so, based on current fishing mortality and 2011 approved yield-limit, the level of commercial fishing effort inWFM-06 could increase from the 2009 levels.

Summary Status WFM-06 Whitefish	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.5 lb
Age at first spawning	3 y
Size at 50% maturity	1.9 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.31 lb (1.30 – 1.32)
Current SSBR	1.29 lb (1.27 – 1.31)
SSBR at target mortality	0.99 lb (0.97 – 1.0)
Spawning potential reduction	
At target mortality	0.99 (0.97 – 1.0)
Average yield per recruit	0.01 lb (0.003 – 0.03)
Natural mortality (*M*)	0.438 y^{-1}
Fishing mortality rates	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	8 y
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0 y^{-1}
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.005 y^{-1} (0.001 – 0.008)
Sea lamprey mortality (ML)	
(average 2007-2009, ages 4+)	N/A
Total mortality (*Z*)	
(average 2007-2009, ages 4+)	0.443 y^{-1} (0.437 – 0.447)
Recruitment (age 3)	
(average 2000-2009)	717,000 fish (466,061 – 2,975,000)
Biomass (age 3+)	
(average 2000-2009)	1,668,200 lb (1,167,740 – 2,168,660)
Spawning biomass	
(average 2000-2009)	1,352,400 lb (946,680 – 1,758,120)
Recommended yield limit in 2011	604,000 lb
Actual yield limit for 2011	250,000 lb

WFM-07 (Ludington)

Prepared by Archie W. Martell Jr.

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 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 no islands or bays and, apart from the shoreline, there are no distinguishing features relevant to whitefish biology. There are several inflows from the Manistee, Little Manistee, Big Sable, Pere Marquette, and Pentwater Rivers, and drowned river mouths at Manistee Lake, Pere Marquette Lake, and Pentwater Lake.

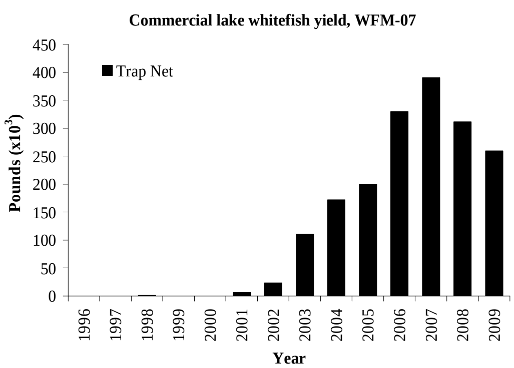
Since 2000, WFM-07 has been a Tribal commercial fishing zone for lake whitefish, part of the Little River Zone with tribal fishing regulated under permitting control of the Little River Band of Ottawa Indians (LRBOI). From 1985 through 2000, there was no significant State commercial fishing effort and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

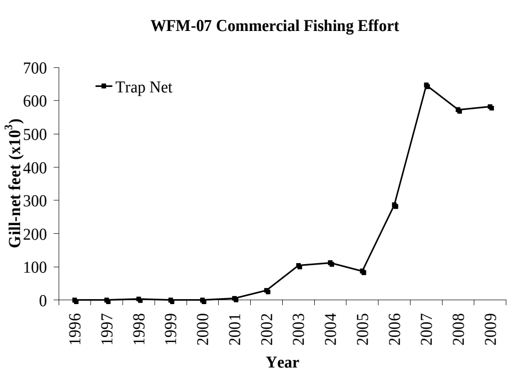
There has been no statistical catch-at-age modeling of the lake whitefish stock in WFM-07 due to a lack of long-term commercial catch-at-age information. Pursuant to the 2000 Consent Decree, the tribes had three years of allowable commercial fishing without harvest limits in this unit during 2001-2003.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

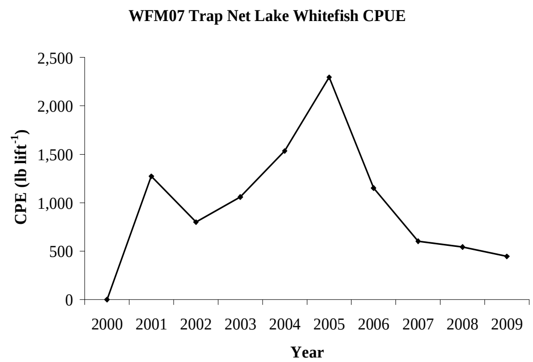
At the conclusion of the 2003 fishing season, three years of commercial trap net fishing activity for lake whitefish was completed by Tribal fishers within this unit. Following the 2000 Consent Decree and the Tribal Management Plan, an annual Harvest Regulation Guideline (HRG) for lake whitefish was 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.

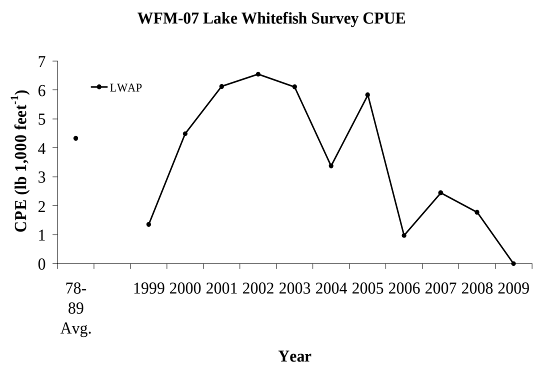
The 2001-2009 average lake whitefish commercial harvest within this unit has been 200,062 lb. In 2001 Tribal commercial fishing activities began, with effort only occurring in October and November. A total harvest of 6,361 lb from 5 trap-net lifts was reported. In 2002 Tribal commercial harvest was 23,165 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. 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 to 445 lb lift^{-1} in 2009. The 2001-2009 average trap net CPUE was 1,078 lb lift^{-1}.









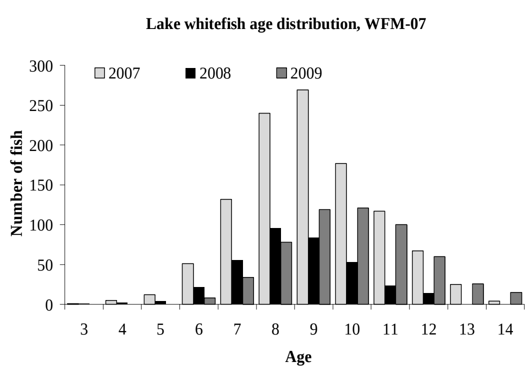
Fishery-independent surveys were conducted during the spring with graded-mesh gill nets (GMGN) following the Lakewide Assessment Plan (LWAP). From 1999 to 2008, GMGN CPUE (number 1000 ft^{-1} of GMGN) for lake whitefish were 1.4, 4.5, 6.1, 6.5, 6.1, 4.3, 5.8, 0.97, 2.45, and 1.77, respectively. In 2009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

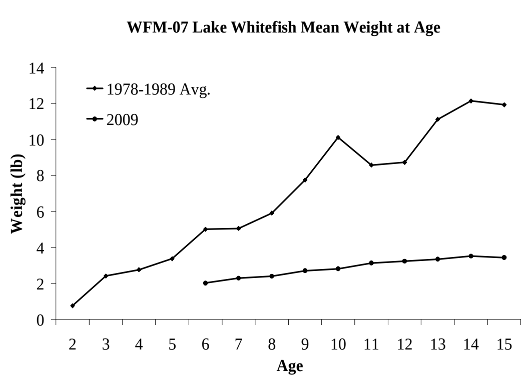
Commercial monitoring during 2004-2009 has shown that whitefish are maintaining a mean length of over 20 inches, larger than the 2001-2003 observations. The mean length of the lake whitefish within this unit is still below that of the 1978-1989 survey and

1983 commercial samples, which averaged over 23 inches.

Similar to average length, the mean weight of lake whitefish from the commercial samples (2.85 lb) in 2009 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 2009 commercial samples was 9.9 y. The current data suggests that the lake whitefish population has an older mean ages 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 2009 survey and commercial samples was substantially lower than the 1978-1989 survey average. This follows a similar trend that has been observed from 2000 to present. The lower weight-at-age indicates that growth rates have been suppressed within this unit compared to historical levels.





Instantaneous mortality rates (*Z*) for WFM-07 lake whitefish were estimated using catch curve analysis. Estimated *Z* for 1978-1989 spring graded-mesh gill-net survey averaged 0.20 y^{-1} for ages 3 through 15. For 2006-2009 *Z* was estimated to be 0.339 y^{-1}, 0.386 y^{-1}, 0.281 y^{-1}, and 0.338 y^{-1}, respectively for ages 7+. The estimated total annual mortality rates calculated for this lake whitefish stock has been below the target maximum total annual mortality rate of 0.65 y^{-1} as outlined in the 2000 Consent Decree.

The lake whitefish stocks within WFM-07 have relatively low exploitation rates as compared to other management zones in northern Lake Michigan. With the development of the tribal commercial fishery, however, there are indications that the abundance of lake whitefish may be decreasing within this management unit as compared to recent and historical observations of relative abundance. The results from the spring GMGN surveys and the commercial harvest, when compared to historical information, shows signs of depressed 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, but is 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

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

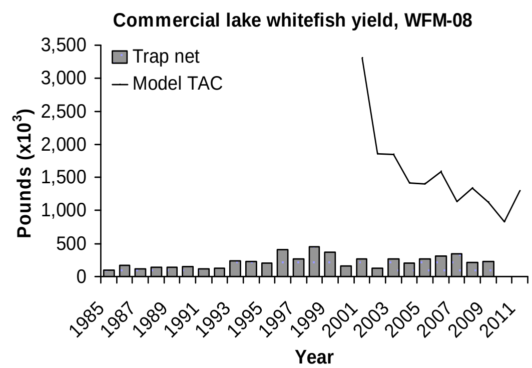
WFM-08 (Muskegon)

Prepared by Randall M. Claramunt

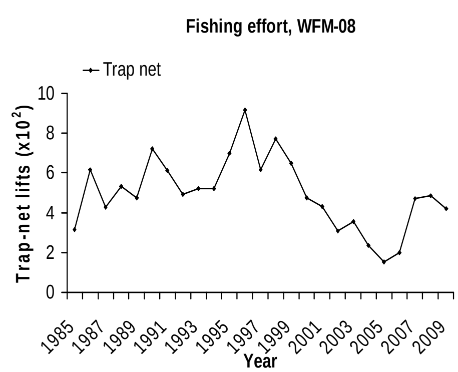
Management unit WFM-08 is the Lake Michigan whitefish zone from about Montague south past Port Sheldon. WFM-08 has a surface area of 1,506,880 acres in Michigan grids 1706-1710, 1806-1810, 1906-1911, and 2006-2011. Apart from the shoreline, inflows from the White, Muskegon, and Grand rivers, and drowned 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 2009 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.

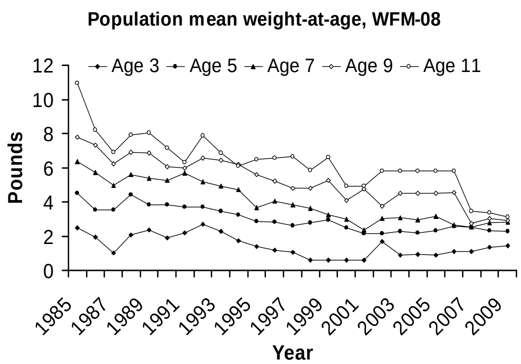
Lake whitefish yield from WFM-08 in 2009 was 229,000 lb. In 2009, yield increased slightly from 2008 (217,000 lb), and was just above the 1985-2008 average of 226,000 lb. Trap-net effort has increased considerably in the last few years, from 198 lifts in 2006, to 471 lifts in 2007, 484 in 2008, and 421 in 2009.



Although trap-net effort has increased since 2006, the current level of commercial effort is approaching the long-term average for this unit of 500 lifts from 1985-2008.

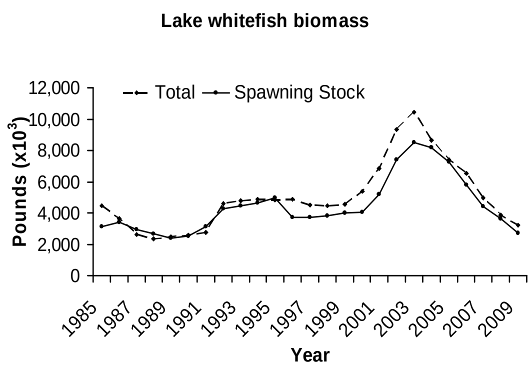


Weight-at-age data have trended downward from 1985 through 2003. After 2003, weight-at-age appeared to have stabilized for most of the age groups, although biological data for the older age groups is limited and appears to be decreasing during the last three years in the time series. Overall, weight-at-age values in 2009 are relatively unchanged from 2008 and approximately 25% lower than the long-term average for ages 4-9 from 1985-2008.

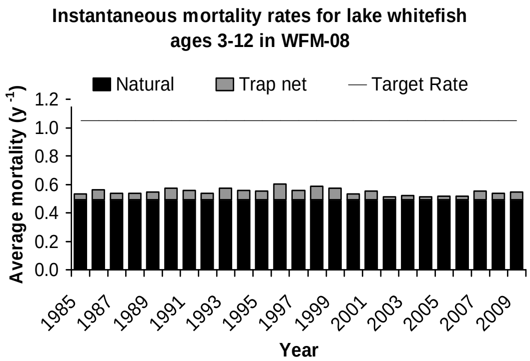


Recruitment, based on the estimated number of age-3 fish, was 1.4 million in 2009. Estimates of recruitment were considerably higher during 1999-2003 (averaged 5.9 million and peaked at 9.0 million), but the estimate for 2009 was slightly lower than the 1985-2008 average of 2.6 million age-3 fish.

Up to 2003, estimates of total fishable biomass and spawning stock biomass continued along increasing trends that have persisted since the early 1990s. In 2004 and 2005, however, fishable biomass and spawning stock biomass appear to have reached a plateau or carrying capacity for this stock. The trend through 2009 suggests that the stock may be experiencing density-dependent controls as total biomass decreased from 10.4 million lb in 2003 to an estimated 3.2 million lb in 2009. Spawning stock biomass followed a similar decline from 8.5 million lb in 2003 to 2.7 million lb in 2009. The ratio of spawning stock biomass to total biomass (age 3+) was close to 1.0 in 2009 (0.83), but slightly lower than the 1985-2008 average ratio of 0.91.

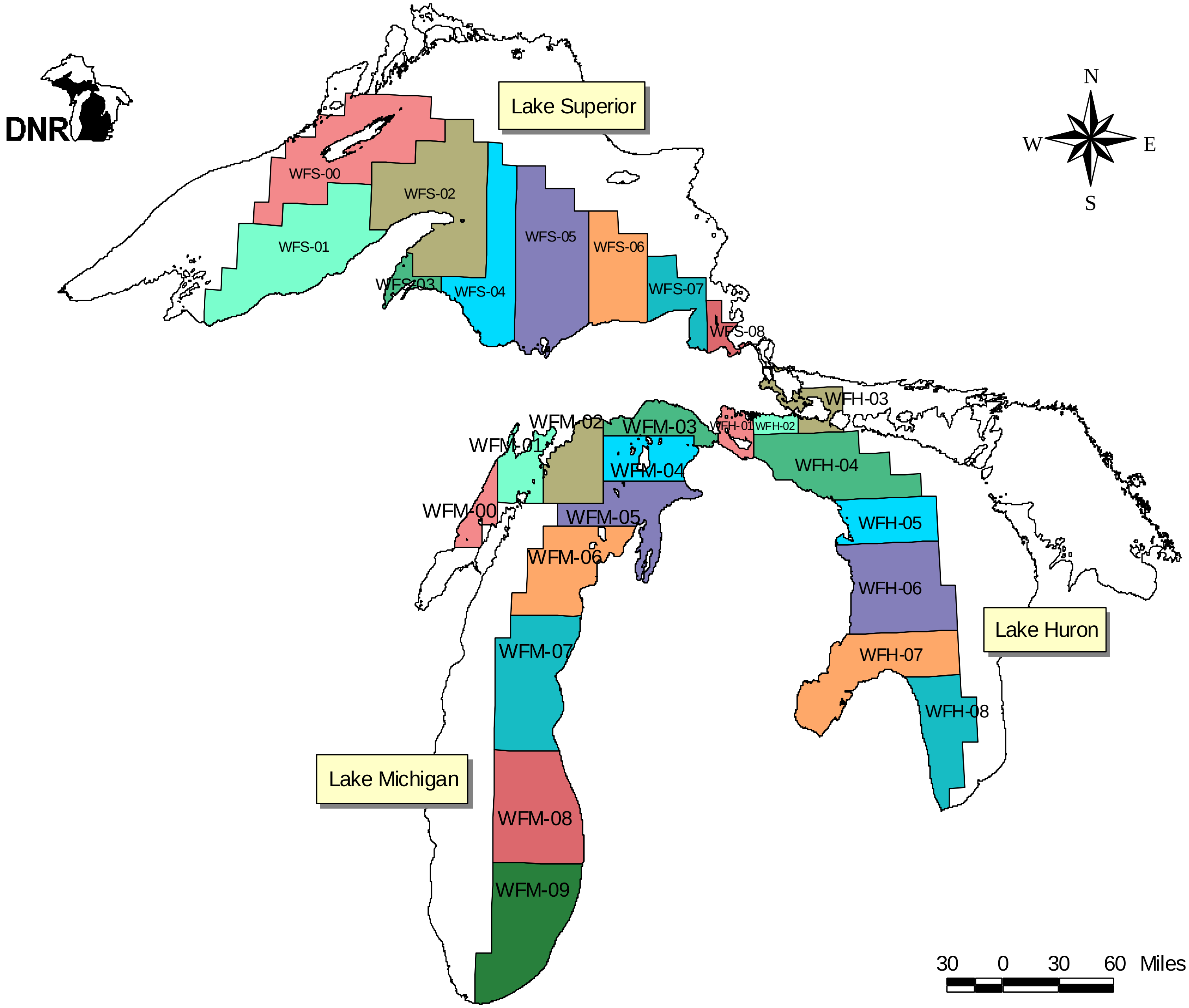


Mortality rates have been relatively stable throughout the time series. Instantaneous total mortality (*Z*) was estimated at 0.532 y^{-1} during 2009, below the target mortality rate of 1.05 y^{-1}. Components of the total rate consisted of 0.042 y^{-1} for instantaneous trap-net fishing mortality (*F*) and 0.490 y^{-1} for instantaneous natural mortality (*M*). Estimates of mortality have been very consistent from 1985-2009 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∞) 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 2009, the growth parameters were estimated at 54.2 for L∞ and 0.51 for K based on survey and commercial data from the entire time series (1985-2009) to better represent growth conditions for this stock.

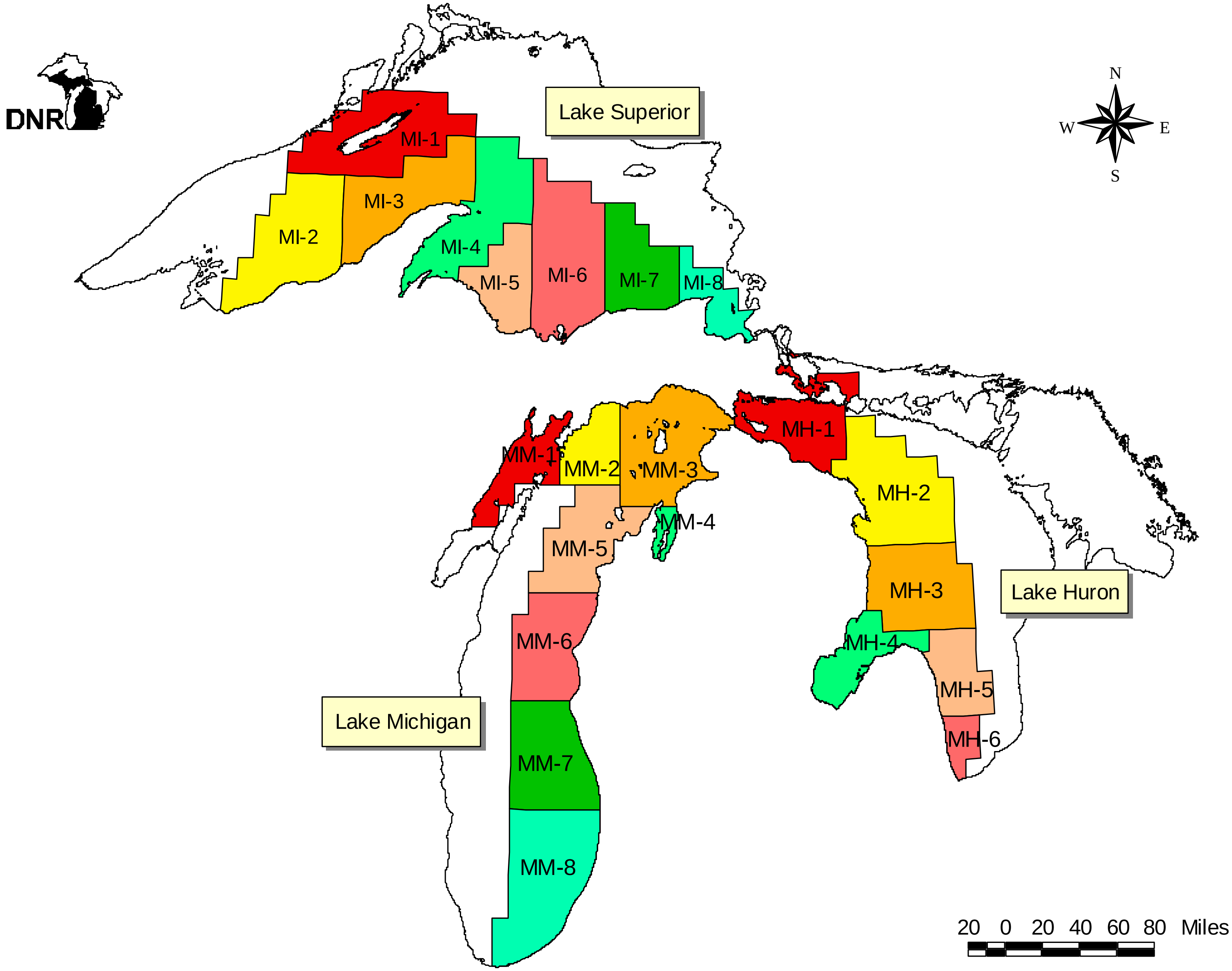


The 2011 yield limit for WFM-08, calculated using the projection model, was 1,302,000 lb (500,000 lb for state-licensed fishers and 802,000 for tribal fishers).

Summary Status WFM-08 Whitefish	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.45 lb
Age at first spawning	3 y
Size at 50% maturity	1.92 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.04 lb (1.03 – 1.04)
Current SSBR	0.95 lb (0.92 – 0.99)
SSBR at target mortality	0.66 lb (0.63 – 0.70)
Spawning potential reduction	
At target mortality	0.67 (0.61 – 0.78)
Average yield per recruit	0.10 lb (0.09 – 0.13)
Natural mortality (*M*)	0.490 y^{-1}
Fishing mortality rates	
Fully selected age to gill nets	N/A
Fully selected age to trap nets	11 y
Gill net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0 y^{-1}
Trap net fishing mortality (*F*)	
Average 2007-2009, ages 4+	0.055 y^{-1} (0.05 – 0.07)
Sea lamprey mortality (ML)	
(average 2007-2009, ages 4+)	N/A
Total mortality (*Z*)	
(average 2007-2009, ages 4+)	0.545 y^{-1} (0.540 – 0.558)
Recruitment (age 3)	
(average 2000-2009)	3,631,000 fish (2,348,110 – 4,051,840)
Biomass (age 3+)	
(average 2000-2009)	6,667,367 lb (4,245,509 – 7,513,818)
Spawning biomass	
(average 2000-2009)	5,712,776 lb (3,624,286 – 6,408,545)
Recommended yield limit in 2010	1,302,000 lb
Actual yield limit for 2011	1,302,000 lb



Appendix 1. Lake whitefish management units.



Appendix 2. Lake trout management units.