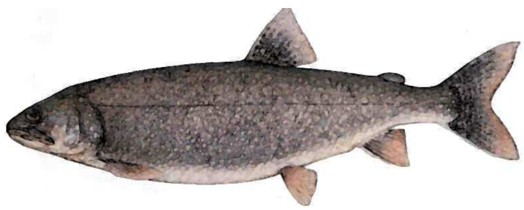
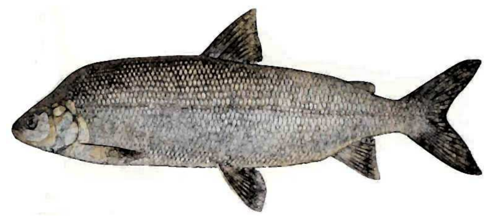
Technical Fisheries Committee Administrative Report 2010: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan, with Recommended Yield and Effort Levels for 2010





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

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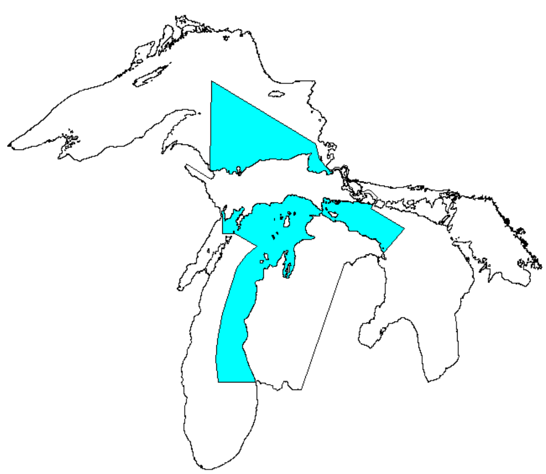
Editors



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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 2010, 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 two 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 2010 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 2010 specified in the Consent Decree.

The 2010 MSC recommended 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 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	MSC recommended yield limit (lb)	Actual yield limit (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	86,163	107,902	NA
		MI-6	118,450	125,780	4.62 million
		MI-7	82,273	95,190	2.76 million
	Huron	MH-1*	205,913	245,000	7.34 million
		MH-2	79,829	79,829	NA
	Michigan	MM-1,2,3*	0	503,000	15.62 million
		MM-4*	80,418	201,218	0.99 million
		MM-5*	171,643	171,643	0.91 million
		MM-6,7	396,823	396,823	NA
Lake whitefish	Superior	WFS-04	81,000	81,000	NA
		WFS-05	423,000	423,000	NA
		WFS-06	no estimate	210,000	NA
		WFS-07	685,000	535,000	NA
		WFS-08	170,000	170,000	NA
	Huron	Northern Combined	2,800,000		NA
		WFH-01		467,000	NA
		WFH-02		500,000	NA
		WFH-03		150,000	NA
		WFH-04		546,000	NA
		WFH-05	1,075,000	962,000	NA
	Michigan	WFM-01	3,644,000	3,644,000	
		WFM-02	792,000	558,000	NA
		WFM-03	3,400,000	2,820,000	NA
		WFM-04	768,000	768,000	NA
		WFM-05	299,000	299,000	NA
		WFM-06	207,000	207,000	NA
		WFM-07	no estimate	500,000	NA
		WFM-08	831,000	831,000	NA

*Units with stipulated harvest limits

In 2010, the MSC, for the first time, implemented a model rotation plan for three lake trout units. Under this plan, full stock assessments will only be completed every three years for units MI-7, MH-2, and MM-67. In rotation years, output from the most recent full assessment will be 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 are then applied to the current population to estimate safe harvest limits for the coming year. The 2009 assessment models for these units were used for calculating the 2010 harvest limits and will be used for 2011, with full stock assessments scheduled for 2012.

In Lake Superior there are 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 remains high (range 0.137 to 0.21 y^{-1} average on ages 6-11) in all Lake Superior units and is 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 more than doubled from 2008 to 2009, but it is estimated that siscowets make up 41% of the harvest in this unit. Mortality and harvest of lean lake trout remain below targets. Increases in yield are possible for all 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. The MSC had planned to write a summary of this unit and its fishery for this report, but time constraints prevented its completion. It will be included in the 2011 version of this report.

There is growing evidence for widespread natural reproduction in the main basin of Lake Huron. For the first time in the data series, unclipped fish were present above background levels (i.e. 5%), representing up to 10% of commercial fishery and survey samples in U.S. waters. In the Canadian commercial fishery the proportion of unclipped fish exceeded 20% in 2009. Preliminary results from 2010 surveys and commercial monitoring indicate that that this trend continues. While not all areas showed high levels of unclipped fish, the presence of wild fish in the population warrants monitoring and inclusion into the stock assessment models in future years. Currently, the stock assessment model applies only to hatchery fish, but beginning in 2011, the model outputs will be adjusted by the observed proportion of unclipped fish in all data sources to account for natural reproduction.

In lake trout management unit MH-1, a stipulation had set a constant total harvest limit of 230,000 lb from 2007 through 2009. During these years, the average harvest for commercial and recreational fishers combined was 235,000 lb. The assessment model estimated that the maximum total mortality target had been reached in the most recent years. For a number of reasons, including the ability to account for the growing proportion of unclipped fish, some concerns were raised about the model's ability to adequately reflect the lake trout population in this unit. Ultimately, the model recommended harvest limit for 2010 was unacceptable to the parties, and a special Executive Council meeting was held to set a lake trout harvest limit for MH-1. The Parties agreed upon a new stipulation, which set a total harvest limit of 245,000 lb for both 2010 and 2011, split between CORA (220,000 lb) and the State (25,000 lb). Because the State overharvested lake trout in 2009, a 5,304 lb penalty was subtracted from the State's harvest limit and added to

CORA's harvest limit for 2010. Steps to improve the MH-1 model are ongoing (detailed in the MH-1 section of this report), with hopes of increased confidence in its ability to accurately reflect the lake trout population when a model-generated limit is required in 2012.

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 in rotation this year, and a full assessment was not completed. The lamprey-induced mortality on lake trout continues to be relatively low (< 0.10) in both MH-1 and MH-2. These low mortality rates have allowed for the increases in harvest that have been observed in MH-1 in recent years. Continued control of sea lamprey in MH-1 and MH-2 is necessary to keep mortality rates below target and maintain yields at the level recently observed.

In Lake Michigan management areas wild lake trout are scarce, and the assessment models and target mortality rates apply only to stocked fish. For 2010, full assessments were not run on any management unit in Lake Michigan. All units had population status updated from the 2009 model using current lamprey and harvest information, and a TAC was then projected for 2010. This method applied to MM-123, MM-4, and MM-5 for 2010 only, but MM-67 is in the rotation plan and will not have a full assessment completed until 2012. The recently settled stipulations in MM-123, MM-4, and MM-5 and the need to improve some facets of these assessment models were the reasons for this procedural change for 2010.

In unit MM-123 lake trout mortality is above target. Substantial rates of sea lamprey-induced mortality are causing the excessive total mortality. Biomass of young fish is growing; 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 excessive sea lamprey mortality would effectively prevent any commercial or recreational harvest if lake trout were managed according to the original Consent Decree mortality limits. 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 were not estimated through the SCAA modeling process for MM-4 in 2009, but due to increased harvest, they are likely above target. The stipulation for MM-4 set a 2009 harvest limit of 201,059 lb, while the model recommended harvest limit was 104,974 lb. Total harvest in MM-4 in 2009 was 170,594 lb, the highest yet observed under the current Consent Decree. Lamprey mortality in this unit has been between 0.10 and 0.12 since 2004.

Mortality rates in MM-5 and MM-67 are below target. In MM-5 there was no commercial harvest in 2009. This was partly due to a renovation being completed at the Leland Marina, which prevented easy access for fishers during parts of the year, causing them to shift their effort to MM-4. Lamprey mortality in MM-5 has been below 1998 baseline levels since 2004, but the potential for harvest in this unit is more dependent upon behavior of the fishers rather than availability of the resource. The 2009 commercial harvest of lake trout in MM-67 declined from the 2008 peak, and only represented 35% of the total TAC available. Overall mortality in this unit remains well below target, as the recreational fishery only harvests between 10 and 20% 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 most Lake Huron whitefish units, biomass peaked in the mid to late 1990s, as did commercial yield. The exception would be unit WFH-05, where 2007 commercial yield was the highest in the modeled time series. 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 changed how many of the Lake Huron whitefish stocks were modeled for 2010. In place of individual models for WFH-01, WFH-02, and WFH-04, these units were combined with data from WFH-03 (which did not have a functioning stock assessment model) to create a northern Lake Huron whitefish model. This likely better represents the whitefish stocks in this area. The mark-recapture movement study completed in recent years suggested significant movement among the stocks in northern Lake Huron. The Consent Decree requires that individual quotas be set for each management unit, so the Biological Services Division of CORA still set HRGs for individual units after examination of the combined model output.

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 have generally declined since the 2000 Consent Decree was implemented. However, in central and southern units, yield has remained similar or even increased under the provisions of the Decree. Natural mortality remains the largest mortality source in many Lake Michigan units.

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 2010, the HRGs for both of these units remained consistent with their recent levels. Another management unit, WFM-06, did not have a full assessment completed for 2010. Commercial harvest was minimal (<100 lb) in 2008 and no biological samples from the commercial fishery were available to update the model. Instead, the 2009 model output was used and projected forward an additional year to calculate the limit for 2010. This unit, along with unit WFM-08, is being evaluated as a candidate for an alternative harvest policy.

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 2010 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. 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). 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:

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

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 was generally robust to fairly high fishing rates.

Population at the Start of the 2010 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 2010 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2010, 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. Likewise, sea lamprey-induced mortality was set to the average of the values in the last three years of the SCAA.

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 2010

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 2010 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 2010 TACs for MI-5, MI-6, and MI-7 were calculated per the Consent Decree. However, the 2010 TACs for these units decreased by more than 15% compared to the 2009 TACs. The TFC agreed to accept higher estimated TACs for these units in 2010 limited by a 15% decline from the 2009 TACs.

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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RECOMMENDATIONS AND FUTURE DIRECTIONS TO IMPROVE ASSESSMENTS

Prepared by the Modeling Subcommittee

We annually revise our list of recommendations to improve stock assessments. The revised list reflects improvements made in recent years, ongoing work, and future plans to address assessment needs.

Data collection and processing

A. Accurate and complete data on extractions and other deaths caused by fishing is essential if SCAA models are to produce reliable estimates.

Current efforts:

i. We have identified the incorporation of recreational harvest of lake whitefish into the stock assessment models as an important step.

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. The next step is for the MSC to determine the most appropriate way to incorporate these data. 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.

ii. Better estimates of hooking mortality from recreational catch and release fishing are required.

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 more thorough evaluation was initiated in 2010. Upon its completion the MSC will incorporate results toward improving the accuracy of hooking mortality estimation procedures.

B. Accurate prior estimates of *M* (natural mortality) are essential in SCAA models. Current estimates of natural mortality for lake trout and lake whitefish should be reviewed and revised as necessary.

Current efforts:

i. Empirical estimates of lake whitefish natural mortality have been incorporated into SCAA models in certain units in northern lakes Huron and Michigan. Doing so has improved model performance. In units that lack empirical estimates, the

MSC has also made strides to standardize how *M* is calculated based on von B parameters. This standardization should be periodically evaluated.

ii. 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 to make *M* age specific. If this change improves the model, the MSC will explore the possibility of incorporating this procedure in other lakes.

C. The basis for stock boundaries and assumed movement or lack of movement between stocks needs further study.

Current efforts:

i. The lake whitefish tagging studies conducted in lakes Michigan and Huron demonstrated that current stock boundaries likely do not contain discrete populations of whitefish, particularly in northern Lake Huron. Therefore in 2009, we combined data from four of the Lake Huron whitefish management units into a single stock assessment model that will be used moving forward.

ii. A graduate student at MSU's QFC will be evaluating the impacts of stock intermixing under our currently defined management unit structure. The results should help quantify the impacts of assuming that discrete stocks exist even though they do not.

iii. A study seeking to update the movement matrix for Lake Michigan lake trout was completed by a researcher at the University of Michigan in 2010. She found that the current matrix adequately represents movement of stocked lake trout from their stocking locations. In the future, stocking assumptions and matrices may be updated as the mass marking program is implemented. The program will eventually mark each lake trout stocked into the Great Lakes with a coded wire tag, increasing sample sizes for basic post-stocking movement evaluations.

D. Uses for the lake whitefish fishery independent survey should continue to be explored.

Current efforts:

i. The use of survey data as an index of abundance may be more appropriate than the aggregate fishery catch-effort approach currently employed. However, preliminary attempts to utilize survey cpe in some whitefish units have been unsuccessful. As the time series of survey data lengthens, efforts to incorporate these surveys in whitefish models should continue.

ii. In Lake Huron, lake trout catch data from the whitefish surveys have been combined with the standard spring lake trout assessments in the mixed model estimates of survey CPE. The use of this new survey index will be implemented in the 2011 Lake Huron lake trout assessments.

E. Existing practices used to estimate fishery CPE for the whitefish models use aggregate commercial catch and effort data. An alternative approach, which incorporates individual fisher catch and effort data, was introduced through research completed at MSU's QFC.

Current efforts:

i. The MSC will evaluate mixed model estimates of commercial CPE which incorporate individual fisher catch and effort data and implications for lake whitefish population assessments.

F. For lake trout, calculations of the effects of recreational fishery size limit regulations and conversions of length-specific sea lamprey mortality to age-specific rates both depend upon the coefficient of variation (CV) in lengths about the mean length at age. Currently this CV is assumed to be the same for all ages and stocks, but it is not applied consistently and disparate data sources are sometimes used in calculating the variance. The validity of this assumption (equal variance across stocks and ages) needs to be assessed.

Current efforts:

i. A Dingell-Johnson funded project is currently underway with MDNR.

Models

A. Estimates of uncertainty for data used in the models and our assumptions about uncertainty need evaluation. Research completed at Michigan State University has lead to recommendations for improvements that the MSC will evaluate and incorporate into assessment models.

B. The need to assess fishery selectivity has been recognized since early in this modeling process. Researchers at Michigan State University have conducted broad scale evaluations of the models used to estimate selectivity as well as the addition of time-varying components in estimating catchability.

Current efforts:

i. Individual modelers continue to evaluate the model functions (e.g. gamma vs. double logistic) and time varying components (e.g. random walk) used to estimate selectivity, as well as the addition of time-varying components to estimate catchability. We have made changes in the estimation procedures in some units after evaluation and evaluation continues in others.

C. Current approaches to the modeling and estimation of recruitment and how we project it forward into the future need to be evaluated. We should also evaluate adding environmental variables that could influence recruitment based on research completed at Purdue University.

Reporting and Time Frames

The current time frame for calculating lake trout harvest limits is very narrow and does not allow adequate time for model evaluation given the constraints of data availability. The time frame for developing lake whitefish quotas is a year longer than for lake trout and is sufficient. The timing of data availability and target dates for delivery are summarized below.

Lake Trout

The Consent Decree sets the overall deadline for data availability for lake trout at March 1. We moved this date to February 15 to allow additional time to run the SCAA models and calculate harvest limits; however, some parties still do not submit all the required data by the deadline. We set the second full week in March for our annual meeting to produce preliminary lake trout harvest limits. This allows time for group discussion of model output and diagnostics before the March 31 deadline for preliminary harvest limits.

There is some difficulty with the data submission deadline as sometimes data needs extensive processing before it can be used in the models. Parties need to make better efforts to meet the data submission deadlines. Issues associated with individual data sources and plans for improving timeliness of assessments include:

1. Harvest/Yield:
   a. Commercial yield – Final CORA commercial harvest data cannot be ready by February 15. Preliminary data is projected to account for catch reports not filed by the deadline. Improvements have been made in recent years, but these data need to be made available in a more timely fashion.

   b. Recreational harvest – the State has provided these data by February 15.

2. Biological data-commercial:
   a. These data can be available by February 15. The age composition, mean weight of a harvested fish, mean length-at-age, and composition of siscowets, wild, and hatchery fish are model inputs.

   b. Data from monitoring of Canadian commercial fisheries is readily provided by the Ontario Ministry of Natural Resources; however, in some cases OMNR is unable to sample commercial fishermen or sample sizes are smaller than preferred. Improved data collection where possible would improve the Lake Huron lake trout models.

   c. Occasionally, data from Tribal fisheries (Keweenaw Bay Indian Community) in 1842 Waters of

MI-5 are not available by the deadline. If not provided by March 1 we will proceed without it and update the values in the following year. Age composition, mean weight of a harvested fish, and composition of wild and hatchery fish are model inputs.

3. Biological data-recreational:
   These data have been available by February 15.

4. Stocking data:
   These data have been provided by the USFWS and available by February 15.

5. Survey data:
   a. Survey CPUE – These data can be ready by February 15 though occasionally agencies have not met the deadline. Delays restrict the ability of modelers to complete mixed model analyses, which are required to provide input to the CAA models.

   b. Age composition – These data can be ready by February 15 though occasionally agencies have not met the deadline. If not available in a timely manner the modeler has the option to proceed without the most recent year's data.

   c. Mean length- and weight-at-age – These data can be ready by February 15 though occasionally agencies have not met the deadline. The data are required to provide estimates for the von Bertalanffy model, a required component for lamprey mortality estimation.

   d. Sea lamprey marking – These data can be ready by February 15 and agencies mostly meet this deadline. The information is required to provide estimates of lamprey mortality which we estimate outside of the CAA model process.

Lake whitefish

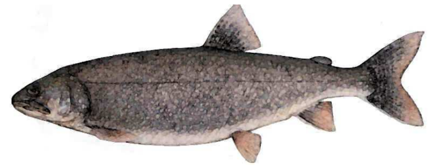
The Consent Decree sets October 1 as the deadline for the previous year's data. We moved this deadline to August 1 to allow additional time for calculating harvest limits. Because of the one year time lag, data should be available by the data submission deadline, although some parties continue to provide data after August 1. The MSC has agreed that models should move forward even if all of the data have not been provided. We set the third full week in September for our annual meeting to produce preliminary lake whitefish harvest limits. This allows for group discussion of model output and diagnostics before the November 1 deadline for preliminary harvest limits.

Other general comments

A. Alternative harvest policies were evaluated by a graduate student at Michigan State University. Possible implementation of the results of this research was evaluated for WFM-06 and WFM-08 during early 2010. The MSC determined that a conditional constant catch policy based on the classical approach to estimate a stock's maximum sustainable yield was not practical. We do not have a sufficient understanding of lake whitefish recruitment dynamics as an input into estimating maximum sustainable yield and the resulting constant catch limit. Instead, the MSC will be exploring other options for stabilizing harvest limits and changing the periodicity of full stock assessments.

B. We have incorporated fall age composition data from the Drummond Island Refuge into the MH-1 stock assessment model. This has been made a part of the model fitting process and is compared to values that can be predicted from data already in the model. The MSC may review fall age composition data for other units and explore possible inclusion if spatial and temporal coverage allow sufficient confidence in their values.

STATUS OF LAKE TROUT POPULATIONS



Lake Superior

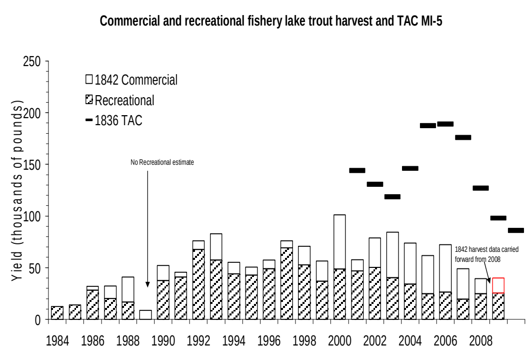
MI-5 (Marquette - Big Bay)

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.

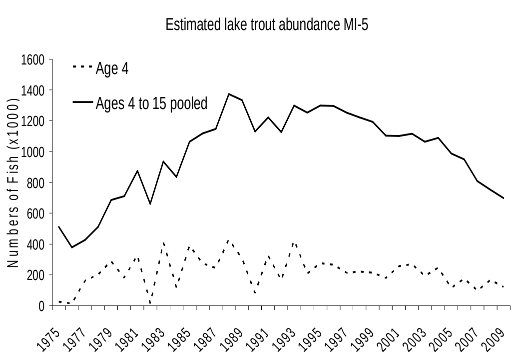
The only tribal commercial fishery is a large mesh gill-net fishery that is centered around Marquette and Big Bay in 1842 Treaty waters. This fishery mainly targets lake whitefish with lake trout as bycatch. However, lake trout have been targeted near spawning reefs in Marquette during recent fall fisheries. 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 2004 to 2008, tribal yield averaged 39,300 lb and tribal large-mesh gill-net effort averaged 680,000 ft y^{-1}.

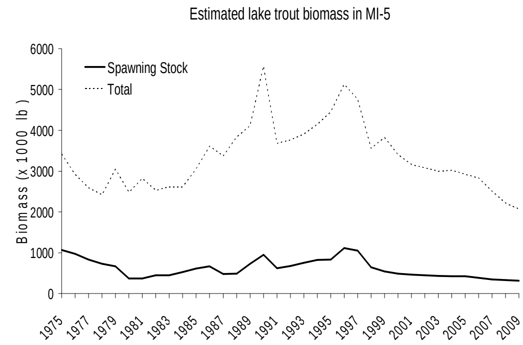
Generally, the commercial fishery is conducted from late winter through early October, with a dome-shaped selectivity with peak age between 7 and 10. The commercial fishery operates in various grids near Marquette, and the overall impacts on the MI-5 population are nominal. However, in 2000, and 2003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



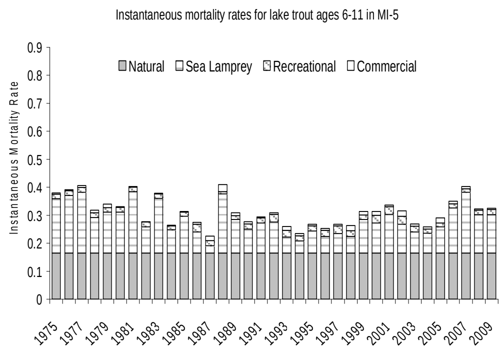
Recreational harvest of lake trout comprises both charter and sport angler fisheries. Most of this activity is centered around the port of Marquette, though some lake trout are harvested at Stannard Rock, an offshore reef. There are no seasonal restrictions on the sport fishery, though most of the fishery 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 2005 to 2009 was 6,500 fish (24,200 lb) y^{-1}. Recreational effort has declined from 146,000 angler hours in 1986 to 44,249 angler hours in 2009.

Abundance of wild lake trout increased more than two-fold since 1975 and has averaged about 966,000 fish (age 4 and older) during 2000 to 2009. Total biomass of age-4 and older lake trout averaged 2.8 million lb during 2000-2009. Lake trout biomass declined from 4.8 million lb in 1996 to 2.1 million lb in 2009. Spawning stock biomass averaged 405,000 lb during the last 10 years. Although lake trout abundance has increased since the mid 1970s, spawning stock biomass has declined due to significant decreases in growth.





Apart from background natural mortality, sea lamprey-induced mortality has been the dominant mortality source since 1975, although it declined to low levels in the mid-1990s. Since 1994, sea lamprey mortality has progressively increased and in 2007 was at the highest level since 1981. With the exception of 1988 and 2005, recreational fishing mortality has been higher than commercial fishing mortality for ages 6-11 lake trout. However, commercial fishing mortality on older lake trout, due to harvest during the spawning season, is higher than recreational fishing (see MI-5 section of the 2006 Status of Stocks Report). Average total annual mortality (*A*) for lake trout age 6 to 11 averaged 29.5% during 2007 to 2009, which has increased since the 1990s due to increases in sea lamprey mortality. Spawning stock biomass produced per recruit during 2007 to 2009 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 2010 in 1836 Treaty waters is 86,163 lb, allocated as 82,515 lb for the state recreational fishery and 3,648 lb for the tribal fishery. The recommended yield limit for 1842 Treaty waters is 119,800 lb.

The 2010 TAC is lower than the 2009 because of declining abundance of lake trout due to lower recruitment and steadily increasing mortality since the mid-1990s.

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

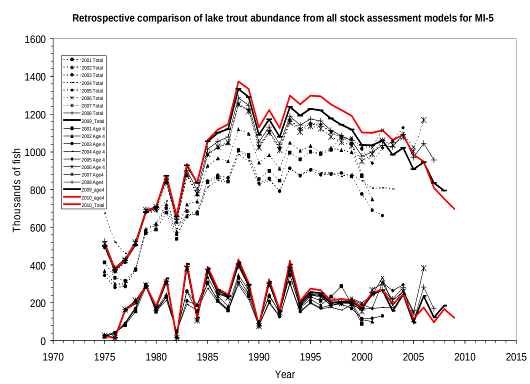
Notable stock dynamics

Commercial yield declined by more than 50% from 2007 to 2008 in MI-5. Commercial yield data for 2009 were not available at the time of this assessment and were assumed to equal the 2008 values. Summer survey CPUE has declined since 2004.

Model diagnostics

As with last year's model, 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 abundances estimated by the 2010 model was generally consistent with those estimated by the 2009 model. The recent assessment models (2005 through 2010) 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	5.094 lb (SE 0.499)
Current SSBR	1.2 lb (SE 0.08)
SSBR at target mortality	0.447 lb (SE 0.011)
Spawning potential reduction	
At target mortality	0.236 (SE 0.009)
Average yield per recruit	0.249 lb (SE 0.031)
Natural mortality (*M*)	0.165 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	15
Sport fishery (2006-2008)	8
Commercial fishing mortality (*F*)	
(average 2006-2008, ages 6-11)	0.006 y^{-1} (SE 0.001)
Sport fishing mortality (*F*)	
(average 2006-2008, ages 6-11)	0.015 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
(average ages 6-11, 2006-2008)	0.13 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2006-2008)	0.323 y^{-1} (SE 0.008)
Recruitment (age 4)	
(average 1999-2008)	181,620 fish (SE 25,563)
Biomass (age 4+)	
(average 1999-2008)	2,821,400 lb (SE 337,990)
Spawning biomass	
(average 1999-2008)	405,120 lb (SE 52,193)
MSC recommended yield limit in 2010	86,163 lb
Actual yield limit in 2010	107,902 lb

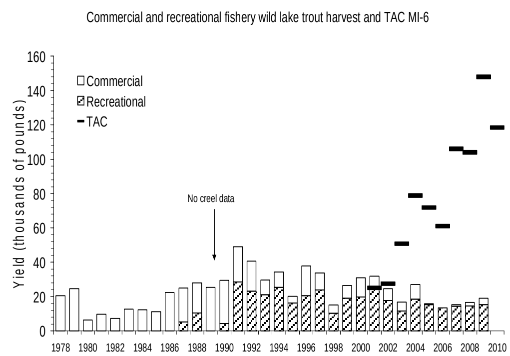
MI-6 (Au Train - Munising)

Prepared by Shawn P. Sitar

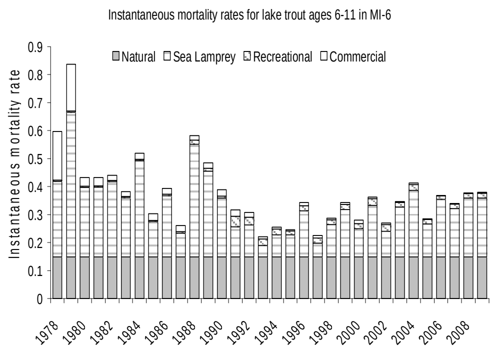
Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 1.8 million acres. This management unit includes Big Reef, an offshore reef complex about 20 miles northeast of Munising. This management unit contains the deepest waters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

The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery that is centered east of Grand Island. This fishery mainly targets lake whitefish with lake trout as bycatch. Tribal commercial yield of wild lake trout increased through the 1980s following the population increase at the time. Commercial yield and effort decreased in the early 1990s and remains at a low level. Yield peaked in 1989 at 25,600 lb with 2.4 million ft of gill net and declined to an average of 2,200 lb during 2007 to 2009. Total effort averaged 314,000 ft during the last three years.

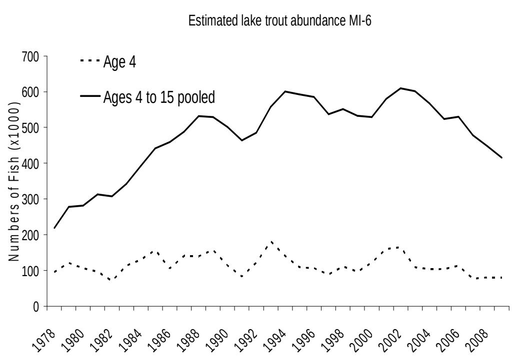
Recreational harvest of lake trout comprises fish caught by both charter and sport angling. Most of the recreational harvest was from the Au Train Bay and Grand Island areas, although some harvest was also from Big Reef. Recreational harvest of wild lake trout has increased through the late 1980s and peaked at 6,300 fish (28,500 lb) in 1991. Harvest has steadily declined since 2001 and corresponded to declines in effort. During 2007 to 2009, recreational fishery harvest and effort averaged 3,500 fish (14,500 lb) and 43,100 angler hours. In the last five years, wild fish composed nearly all (> 98%) of the total recreational and commercial harvest of lean lake trout.

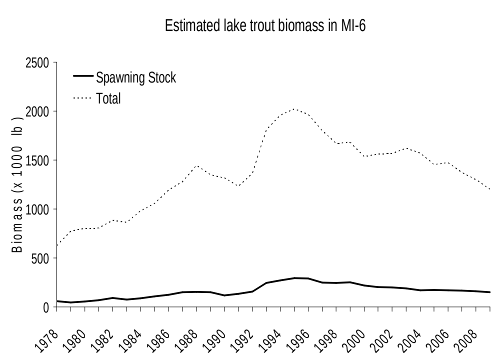


Sea lamprey mortality has been increasing since 1997, and in recent years it has been the highest mortality source for age 6 to 11 lake trout in MI-6. Sea lamprey mortality estimates during the last five years are at their highest levels since 1989. Recreational fishing mortality has been higher than 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 30.6 % during 2007 to 2009, which is below the target maximum rate of 45%. Total mortality has been increasing in recent years primarily due to sea lamprey mortality.



In recent years, lake trout abundance averaged 528,000 fish y^{-1}, while population biomass trended downward in this unit due to declines in somatic growth. During 2000-2009, population biomass averaged 1.5 million lb per year while average annual spawning stock biomass was 180,000 lb. Recruitment of age-4 lake trout in the last 10 years averaged 111,300 fish.





The recommended yield limit for 2009 is 118,450 lb, of which 59,225 lb is allocated to the state recreational fishery and 59,225 lb to the tribal commercial fishery. The 2010 TAC is lower than the 2009 TAC because of declining abundance and the 2010 model estimated lower recruitment than the 2009 model.

While mortality rates apply only to wild lean lake trout, the yield limit includes both wild and hatchery lean lake trout. In calculating the limit, the Modeling Subcommittee assumed that 0.9% 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.

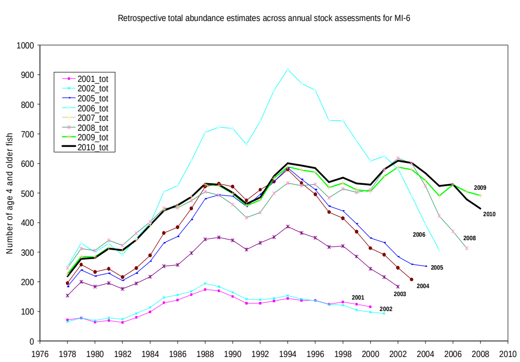
Notable stock dynamics

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.

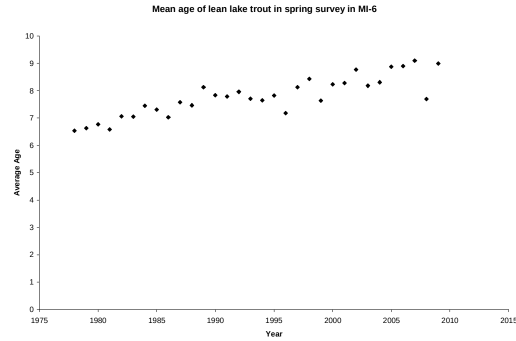
Spring survey lean lake trout catch per unit effort (CPUE) in 2008 declined by more than 50% from the previous few years. In 2009, spring survey CPUE was 50% higher than in 2008, returning to about 2007 level. This may be because the 2008 survey in MI-6 was conducted in June (late spring) when lean lake trout distribution likely changed, and they were not as vulnerable to bottom gill nets at the target sampling depths.

Model diagnostics

Confidence in this model is consistently 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. The model in its current form does converge to a single solution and is not sensitive to starting conditions. The model requires strict bounds on some of the selectivity parameters to converge. Retrospective analyses on this model indicate a trend in recent years. Each year the model is run, abundance estimates are higher than previous model runs, which may indicate that more recent observed data used in the model are more consistent.



Even with the low level of confidence we have in the model, it is unlikely that the stock is being over-fished. Extractions from the fisheries, which are well below the imposed harvest limits, are low relative to the time series.



Model predictions and the age-composition data do not indicate a population that is decreasing in age. Mean age has been steadily increasing in the surveys, which could be a function of an ageing population and/or delayed recruitment to the gear because of decreased growth rates. Also, size at age has decreased over the last ten years, which may indicate that factors other than adult mortality could be influencing the productivity of the population.

Probability intervals for key population quantities 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.

Summary Status MI-6 Lake Trout	**Value (Standard Error)**
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	6.012 lb (SE 0.551)
Current SSBR	1.11 lb (SE 0.07)
SSBR at target mortality	0.430 lb (SE 0.009)
Spawning potential reduction	
At target mortality	0.184 (SE 0.007)
Average yield per recruit	0.128 lb (SE 0.019)
Natural mortality (*M*)	0.149 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2006-2008)	4
Sport fishery (2006-2008)	8
Commercial fishing mortality (*F*)	
(average 2006-2008, ages 6-11)	0.003 y^{-1} (SE 0.001)
Sport fishing mortality (*F*)	
(average 2006-2008, ages 6-11)	0.015 y^{-1} (SE 0.002)
Sea lamprey mortality (ML)	
(average ages 6-11, 2006-2008)	0.158 y^{-1}
Total mortality (*Z*)	
(average ages 6-11, 2006-2008)	0.325 y^{-1} (SE 0.008)
Recruitment (age 4)	
(average 1999-2008)	111,290 fish (SE 14,288)
Biomass (age 4+)	
(average 1999-2008)	1,466,800 lb (SE 117,470)
Spawning biomass	
(average 1999-2008)	179,620 lb (SE 14,633)
MSC recommended yield limit in 2010	118,450 lb
Actual yield limit in 2010	125,780 lb

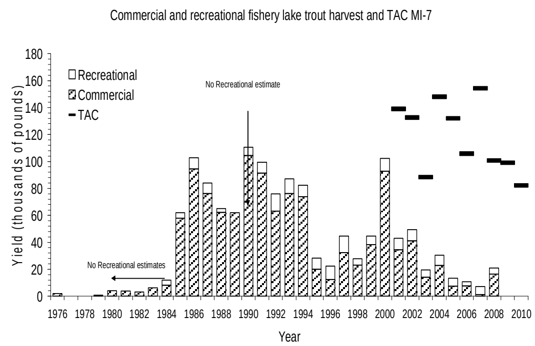
MI-7 (Grand Marais)

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 17,100 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 2007 to 2009 has averaged 962,000 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 2007 to 2009 was 1,300 fish (5,800 lb). The average sport effort for the same time period was 14,600 angler hours.



The 2010 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.

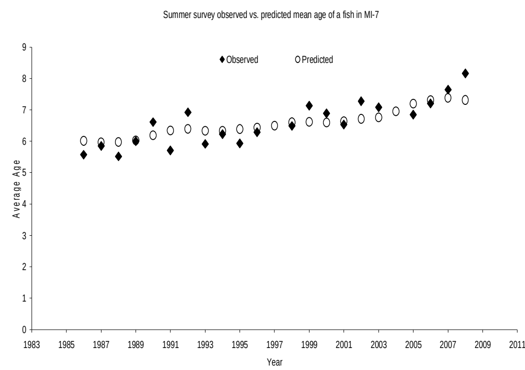
Sea lamprey predation has generally been the dominant mortality source for lake trout in MI-7 with the exception of 1990 to 1994. Commercial fishing mortality increased significantly in 1985 and exceeded sea lamprey-induced mortality from 1990 to 1994. Commercial fishing mortality declined during 1995 to 1998, and increased between 1999 and 2000. In recent years, commercial fishing has declined to very low levels, but resurged in 2009. The most recent estimate of sea lamprey mortality for this unit is more than triple the 1997 level. However, the most recent estimate of spawning stock biomass per recruit (SSBR) for MI-7 is above the target value, indicating that total mortality rates are not exceeding the target.

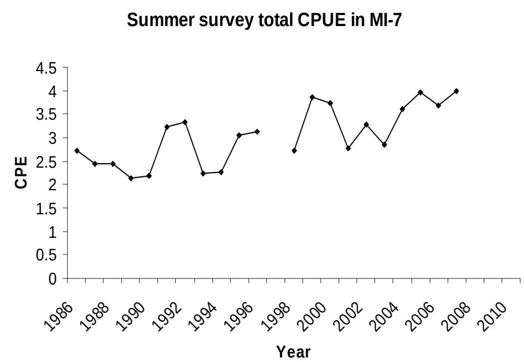
The recommended yield limit for 2010 is 82,273 lb with 24,682 lb allocated to the state recreational fishery and 57,591 lb to the tribal commercial fishery. These limits were calculated on the basis of the target mortality rate (*A*) of 45% and an allocation of 30% to the state and 70% to the tribes, 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 1.6% of the lean lake trout yield would be hatchery fish. 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 actual 2010 yield limit was subject to the 15% rule, and was set at 28,865 lb for the state recreational fishery and 66,325 lb for the tribal commercial fishery.

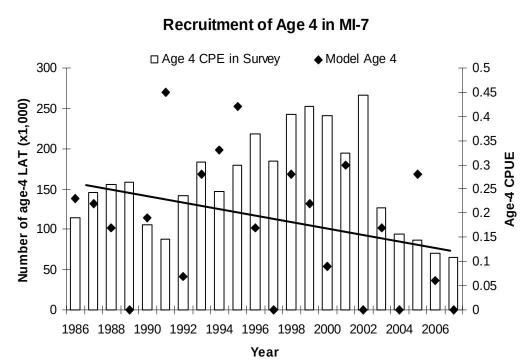
The 2010 TAC is less than the 2009 TAC because stock abundance has been on the decline since 2002, primarily due to declines in recruitment and increases in sea lamprey-induced mortality.

Notable stock dynamics

No commercial monitoring data were available for 2004-2009. Total commercial yield has increased in recent years from 600 kg in 2006 to 15,300 kg in 2009. Recent increases in sea lamprey-induced mortality have caused the reduction in stock size and TAC. Furthermore, there have been significant declines in recruitment since 2002 which is not apparent in overall summer survey total CPUE, which has remained high due to increases in the catch of older fish. Both total CPUE and average age in the summer survey have increasing trends. Observed age 4 CPUE in the summer survey has declined since 1986, which has signaled the SCAA model to estimate a decline in age 4 abundance estimates.







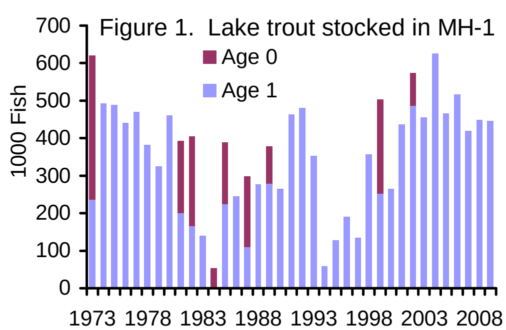
Lake Huron

MH-1 (Northern Lake Huron)

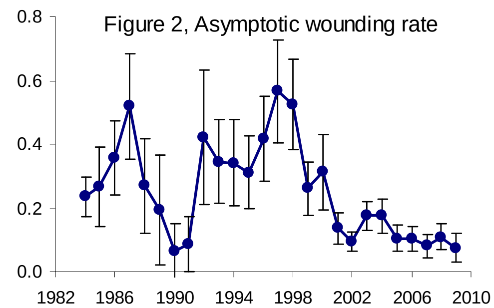
Ji X. He, Mark P. Ebener, and Adam Cottrill

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 2008, non-clipped lake trout made up 5.6% of the survey and fishery catch; while the percentage of unclipped fish exceeded 20% in spring surveys along the north-east shore and in commercial biological samples from Ontario QMA4-1. In 2009, non-clipped lake trout represented 4% of tribal commercial fisheries samples, and 26% in Ontario QMA4-1 commercial fisheries samples.

The total number of age-1 lake trout stocked into MH-1 in 2009 was 445,700 (Figure 1), of which 120,392 were planted in the Drummond Island Refuge. The average number of yearling equivalents stocked during 2003-2007 was 504,263. After adjusting for movement among management units of Lake Huron's main basin, there were an estimated 569,982 age-1 lake trout in MH-1 in 2009.



Age-specific, sea lamprey-induced 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) lake trout 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 (Figure 2). At age 7, the estimated instantaneous mortality by sea lamprey predation was 0.217 y^{-1} in 1998, and the average was 0.073 y^{-1} during 2006-2008.



Total commercial harvest in 2009 in MH-1 and QMA4-1 was 233,118 lb, of which the CORA fisheries accounted for 222,999 lb. The yearly average harvest during 2003-2005 was 157,761 lb, of which the CORA fishery accounted for 134,598 lb. The average harvest from 2006 through 2008 was 267,025 lb, of which the CORA fishery accounted for 244,642 lb. The commercial harvest by tribal fishers included estimates of discard mortality from both the trap net fishery and large-mesh gill-net fishery after 2001.

Tribal large-mesh gill nets accounted for 96% of total commercial harvest in 2009. On average, tribal large-mesh gill nets accounted for 81.1% of annual total commercial harvest during 2003-2005, and averaged 86% during 2006-2008. Ontario large-mesh gill-net fisheries accounted for 4% of the total commercial harvest in 2009, which was lower than the 2003-2005 average of 15%, and the 2006-2008 average of 8%. Tribal trap net and small-mesh gill net (2.5-3.0 inch stretch) harvest of lake trout was negligible in 2009, primarily because trap-net fisheries are prohibited from harvesting lake trout.

The recreational harvest was 25,304 lb in 2009. The yearly average was only 2,983 lb during 2001-2005, but the annual harvest increased to 7,023 lb in 2006, 17,021 lb in 2007, and 19,529 lb in 2008. The recreational harvest after 2002 included the estimates of discard mortality from the fishery. Overall, the recreational harvest still represents a small portion of MH-1 lake trout harvest (Figure 3).

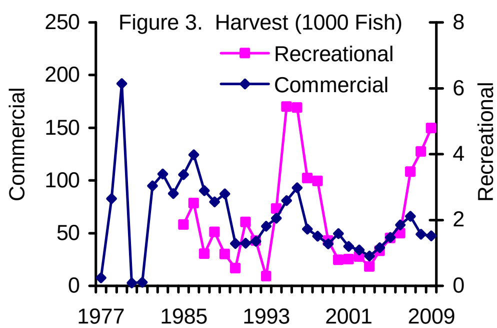


Figure 3. Harvest (1000 Fish)

Target spawning stock biomass per recruit (SSBR) was based on a limit of 47% annual mortality (*A*) for age-5 and older lake trout, and was in the range of 0.05-0.36 (Figure 4). The large variation in target SSBR was mostly due to the temporal variation in the survival from age 1 to age 2, while average body weight and maturity at age also varied among years.

The annual estimate of SSBR was based on age-specific mortality rates, of which commercial and recreational selectivity was estimated using a double logistic function. The estimated SSBR was far below the target before 1998 (Figure 4), because of high mortality caused by commercial harvest and sea lamprey predation. From 1998 through 2000, the difference between target and estimated SSBR was reduced, due to the treatment of the St. Marys River and subsequent reduction in the abundance of parasitic sea lamprey. The estimated SSBR was higher than the target each year during 2001 through 2006, showing that over-all-age annual mortality was below 47%. During 2007 through 2009, however, the estimated SSBR was lower again than the target each year.

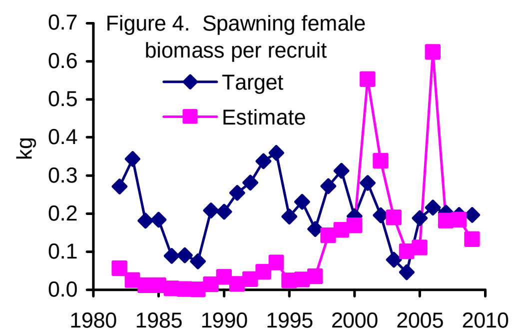


Figure 4. Spawning female biomass per recruit

Estimated spawning stock biomass (SSB) was almost negligible until the late 1990s, increased steadily from 1998 to 2006, and then decreased during 2007 through 2009 (Figure 5). These changes in estimated SSB were consistent with the comparisons between the estimated and target SSBR (Figure 4).

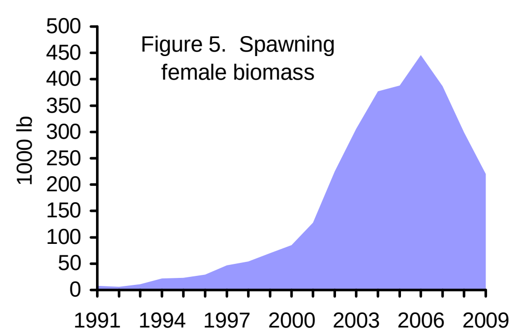


Figure 5. Spawning female biomass

Annual fishery harvest during 2007 through 2009 did not exceed the model recommended total allowable harvests

(TAC), but these TAC calculations were based on the target SSBR that did not consider recent declines in lake trout growth and delays in the age of recruitment. Age-5 and younger lake trout accounted for more than 90% of the commercial harvest in MH-1 before 1995. That percentage declined to 71% in 2001, 36% in 2004, and only 11% by 2008. Age-5 lake trout accounted for 25-30% of the estimated TAC each year during 2007 through 2009, as the annual mortality limit of 47% was applied to this age. The observed harvest actually came from the spawning stock that was fully recruited to the fishery. Thus, for age groups older than 5, age-specific mortality was higher than 47%, although mortality was below the limit when age 5 was included.

Delays or dynamic changes in age at recruitment were not addressed in this year's harvest recommendation. In addition, the assessment model this year also involved three other unresolved issues. First, there was no fishery-independent spring survey of lake trout in MH-1 in 2009 because a season-long bloom of *Cladophora*, which fouls survey gear and dramatically reduces catchability. Consequently, the model outputs were sensitive to minor changes in data inputs.

Second, the model showed strong retrospective patterns in the estimates of yearling survival and spawning stock biomass. From 1999 to 2008, new data for each year always led to increases in the previous year's estimates of yearling survival and spawning stock biomass, although 2008 and 2009 estimates were similar. Such retrospective patterns were not new with the model, as relevant concerns were expressed in the previous reports, but this was the first year we developed a program to reveal the issue thoroughly. These retrospective patterns were also not surprising. By 2000, it was rare to see lake trout old than age 9 in MH-1; the stock was dominated by age-4 and age-5 lake trout, and the age 5 catch rate was reliable for estimating yearling survival of year classes of 1973 through 1995. During 2001 through 2009, the observed age structure expanded rapidly to age 24, due largely to the success in sea lamprey control. Meanwhile, there was also a delay in full recruitment from age 5 to age 7. It is a new technical challenge to assess a stock that has rapid changes in both age structure and total abundance.

Finally, the stock assessment model predicted a 50% decline in SSB after 2006. We are unsure of the severity of this decline. On one hand, a decline in SSB was possible, given the observed delay in recruitment, and the likely recent decline in yearling survival due to the food-web changes that has already caused the collapse of Chinook salmon in Lake Huron. On the other hand, the annual spring surveys in 2008 did not suggest severe declines in catch rate, and 2009 summer and fall surveys in MH-1 did not show any declines in catch rates.

The four issues discussed above could not be resolved this year, because there were several previously identified improvements in the stock assessment model that needed to be implemented or further evaluated first. These included: (1) consistent use of April-June sea lamprey wounding data; (2) develop abundance indices using both spring and summer gill netting surveys; (3) expand the recreational age structure to age 15; (4) using time-varying length at age to convert length-based wounding rates to age-specific mortality by sea lamprey predation; (5) evaluate setting age-2 sea lamprey mortality to zero; and (6) evaluate whether to include information from fall spawning surveys in the model.

The overall structure of the assessment model has proved to be sound. The model fitted all fisheries data very well, including total numbers for the recreational and commercial harvests, total biomass of commercial harvests, and the age compositions for both recreational and commercial fisheries. No apparent residual patterns were identified. The model also fit survey age composition very well, and survey catch rates for recent years although there was some lack of fit for the early years of the time series. This lack-of-fit was associated with the fact that annual survey catches were dominated by ages 3-5 in early years but by much more and older age groups in recent years.

The final model converged to a unique solution with the maximum gradient of 0.0000527. In order to assess the stability of the parameter estimates we ran an MCMC simulation of 1,000,000 draws, saving every 200th, and discarding the first 1000 saved simulations as a burn-in period. After the first few years (1977-1980) of the MCMC cycles, year specific spawning biomass looked good, and MCMC distribution of the objective function also looked very good. All of the estimated parameters with specified initial values were tested, including catchability for the survey and fisheries, selectivity for the survey and fisheries, the first year's (1977) numbers at ages, yearling mortality, and the natural mortality. Parameter estimates were not sensitive to initial values and the MCMC distributions suggested that the parameters were well estimated.

The recommended harvest limit was 185,322 lb for the tribes, and 20,591 lb for the state. The allocation of the TAC was 90% for the tribes and 10% for the state, based on the Section VII.A.7.d of the 2000 Consent Decree. The new recreational fishery size regulation was implemented in the TAC calculation.

The largest source of uncertainty in the stock assessment model came from estimating yearling survival. Survey and fisheries data of recent years are not currently informative for these estimates because there is at least a two-year delay between the time of stocking and recruitment to the survey and fishing gear. As a consequence there is a large degree of uncertainty in estimating the survival up to age 4 for recent year classes. Additionally, consideration should be given to modifications to the model that would account for the increasing recruitment of wild lake trout. Finally, we will need to revisit the issue of retrospective patterns after making all of the needed improvements in the use of data and in the model structure.

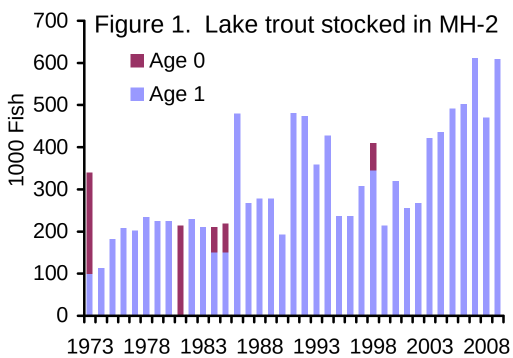
Summary Status MH-1 Lake Trout	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.05 lb
Age at first spawning	3 y
Size at 50% maturity	3.67 lb
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	2.249 lb (SE 1.21)
Current SSBR	0.354 lb (SE 0.22)
SSBR at target mortality	0.326 lb (SE 0.173)
Spawning potential reduction	
Current SPR	0.158 (SE 0.027)
SPR at target mortality	0.145 (SE 0.087)
Average yield per recruit	0.358 lb (SE 0.185)
Natural mortality (*M*)	0.193 y^{-1}
Fishing mortality	
Age of full selection	
Commercial fishery (2007-2009)	7 y
Sport fishery (2007-2009)	7 y
Commercial fishing mortality (*F*)	
(average 2007-2009, ages 6-11)	0.312 y^{-1} (SE 0.065)
Sport fishing mortality (*F*)	
(average 2007-2009, ages 6-11)	0.025 y^{-1} (SE 0.007)
Sea lamprey mortality (ML)	
(average 2006-2008, ages 6-11)	0.073 y^{-1}
Total mortality (*Z*)	
(average 2007-2009, ages 6-11)	0.602 y^{-1} (SE 0.072)
Recruitment (age 1)	
(average 2000-2009)	577,352 fish (SE 48,150)
Biomass	
(average 2000-2009)	1,902,000 lb (SE 139,240)
Spawning biomass	
(average 2000-2009)	286,130 lb (SE 30,748)
MSC recommended yield limit for 2010	205,913 lb
Actual yield limit for 2010	245,000 lb (plus estimated throwback mortality)

MH-2 (North-central Lake Huron)

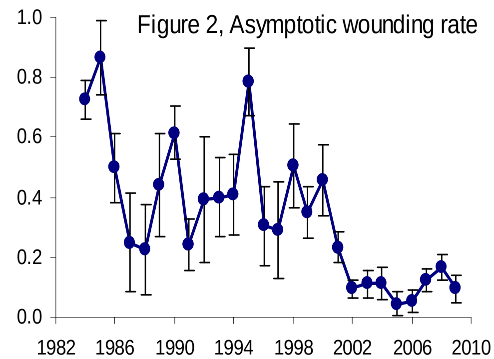
Ji X. He and Adam Cottrill

Lake trout management unit MH-2 (north-central Lake Huron) covers Michigan statistical district MH-2, Ontario quota management areas (QMA) 4-2, 4-3, and 4-7, and approximately 50% of the no-fishing zone of Six Fathom Bank Refuge. Adjacent to the refuge, Ontario water shallower than 40 fathoms is also a protected area 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 2008 and 2009, non-clipped fish accounted for more than 22% of lake trout samples from Ontario commercial fisheries in this unit.

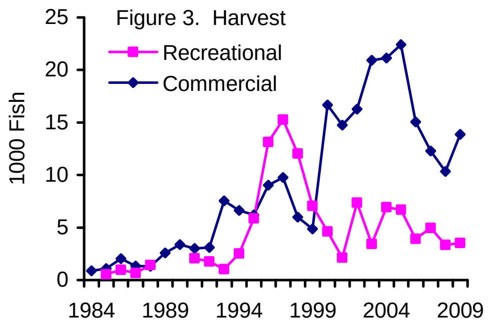
Total age-1 lake trout stocked in 2008 was 609,621, including 4,313 in Ontario QMA 4-3 (Figure 1). The average number of yearling equivalents stocked during 2004-2008 was 502,468. After adjusting for the movement among management units of Lake Huron's main basin, total 2009 age-1 lake trout in MH-2 was 512,097 fish in 2009.



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 significantly lower than the 1998 level since 2001 (Figure 2). At age 7, the estimated instantaneous mortality by sea lamprey predation was 0.262 y^{-1} in 1998, and the average was 0.096 y^{-1} during 2006-2008.

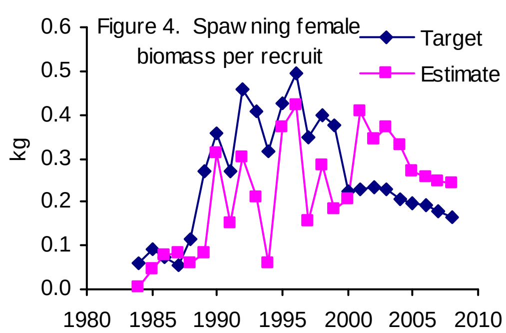


Both commercial and recreational harvest occurs in this region of Lake Huron (Figure 3). The majority of commercial harvest came from Ontario large-mesh gill nets, and there was no commercial fishery in Michigan waters. Total commercial harvest in 2009 was 54,335 lb, compared with yearly average of 47,549 lb from 2006 through 2008. The reported recreational harvest included both total retention of fish caught and estimates of release-kill after 2002. On average, recreational harvests during 2003 through 2007 were 26,900 lb. The harvest decreased to 20,991 lb in 2008, and slightly increased to 21,743 lb in 2009.

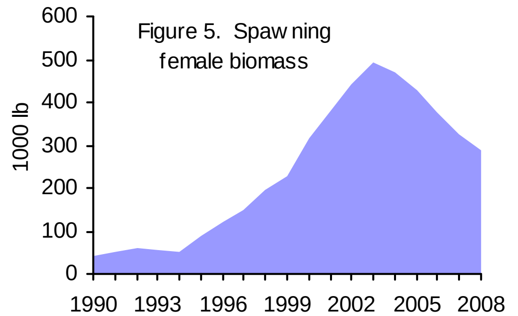


Target spawning stock biomass per recruit (SSBR) was based on a limit of 40% annual mortality (*A*) for age-5 and older lake trout, and was in the range of 0.06-0.48 (Figure 4). The large temporal variation in target SSBR was mostly due to the variation in the survival from age 1 to age 2, although body weight and maturity at age also varied among years.

The annual estimate of SSBR was based on age-specific mortality rates, of which commercial and recreational selectivity was described using a double logistic function. The estimated SSBR was below target before 2000 (Figure 4), and the largest mortality source was sea lamprey. After 2000, the estimated SSBR was higher than target, so over-all-age annual mortality was lower than the mortality limit of 40%.



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 5). In the past five years, however, SSB decreased to 287,000 lb by 2008, and the decrease was more than 40% 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 (Figure 4).



The calculation of target SSBR in recent years did not consider recently observed declines in growth and delays in recruitment. In MH-2, lake trout were fully recruited by age 5 before 2003, but were not fully recruited until age 7 after 2006. From 1998 to 2002, average proportion of age 4 and 5 in survey catches was 0.13 and 0.26, and in recreational catches was 0.17 and 0.27. In 2007 and 2008, average proportion of age 4 and 5 in survey catches was only 0.004 and 0.04, and in recreational catches was only 0.006 and 0.04. With a given set of life-history parameters such as body weight at age, maturity at age, and most importantly the survival from age 1 to age 2, applying the annual mortality limit of 40% to pre-recruit ages might have led to underestimation of target SSBR and allocation of very high fishing mortality to spawning stock.

We did not conduct a full assessment for MH-2 this year. We updated sea lamprey induced mortality using April-June wounding data, 1984-2009. We then used 2009 harvests to update the stock status based on the last year's full assessment, including numbers at ages, and the total mortality. From the updated stock status and the projection model used in previous years, the 2010 total allowable harvest was 75,885 lb for the state, and 3,994 lb for the tribes. The allocation was 95% for the state and 5% for the tribes, as in Sections VII.A.3 and VII.A.4 of the 2000 Consent Decree.

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. 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. In the last ten years, on average, 934,850 yearling lake trout have been stocked into MM-123 and approximately 64 percent of these fish were stocked into the northern refuge. The newly drafted lake trout implementation strategy for lake trout rehabilitation calls for stocking of 1.44 million lake trout in MM-123. In 2009, 1,442,322 yearling lake trout were stocked.

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 harvested as by-catch.

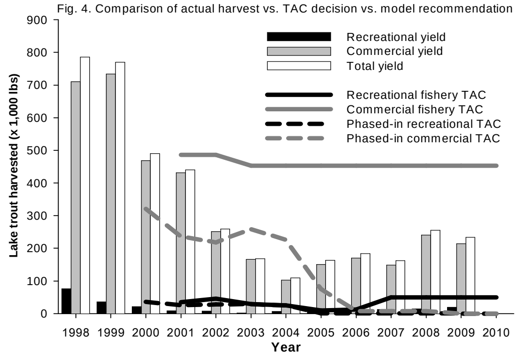
The tribal large-mesh gill-net fishery accounts for the majority of the lake trout yield from MM-123. After the implementation of the 2000 Consent Decree, the tribal commercial yield of lake trout decreased to a low of 102,854 lb in 2004. Since then, yield had been gradually increasing and was 240,253 lb in 2008. In 2009, the tribal commercial fishery harvested 239,305 lb of lake trout.

The recreational fisheries for lake trout are comprised of both charter and sport anglers. In 1991, the minimum size limit for sport fishing in MM-123 was increased from 10 to 24 inches and resulted in a decline in recreational yield. 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 2009. The recreational fishery yield has been increasing and was 19,591 lb in 2009.

Sea lamprey mortality rates in northern Lake Michigan have averaged 0.15 y^{-1} (avg for ages 6-11) from 1981-2008. With the exception of 1993, lamprey-induced mortality had generally been below the long-term average until the year 2000. Since the year 2000, lamprey mortality rates have been above the long-term average, reaching 0.35 y^{-1} in 2005. For the recent three years (2006-2008) lamprey mortality rates have averaged 0.28 y^{-1}.

The yield limit for 1836 Treaty waters in 2010 is 50,000 lb for the state recreational fishery and 453,000 lb for the tribal commercial fishery. These values reflect an agreed upon 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 (Figure 4). 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 2009 are essentially zero because the combination of sea lamprey and natural mortality are above spawning stock biomass and mortality targets for the unit.

Fig. 4. Comparison of actual harvest vs. TAC decision vs. model recommendation



Model evaluation and changes:

To allow time to evaluate potential improvements to the model and modeling process, the full MM-123 stock assessment model was not run in 2010. The method used to generate a TAC was the same as those units in the rotation plan. We used the 2009 assessment and updated estimates of sea lamprey mortality through 2009 as well as commercial and recreational harvest values. Using the previously determined 2009 estimates of mortality-at-age for commercial and recreational fisheries, and updated 2009 lamprey mortality estimates, we projected the numbers at age for 2009. The estimated numbers at age in 2009 and the average lamprey mortality estimates at age from 2007-2009 were used to project the 2010 TAC for commercial and recreational fisheries.

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, since the historic collapse of lake trout, 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. In each of the last ten years, on average, 280,591 yearling lake trout have been stocked into Grand Traverse Bay and 233,675 fish were stocked in 2009.

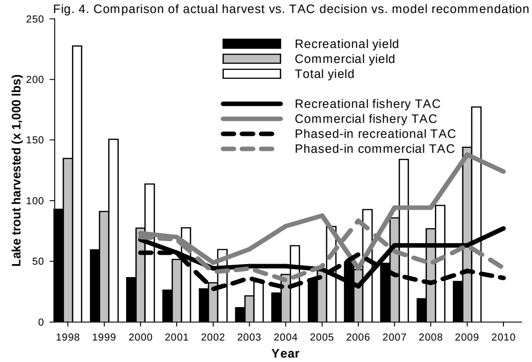
Only tribal fishermen licensed by the Grand Traverse Band of Ottawa and Chippewa Indians may commercially harvest fish in this management unit. There are three types of tribal commercial fisheries: large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill-net fishery, while primarily 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 rose from an average of 70,370 lb in 2007 and 2008 to 137,312 lb in 2009. Large-mesh gill-net effort in tribal fisheries increased from 0.5 million feet of net in 2007 and 2008 to 1.1 million feet in 2009.

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. From 1992-1996, the minimum size limit to harvest lake trout increased from 10 to 24 inches. In 1996, the season for harvesting lake trout was lengthened, from May 1 through Labor Day to Jan 1 through September 30. Mid-way through 1997 the minimum size limit was decreased to 20 inches and remained so through 2002. In 2003, the bag limit was raised from 2 to 3 fish and the minimum size limit increased to 22 inches. In 2006, regulations were again changed to protect larger spawning lake trout. A slot limited was adopted where anglers are only allowed to keep fish between 20 and 25 inches, but they are allowed one trophy fish greater than 34 inches. From 2004 – 2009 anglers harvested an estimated 34,884 lb of fish annually. In 2009, the estimated angler harvest of 33,282 lb was slightly below the average.

In the past four years (2005-2008) lamprey mortality has averaged 0.11 y^{-1}. In 2008 estimated mortality rates remained similar to the average at 0.10 y^{-1}.

The model recommended harvest limit for 2010 in the Grand Traverse Bay management unit is 80,418 lb, of which 36,188 lb was allocated to the state recreational fishery and 44,230 lb to the tribal commercial/subsistence fishery. This represents a shift in the allocation among the parties from 40 percent state and 60 percent tribal to a 45/55 allocation of the resource. The model recommended harvest limit is lower than the limit recommended in 2009 because the harvest in 2009 was 63 percent higher than the model recommended harvest. In August 2009 the Parties agreed to a stipulation to the 2000 Consent Decree which described how harvest limits would be set for MM-4 from 2007 until sea lamprey mortality is significantly below 1998 levels for 3 consecutive years, at which time the method of establishing the harvest limit will be reviewed by the Technical Fisheries Committee. This stipulation stated that the Tribal harvest limit will not be less than 94,300 lb, and the State harvest limit will be 77,200 lb for 2010. 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 2009 did not reach the limit of 63,000 lb, the actual Tribal harvest limit in 2010 was 94,300 lb plus the leftover amount from the State, 29,718 lb, for a total of 124,018 lb.

Fig. 4. Comparison of actual harvest vs. TAC decision vs. model recommendation



Model evaluation and changes:

To allow time to evaluate potential improvements to the model and modeling process, the full MM-4 stock assessment model was not run in 2010. The method used to generate a TAC was the same as those units in the rotation plan. We used the 2009 assessment and updated estimates of sea lamprey mortality as well as commercial and recreational harvest values. Using the previously determined 2009 estimates of mortality-at-age for commercial and recreational fisheries, and updated 2009 lamprey mortality estimates, we projected the numbers at age for 2009. The estimated numbers at age in 2009 and the average lamprey mortality estimates at age from 2007-2009 were used to project the 2010 TAC for commercial and recreational fisheries.

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 is highly used 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, 210,000 yearling lake trout were stocked into the MM-5 management unit annually. In 2009, 107,500 lake trout were stocked in this unit.

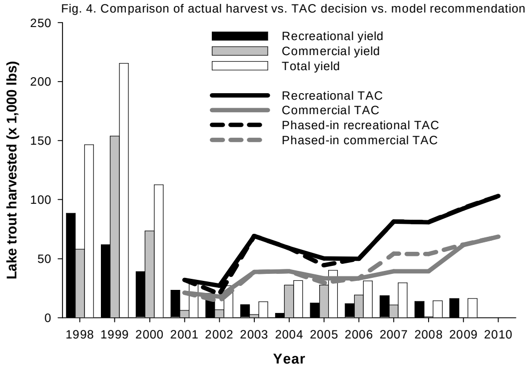
Although both State and Tribal commercial fishermen harvest fish in the management unit, state-licensed commercial fisheries are primarily trap-net operations targeting lake whitefish. State-licensed fishermen are not permitted to harvest lake trout, and as a result, are not included in lake trout harvest allocations. The Chippewa Ottawa Resource Authority oversees three types of tribal commercial fisheries in this area including large-mesh gill net, small-mesh gill net, and trap net. The 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 regions 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. The yield of lake trout in commercial fisheries increased to 27,601 lb in 2004 and has steadily declined to 300 lb in 2008 and no lake trout were harvested in 2009.

Recreational fisheries for lake trout are primarily managed by the State of Michigan and include both charter and sport anglers. The sport fish harvest regulations in the MM-5 management unit of Lake Michigan have historically allowed for the take of 10-inch lake trout. In 2001 the minimum harvest limit was changed to 22 inches and in 2003 the size limit was further increased to 24 inches. The fishing season was extended in 2003, shifting from May 1 - Labor Day to May 1 - Sept 30 and the bag limit was raised from 2 to 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 23 inches and below with one trophy fish greater than 34 inches being allowed. Recreational fishery yields have averaged 14,558 lb from 2005-2009 and was 16,149 lb in 2009.

During the last four years (2005-2008), lamprey mortality rates have averaged 0.11 y^{-1} and in 2009 were similar to the average at 0.10 y^{-1}.

The model recommended yield limit for 2008 in unit MM-5 was 171,641 lb, and is based on a target mortality rate of 45%. Of this yield, 103,016 lb were allocated to the state recreational fishery and 68,627 lb to the tribal commercial and subsistence fisheries. Allocations were based on a 60 percent allotment for the state of Michigan and 40 percent to tribal fisheries. In August 2009 the Parties agreed to a stipulation to the 2000 Consent Decree. The stipulation established a floor for the Tribal harvest limit at 39,200 lb, which will be in place until sea lamprey mortality rates are significantly below 1998 levels for three consecutive years, after which the Technical Fisheries Committee will review the method of establishing the harvest limit.

Fig. 4. Comparison of actual harvest vs. TAC decision vs. model recommendation



Model evaluation and changes:

To allow time to evaluate potential improvements to the model and modeling process, the full MM-5 stock assessment model was not run in 2010. The method used to generate a TAC was the same as those units in the rotation plan. We used the 2009 assessment and updated estimates of sea lamprey mortality through 2009 as well as commercial and recreational harvest values. Using the previously determined 2009 estimates of mortality-at-age for commercial and recreational fisheries, and updated 2009 lamprey mortality estimates, we projected the numbers at age for 2009. The estimated numbers at age in 2009 and the average lamprey mortality estimates at age from 2007-2009 were used to project the 2010 TAC for commercial and recreational fisheries.

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 179,455 yearling lake trout have been stocked into non-refuge southern treaty waters, while an additional 332,314 fish were stocked into the mid-lake refuge area, much of which is in Wisconsin waters.

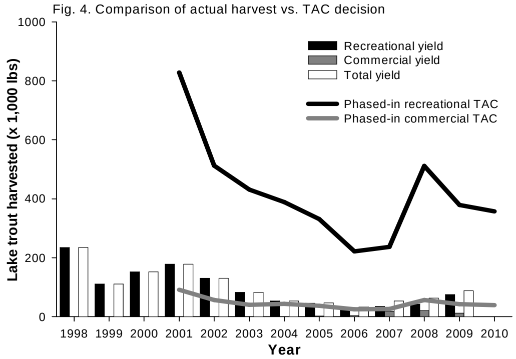
In 2009, the State's commercial fishery in southern treaty waters of Lake Michigan was comprised of two trap-net operations and one small-mesh gill-net operation, which targeted bloater chubs. The 2009 Tribal commercial fishery within this area consisted of five permitted trap nets, and five permitted 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. As a result, state commercial fishermen are not included in lake trout harvest allocations. The yield of lake trout in commercial fisheries has averaged 6,394 lb over the last 9 years (2001-2009). In 2009 the yield of lake trout was 14,596 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 average yield of lake trout in recreational fisheries from 2001-2009 was 74,698 lb. In 2009, recreational fisheries yielded 75,636 lb of lake trout.

Sea lamprey-induced mortality is lower in southern treaty waters of Lake Michigan relative to the northern management units. In recent years (2006-2008), lamprey mortality rates have averaged 0.08 fish y^{-1}. In 2008 rates were somewhat higher at 0.11 fish y^{-1}.

The model recommended yield limit for MM-67 in 2010 was 396,823 lb and was accepted by the parties. The state recreational fishery is allocated 90 percent or 357,141 lb and the tribal fishery 10 percent or 39,682 lb. Both recreational and commercial fisheries are well below established TAC levels.

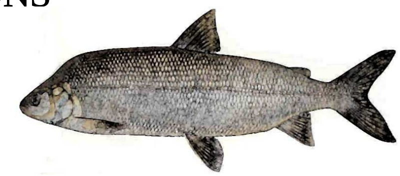
Fig. 4. Comparison of actual harvest vs. TAC decision



Model adjustments and changes:

This unit was part of the rotation plan that was implemented in 2010, and as a result the full stock assessment model was not run. To generate a TAC we used the 2009 assessment and updated estimates of sea lamprey mortality through 2009 as well as commercial and recreational harvest values. Using the previously determined 2009 estimates of mortality-at-age for commercial and recreational fisheries, and updated 2009 lamprey mortality estimates, we projected the numbers at age for 2009. The estimated numbers at age in 2009 and the average lamprey mortality estimates at age from 2007-2009 were used to project the 2010 TAC for commercial and recreational fisheries.

STATUS OF LAKE WHITEFISH POPULATIONS



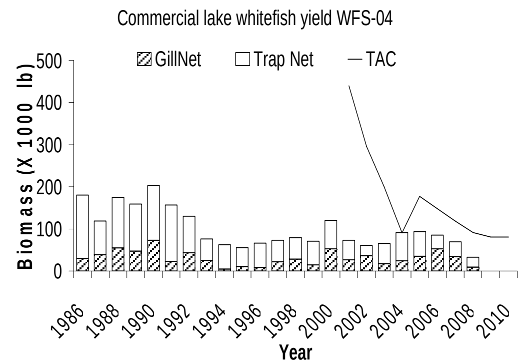
Lake Superior

WFS-04 (Marquette - Big Bay)

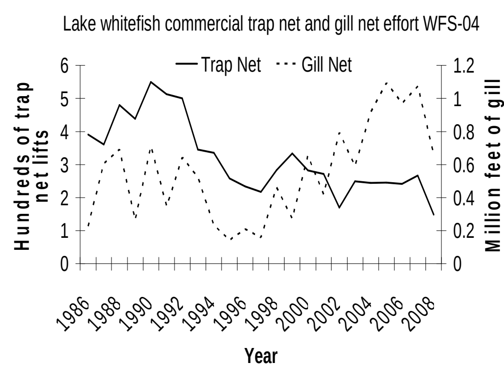
Prepared by Philip J. Schneeberger

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 then this quota is 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 2008 was 32,575 lb. The trap-net fishery produced most of the overall harvest (23,576 lb) and the gill-net fishery caught the remainder (8,999 lb). Compared to 2007, trap-net yield decreased 34% and gill-net yield dropped 74% in 2008. In 1836 waters of WFS-04, lake whitefish yield (all from trap nets) was 1,010 lb, or about a third of the yield taken there in 2007, and only 3% of the overall yield from the entire management unit in 2008.

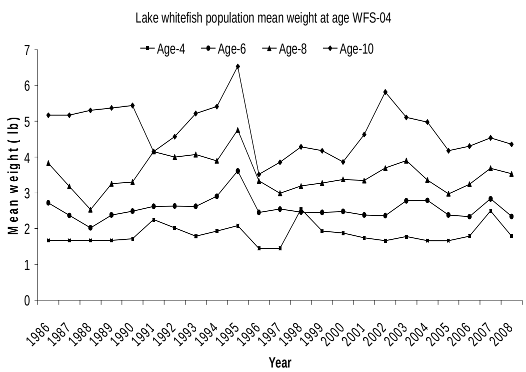


WFS-04 trap-net effort (148 lifts in 2008) declined by 44% and gill-net effort (0.66 million feet in 2008) declined by 38% from 2007 (note that the 2007 value for gill-net effort shown here has been corrected downward from the value provided by GLIFWC for last year's summary report). Only 9% of the trap-net effort and none of the gill-net effort took place in 1836 Treaty waters during 2008.



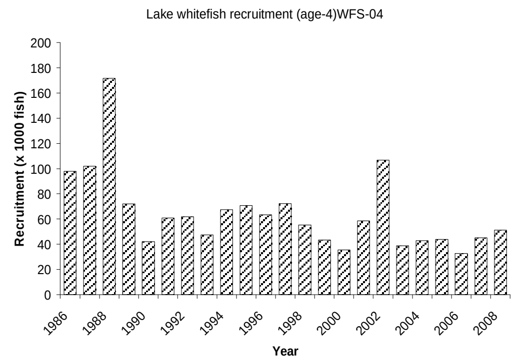
Catch-per-unit effort (CPUE) increased by 20% for the 2008 trap-net fishery but decreased for a second year in a row for gill nets. Despite the increase, 2008 trap-net CPUE is well below the long-term average and gill-net CPUE is at the lowest value in the time series.

Calculations of mean weight-at-age were lower in 2008 after trending higher in recent years. On average, weight-at-age decreased 8% for ages 4-12+ between 2007 and 2008.

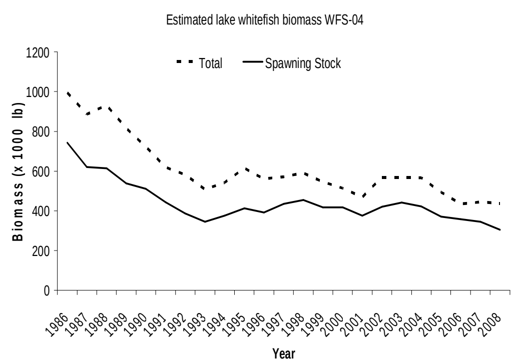


The same von Bertalanffy growth model from last year, which used averages for length-at-age, calculated from lake whitefish data pooled for 2005-2007 from state fisheries, was used again for the current model. This growth model, which was forced through zero by inserting a data point of length 0 mm at age 0, yielded model estimates for growth parameters $L\infty$ and k of 755 mm and 0.178. 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.

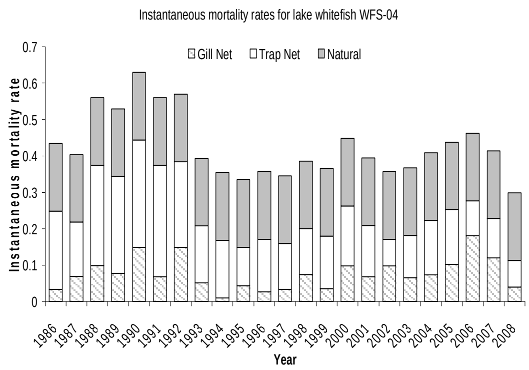
Recruitment (number of age-4 lake whitefish) was estimated at 51,000 fish in 2008. WFS-04 recruitment estimates have remained relatively stable since 2003. The most recent larger-than-normal year class was produced in 1998, as determined by the estimate of age-4 fish in 2002.



Neither total nor spawning stock biomass has fluctuated to any great degree since the mid-1990s. Estimated fishable biomass was 438,000 lb and spawning stock biomass was 305,000 lb in 2008, both values slightly lower than those for 2007. The 2008 ratio of spawning stock biomass to fishable biomass was 0.70; this ratio has varied between 0.66 and 0.82 through the time series of the data set.



Based on the current model, total instantaneous mortality rate (*Z*) for the WFS-04 lake whitefish stock has ranged between 0.30 and 0.46 y^{-1} from 1993 through 2008. The 2008 estimate for *Z* was at the low end of this range and was down 28% from the value estimated for 2007. Estimated instantaneous fishing mortality rates (*F*) were 0.04 y^{-1} for gill nets and 0.07 y^{-1} for trap nets in 2008. Instantaneous natural mortality rate was estimated at 0.18 y^{-1}.



The 2010 yield limit calculated for lake whitefish in the entire WFS-04 management unit is 116,000 lb, the same as for 2009. Comparing this year's summary statistics (below) with those from last year showed most parameters headed in an unfavorable direction: spawning stock biomass per recruit, average yield per recruit, and 3-year averages for recruitment, biomass, and spawning biomass all declined. On the positive side, the 3-year average estimate for total mortality also declined between 2007 and 2008. After applying the prescribed reduction to reflect the proportion of this management unit that is outside the Consent Decree, the 2010 yield limit for lake whitefish in 1836 Treaty waters is again 81,000 lb.

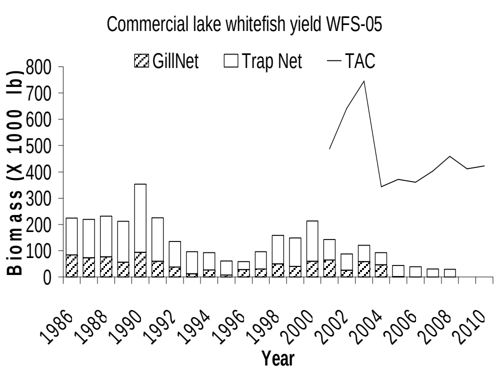
Summary Status WFS-04 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	2.03 lb
Age at first spawning	4 y
Size at 50% maturity	2.06 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	8.071 lb (SE 0.014)
Current SSBR	2.56 lb (SE 0.09)
SSBR at target mortality	0.227 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.317 (SE 0.012)
Average yield per recruit	1.476 lb (SE 0.009)
Natural mortality (*M*)	0.186 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	11
Fully selected age to trap nets	7
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.132 y^{-1} (SE 0.009)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.095 y^{-1} (SE 0.006)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.413 y^{-1} (SE 0.013)
Recruitment (age 4)	
(average 1999-2008)	49,803 fish (SE 2,858)
Biomass (age 3+)	
(average 1999-2008)	504,230 lb (SE 19,674)
Spawning biomass	
(average 1999-2008)	387,560 lb (SE 15,291)
MSC recommended yield limit for 2010	81,000 lb
Actual yield limit for 2010	81,000 lb

WFS-05 (Munising)

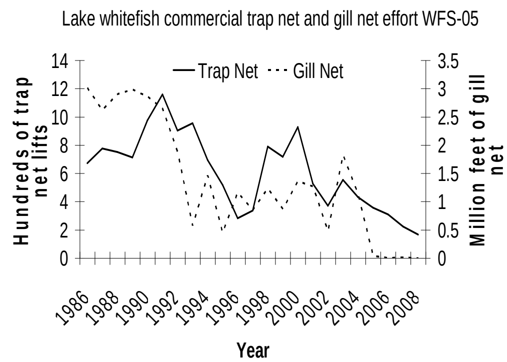
Prepared by Philip J. Schneeberger

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.

Total yield of lake whitefish in WFS-05 for 2008 was 30,000 lb, down 6% from 2007. Trap nets have accounted for virtually all (>95%) of the lake whitefish yield each year between 2005 and 2008. Yield from gill nets had averaged 32% of the annual total from 1986 through 2004 but dwindled to very low levels by 2005 and was zero for 2008. A peak yield of 354,000 lb (73% from trap nets and 27% from gill nets) occurred in 1990 in this management unit.

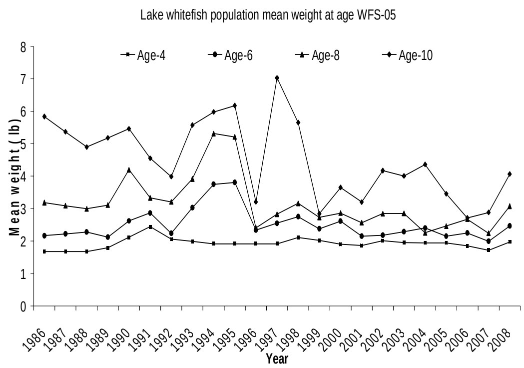


A decline in fishing effort has continued from 2003 through 2008 and is currently at the lowest point in the data series for both trap nets and gill nets. Fishing effort in 2008 was 168 lifts for trap nets and zero for gill nets.



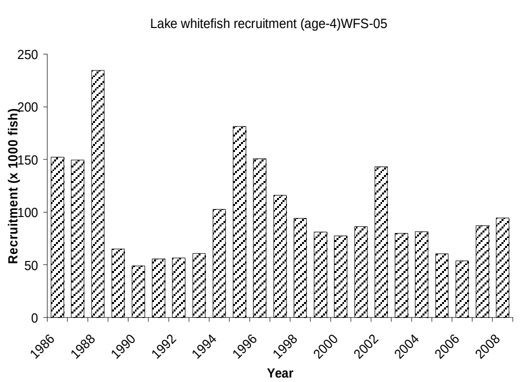
Catch-per-unit effort (CPUE) for the trap-net fishery has increased steadily since 2004 and the 2008 value is the highest since 1997. Gill-net CPUE had also shown substantial increases from 2003 through 2006 when it peaked at the highest value in the time series. The greatly reduced gill-net harvest and effort in 2007 and 2008 precludes meaningful calculation of current gill-net CPUE in WFS-05.

Mean weights-at-age increased sharply for fish of all ages compared to 2007. Weights-at-age were higher in 2008 than during the previous three years or more.

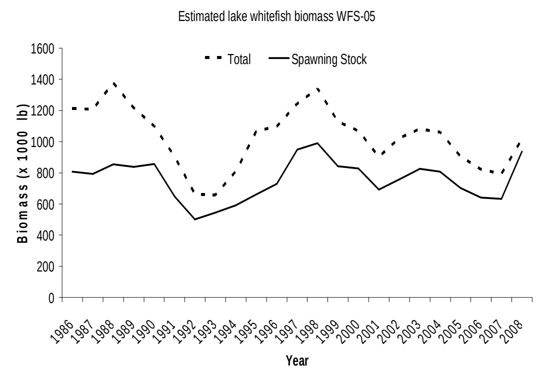


The same von Bertalanffy growth model from last year, which used averages for length-at-age, calculated from lake whitefish data pooled for 1986-2007 from state fisheries, was again used for this year's model. This growth model, which included an inserted data point representing fish of length 75 mm at age 0, yielded model estimates for growth parameters L∞ and k of 780 mm and 0.140. An attempt was made to use length-at-age data from individual fish for the entire time series for the model, but the resulting growth parameters were unrealistic and deemed unacceptable.

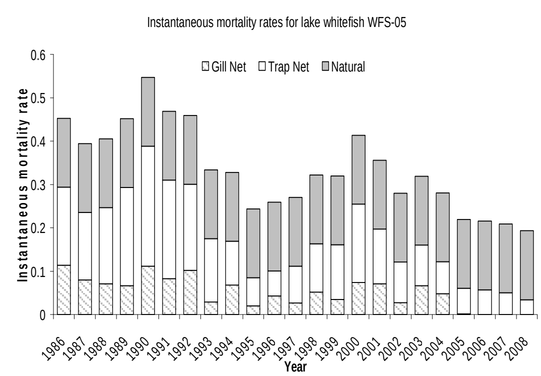
The 2008 estimate of recruitment, reported as annual numbers of age-4 lake whitefish in the population, was 94,000 fish. Based on the current model, this estimate is the highest since 2002, and is close in value to recruitment estimates for 8 of the past 11 years. Highest levels of recruitment have occurred within the data series at seven-year intervals with peaks in 1988, 1995, and 2002.



Biomass estimates in 2008 were 1.02 million lb for the fishable stock (lake whitefish age-4 and older) and 937,000 lb for the spawning stock. The estimates of biomass using the current model have increased steeply since 2007. The 2008 ratio of spawning stock biomass to fishable biomass was 0.92, which was above average for the data series.



Estimates for total instantaneous mortality rate (*Z*) have remained consistently below 0.45 y^{-1} since 1993. The estimate for *Z* was 0.2 y^{-1} in 2008. Natural mortality rate (*M*), estimated at 0.16 y^{-1}, was 82% of the total for *Z* in WFS-05. Instantaneous fishing mortality (*F*) rate was 0 for gill nets and 0.034 y^{-1} for trap nets for 2008.



The calculated 2010 yield limit for WFS-05 was 423,000 lb, a 2% increase from the yield limit for 2009. There is a positive future outlook for lake whitefish in this management unit based on indications that growth, recruitment, biomass, mortality, and trap-net CPUE are all heading in favorable directions.

Summary Status WFS-05 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.85 lb
Age at first spawning	4 y
Size at 50% maturity	2.18 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	9.16 lb (9.13 – 9.18)
Current SSBR	6.13 lb (5.84 – 6.42)
SSBR at target mortality	0.257 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.670 (0.638 – 0.701)
Average yield per recruit	0.791 lb (0.720 – 0.862)
Natural mortality (*M*)	0.159 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. y^{-1}
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.048 y^{-1} (0.042 – 0.055)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.207 y^{-1} (0.201 – 0.214)
Recruitment (age 4)	
(average 1999-2008)	86,132 fish (76,160 – 98,728)
Biomass (age 3+)	
(average 1999-2008)	990,698 lb (891,938 – 1,102,830)
Spawning biomass	
(average 1999-2008)	774,372 lb (690,817 – 868,623)
MSC recommended yield limit for 2010	423,000 lb
Actual yield limit for 2010	423,000 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.

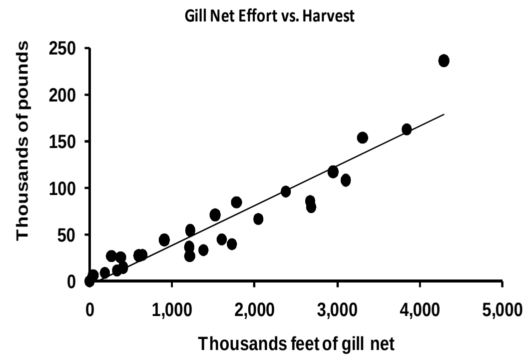
WFS-06 has been an exclusive commercial fishing zone for CORA fishers since 1985. Access to the unit is limited mainly to the Grand Marais area in the west and Little Lake Harbor in the east. A sizeable sport fishery targets whitefish off the pier at Grand Marais, but this yield and effort has not been included in the stock assessment model.

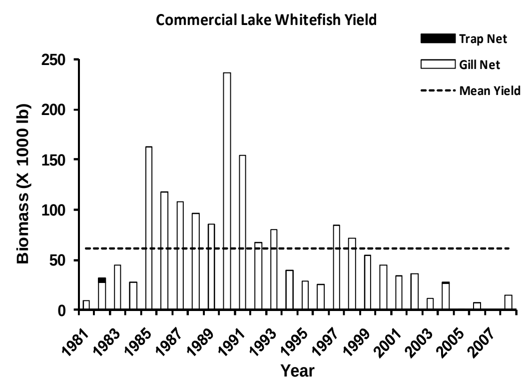
The commercial yield of lake whitefish from WFS-06 has averaged 60,275 lb during 1976-2008. The peak yield was 236,000 lb in 1990 and there was no yield in 2007.

The large-mesh gill-net fishery has accounted for 99% of the entire yield from WFS-06 during 1976-2008. Peak gill-net effort was 4.2 million ft in 1990 and there was no gill-net effort in 2005 or 2007. The commercial yield in 2008 was only 14,700 lb.

There was a direct linear relationship between gill-net effort and yield of whitefish in WFS-06 during 1976-2008. Gill-net effort explained 87% of the variation in gill-net yield during 1976-2008.

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 2010 was 210,000 lb and represents the SCAA model output from 2004 (i.e. data through 2002).





WFS-07 (Tahquamenon Bay)

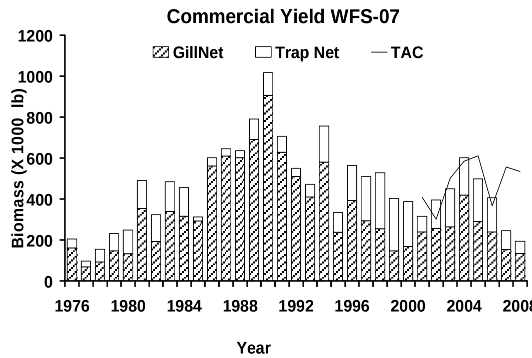
Prepared by Mark P. Ebener

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.

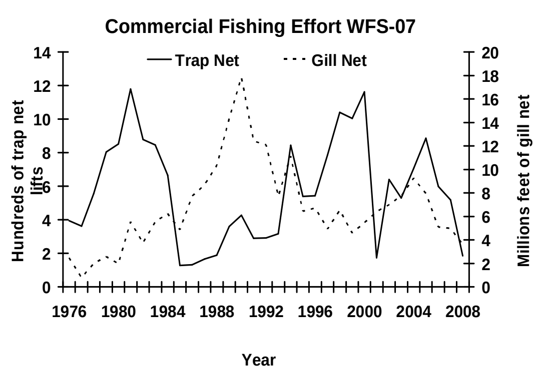
WFS-07 is an important fishing ground for the CORA fishery, and has been an exclusive CORA fishing zone since 1985. Large- and small-boat gill-net fisheries as well as several trap-net fisheries operate in WFS-07. An ice fishery also takes place nearly every winter. There are a large number of relatively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

The commercial yield of whitefish from WFS-07 averaged 482,000 lb during 1976-2008. A peak yield of one million lb occurred in 1990 and the lowest reported yield was 98,000 lb in 1977. The 2008 yield was 229,600 lb and the HRG was 583,000 lb.



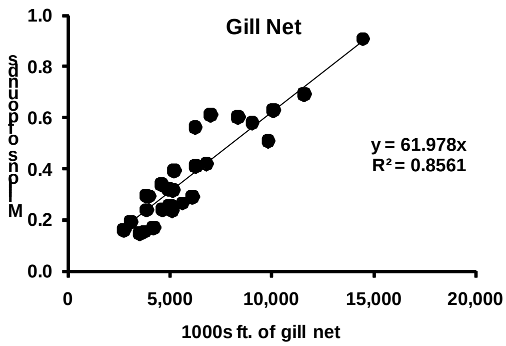
The large-mesh gill-net fishery accounted for 77% of the whitefish yield from WFS-07 during 1976-2008. The trap-net fishery harvested more whitefish from the unit than the gill-net fishery only during 1998-2000. The yield in 2008 was 161,500 lb from the gill-net fishery and 68,100 lb from the trap-net fishery.

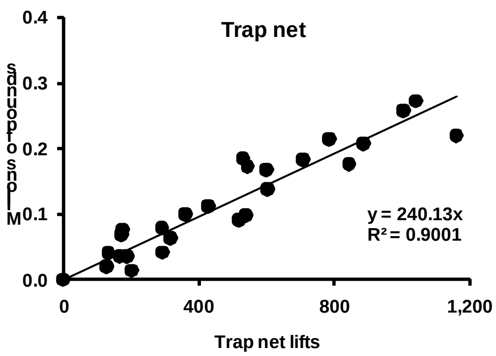
Yield of whitefish from WFS-07 has mirrored changes in fishing effort during 1976-2008. After peaking at 17 million ft in 1990, large-mesh gill-net effort declined to between 3.5 and 9.5 million ft during 1997-2008. Gill-net effort was 3 million ft in 2008. Trap-net effort increased from 128 lifts in 1985 to 1,161 lifts in 2000 before declining to 175 lifts in 2001 and 171 lifts in 2008.



Harvest of whitefish was directly proportional to CORA fishing effort in

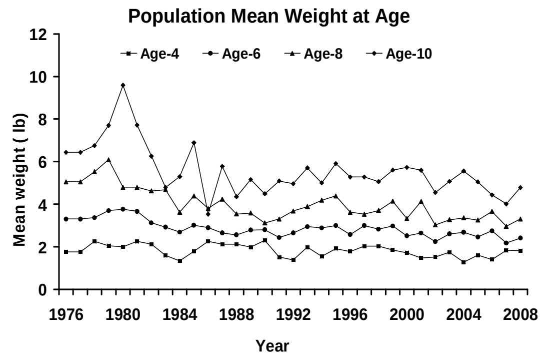
WFS-07 during 1981-2008. Gill net and trap net effort explained 86% and 90%, respectively, of the variation in harvest by each gear during 1981-2008. The average catch-per-unit-effort was 62 lb per 1,000 ft. in the gill-net fishery and 240 lb per lift in the trap-net fishery.



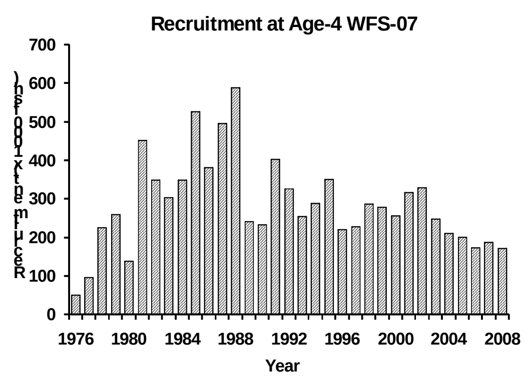


Whitefish caught in WFS-07 are of moderate to large size. Mean weight of a harvested whitefish averaged 3.0 lb from WFS-07 during 1976-2008. Mean weight of a harvested whitefish in 2008 was 2.9 lb, with an average weight in the gill-net fishery of 3.1 lb and 2.6 lb in the trap-net fishery.

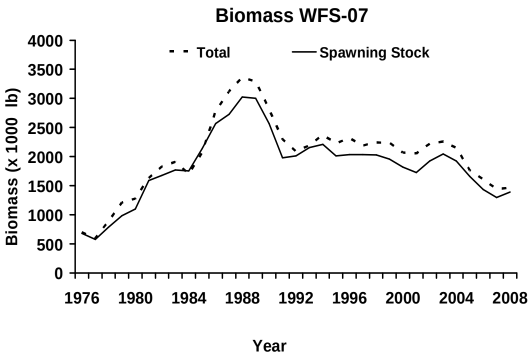
After declining from 1976 to 1990, mean weight at age of whitefish from WFS-07 has remained very constant through time. Mean weight of age 4-9 whitefish has varied little since 1990, while mean weight of age 10 and older fish generally increased from 1990 to 2004 and has declined since.

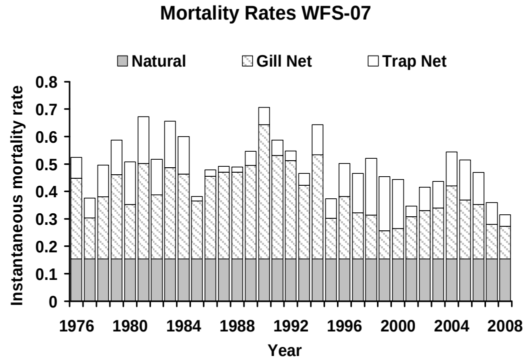


Estimated recruitment of age-4 whitefish to the fishable population peaked in 1988 and has declined continually since then. The stock assessment model estimated that an average of 285,000 age-4 whitefish recruited to the fishable population each year during 1976-2008. Recruitment varied from 50,000 fish in 1976 to 588,000 fish in 1988. Recruitment was estimated to be 187,000 and 171,000 whitefish in 2007 and 2008, respectively. Recruitment levels during 2006-2008 were estimated to be lower than other years except 1976, 1977, and 1980.



Average total biomass of age-4 and older whitefish peaked at 3.4 million lb in 1988 and has declined ever since. The total biomass was 1.5 million lb in 2008, compared to a spawning biomass of 1.4 million lb. The estimated biomass of whitefish in 2008 was equal to levels observed in the early 1980s.





Using Pauly's relationship between average water temperature occupied by a fish (4^oC) and von Bertalanffy growth parameters L∞ (79.1 cm) and k (0.13581) natural mortality was estimated to be 0.15 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 1980-2007. A mean length of 41 mm was used for age-0 whitefish in the growth model and represents the estimated mean value for fish caught in seines in lower Whitefish Bay management units WFS-07 and WFS-08 from May through mid October of 1993-2001.

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 0.50 y^{-1} during 1976-2008 and ranged from a low of 0.31 y^{-1} in 2008 to a high of 0.71 y^{-1} in 1990. Fishing mortality averaged 0.34 y^{-1} during 1976-2008. Gill-net mortality averaged 0.25 y^{-1} and trap-net mortality 0.10 y^{-1} during 1976-2008. Gill-net fishing mortality in 2008 was 0.12 y^{-1}, and trap-net mortality was 0.04 y^{-1}.

The projection model estimated that fishing mortality could be increased by 2.63 times in 2010 above levels estimated for 2006-2008. As a consequence, the recommended yield limit was estimated to be 685,000 lb in 2010. Previous recommended yield limits were 636,000 lb in 2009, 583,000 lb in 2008, 551,000 in 2007, 367,000 lb in 2006, 611,000 lb in 2005, 585,000 lb in 2004, 502,000 lb in 2003, 302,000 in 2002, and 409,000 lb in 2001.

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. Consequently, reliability of the stock assessment model and projected estimates of total allowable catches were rated as low.

Summary Status WFS-07 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.68 lb
Age at first spawning	4 y
Size at 50% maturity	2.15 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	8.253 lb (SE 0.001)
Current SSBR	2.18 lb (SE 0.12)
SSBR at target mortality	0.291 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.264 (SE 0.015)
Average yield per recruit	1.612 lb (SE 0.018)
Natural mortality (*M*)	0.154 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	6
Fully selected age to trap nets	6
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.148 y^{-1} (SE 0.011)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.08 y^{-1} (SE 0.005)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.381 y^{-1} (SE 0.015)
Recruitment (age 4)	
(average 1999-2008)	236,790 fish (SE 7,780)
Biomass (age 3+)	
(average 1999-2008)	1,927,300 lb (SE 75,266)
Spawning biomass	
(average 1999-2008)	1,717,000 lb (SE 71,306)
MSC recommended yield limit for 2010	685,000 lb
Actual yield limit for 2010	535,000 lb

WFS-08 (Brimley)

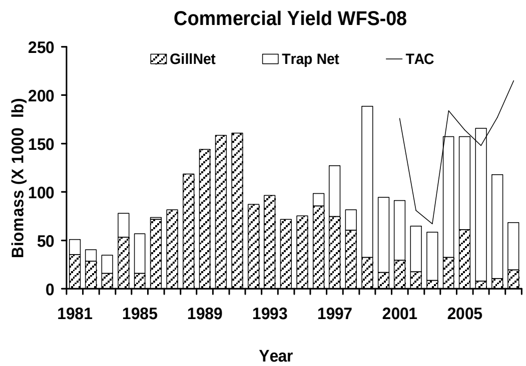
Prepared by Mark P. Ebener

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.

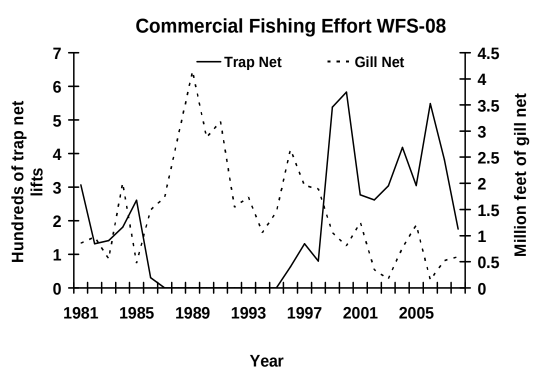
There are probably four reproductively isolated stocks of whitefish that contribute to the commercial fishery in WFS-08. Whitefish that spawn in WFS-07, two areas of WFS-08, and a fourth population that spawns in Canadian waters of management unit 34 all contribute to the fishery.

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.

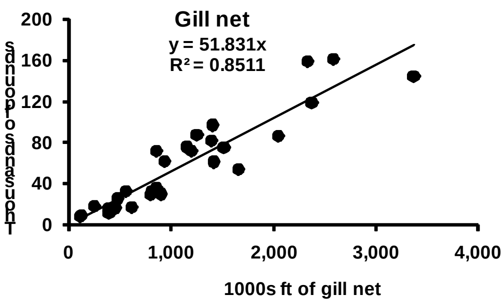
The commercial yield of whitefish from WFS-08 has averaged 97,500 lb during 1981-2008. Annual yields ranged from 35,000 lb in 1983 to 188,000 lb in 1999. The peak yield of 195,000 lb occurred in 1979, just prior to the creation of CORA. The large-mesh gill-net fishery accounted for 61% of the yield from WFS-08 during 1981-2008. There was no trap-net yield from WFS-08 during 1987-1995. The trap-net yield in 2008 was 38,100 lb, while the gill-net yield was 24,900 lb.

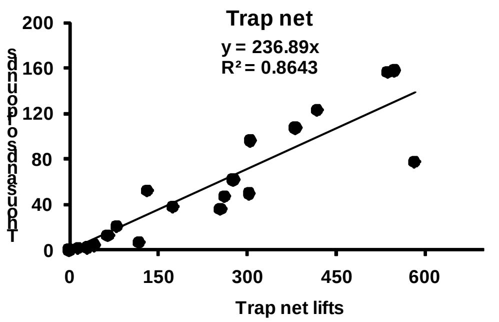


Gill-net effort has been declining in WFS-08 while trap-net effort has increased tremendously. Peak gill-net effort was 4.0 million ft in 1989, but it had declined to 0.12 million ft by 2006. Trap-net effort peaked at 738 lifts in 1979, declined to zero during 1987-1995, increased to 583 lifts in 2000, then declined somewhat before increasing again to 549 lifts in 2006. Fishing effort in 2008 was 0.5 million ft of gill net and 175 trap net lifts.



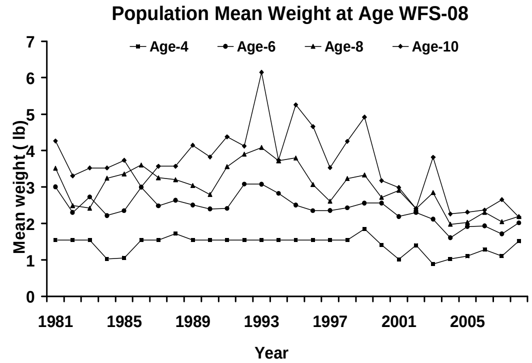
Both gill net and trap net harvest was linearly related to their respective fishing efforts. Fishing effort explained 85-86% of the variation in gill net harvest and trap net harvest in WFS-08 during 1981-2008. Average gill-net CPUE was 52 lb per 1000 ft. and average trap-net CPUE was 237 lb per lift during 1981-2008.



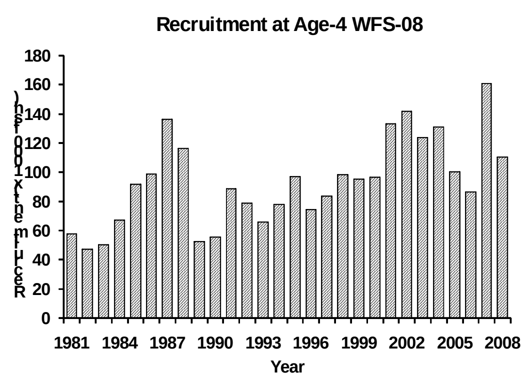


Whitefish in WFS-08 are of moderate to large size. Mean weight of a harvested whitefish in the fishery of WFS-08 averaged 2.7 lb during 1981-2008; 2.2 lb in the trap-net fishery and 3.0 lb in the gill-net fishery. Mean weight of a harvested whitefish in 2008 was 2.1 lb in the trap-net fishery and 3.6 lb in the gill-net fishery.

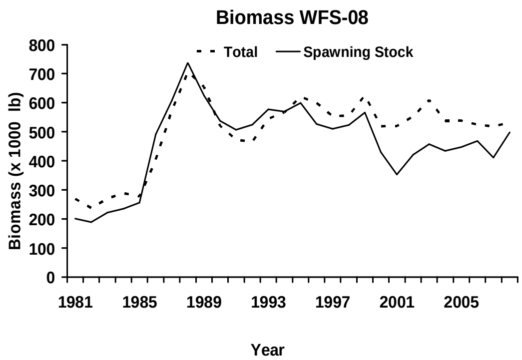
Growth of whitefish in WFS-08 remained fairly stable during 1981-1993, generally declined through about 2004 and has since stabilized and increased slightly. Mean weight of age-4 and age-5 whitefish in 2008 was to similar levels observed prior to 2004, whereas mean weight of age-6 and older whitefish is currently lower than any time during 1981-2008.



Recruitment of age-4 whitefish in WFS-08 has been less variable than in adjacent unit WFS-07. Recruitment increased continually from 1989 through 2001, then stabilized at a higher level than any other time during 1981-2008. The stock assessment model estimated that an average of 93,400 age-4 whitefish recruited to the population each year during 1981-2008. Recruitment peaked at 161,000 age-4 whitefish in 2007, and an estimated 110,000 age-4 whitefish recruited to the fishery in 2008.

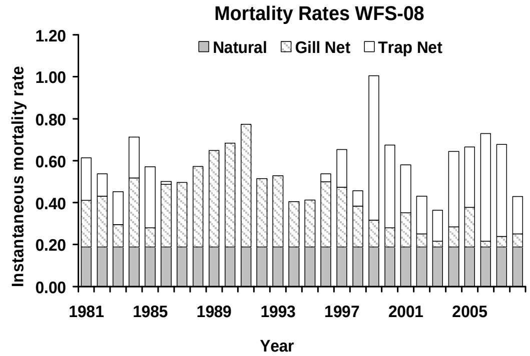


Total fishable biomass has remained relatively stable in WFS-08 since the mid to late 1980s, where spawning biomass has declined somewhat possibly because of declines in growth that occurred after 1993. Total biomass of whitefish averaged 502,000 lb during 1981-2008 and spawning biomass averaged 462,000 lb during the same time. Total biomass was 532,000 lb in 2008 and spawning biomass was 497,000 lb.



Using Pauly's relationship between average water temperature occupied by a fish (4°C) and von Bertalanffy growth parameters L∞ (71.5 cm) and k (0.1522), natural mortality was estimated to be 0.19 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. A mean length of 41 mm was used for age-0 whitefish in the growth model and represents the estimated mean value of fish caught in seines in lower Whitefish Bay management units WFS-07 and WFS-08 from May through mid October of 1991-2001.

Total annual mortality of age-4 and older whitefish has been fairly high but stable in WFS-08 during 1981-2008. Total instantaneous mortality of age-4 and older whitefish averaged 0.58 y^{-1} during 1981-2008 and was 0.43 y^{-1} in 2008. Fishing mortality averaged 0.35 y^{-1} during 1981-2008 and was 0.37 y^{-1} in 2008. Trap-net mortality was 0.18 y^{-1} and gill-net mortality 0.19 y^{-1} in 2008.



Total annual mortality on age-4 and older whitefish was slightly less than the target rate of 1.05 y^{-1} during 2006- 2008. The SPR value at the target mortality rate was 0.39 and greater than the target SPR value of 0.20. Thus the projection model estimated that fishing mortality rate in 2006 could be increased 1.41 times from levels experienced during 2006-2008. The recommended yield limit at this rate of fishing was estimated to be 170,000 lb in 2010. Recommended yield limits in WFS-08 were 132,000 lb in 2009, 215,000 lb in 2008, 177,000 lb in 2007, 148,000 lb in 2006, 164,000 lb in 2005, 184,000 lb in 2004, 67,000 lb in 2003, 81,000 lb in 2002, and 176,000 lb in 2001.

Convergence criteria were not met for the WFS-08 stock assessment model, but probability distributions and trace and autocorrelation plots from the Markov Chain Monte Carlo simulations were acceptable. Consequently, reliability of the stock assessment model and projected estimates of total allowable catches were rated as medium.

Summary Status WFS-08 Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	1.30 lb
Age at first spawning	4 y
Size at 50% maturity	1.58 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	3.243 lb (SE 0.004)
Current SSBR	1.09 lb (SE 0.03)
SSBR at target mortality	0.221 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.338 (SE 0.011)
Average yield per recruit	1.070 lb (SE 0.013)
Natural mortality (*M*)	0.189 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 2006-2008, ages 4+	0.047 y^{-1} (SE 0.004)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.377 y^{-1} (SE 0.022)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.612 y^{-1} (SE 0.025)
Recruitment (age 4)	
(average 1999-2008)	117,860 fish (SE 5,527)
Biomass (age 3+)	
(average 1999-2008)	547,610 (SE 19,196)
Spawning biomass	
(average 1999-2008)	448,670 lb (SE 15,965)
MSC recommended yield limit for 2010	170,000 lb
Actual yield limit for 2010	170,000 lb

Lake Huron

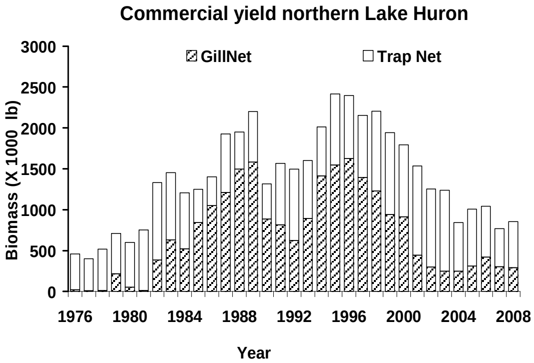
Northern Huron (WFH-01 to WFH-04)

Prepared by Mark P. Ebener

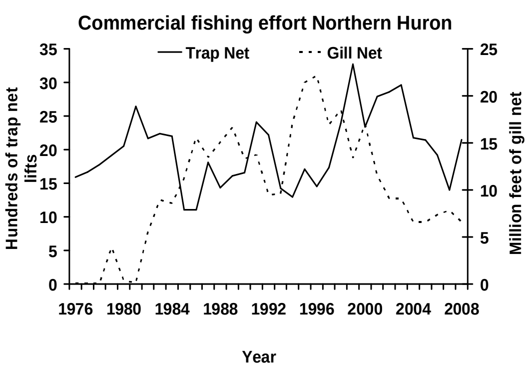
The Northern Huron stock represents the area in Michigan waters of northwest Lake Huron from the Straits of Mackinac east to Drummond Island and south to Presque Isle. Biological and commercial catch information from whitefish management units WFH-01 to WFH-04 were combined to create the Northern Huron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

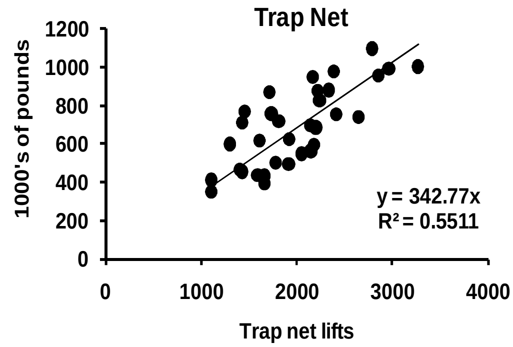
The Northern Huron unit includes the Drummond Island Lake Trout Refuge, the Bay Mills Small Boat Zone, and the Southern Lake Huron Trap Net Zone, all of which were created by the 2000 Consent Decree. Areas north of 40 Mile Point have been an exclusive CORA commercial fishing zone since 1985 and after 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 1.38 million lb during 1976-2008. 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 855,300 lb in 2008. The long-term average harvest during 1976-2008 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. The gill-net fishery harvested 291,900 lb in 2008, while the trap-net fishery harvested 563,400 lb.

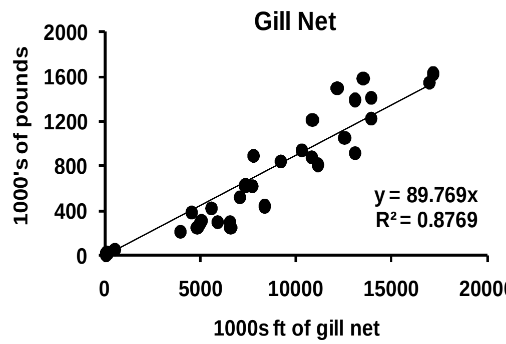


Gill-net effort has declined substantially since the implementation of the Consent Decree, but trap-net effort has not. Large-mesh gill-net effort ranged from a low of 85,000 ft. in 1978 to a high of 17.2 million ft. in 1996 and averaged 8.1 million ft during 1976-2008. Gill-net effort was 17 million feet in 2000 after which it declined almost annually to 6.6 million ft. in 2004. Since 2004 gill-net effort has ranged from 6.6 to 7.8 million ft. Gill-net effort was 6.6 million ft. in 2008. Trap-net effort was variable yet stable ranging from 1,100 lifts during 1984-1985 to 3,271 lifts during 1996 and averaged 1,988 lifts during 1976-2008. After 2000 trap-net effort ranged from 1,400 to 2,900 lifts and was 2,147 lifts in 2008.

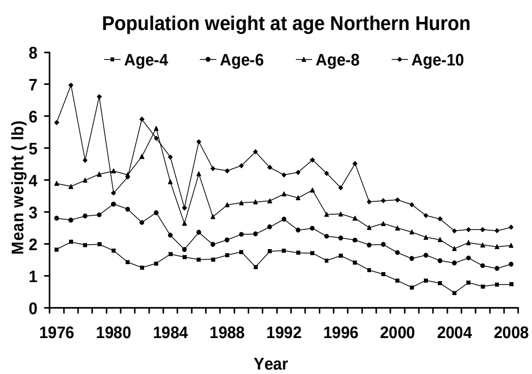


Harvest of whitefish in Northern Huron is directly related to fishing effort. Trap-net effort explained 55% of the variation in trap-net harvest and gill-net effort explained 88% of the variation in gill-net harvest during 1976-2008. Average trap-net catch rate was 343 lb per lift and average gill-net catch rate was 90 lb per 1000 ft. during 1976-2008.

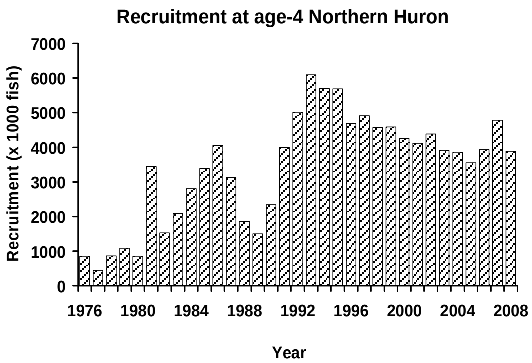




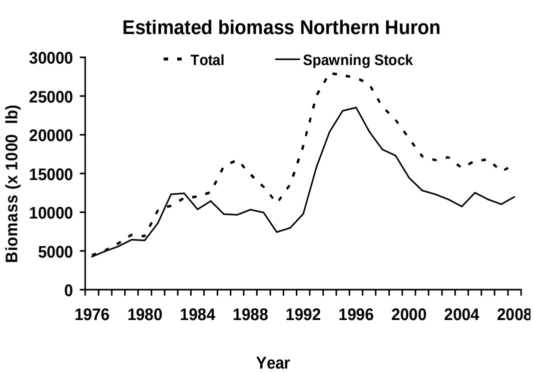
After declining for the better part 15 years, mean weight at age of whitefish in Northern Huron stabilized over the past few years. Mean weight of all ages remained constant from 2004-2008 unlike during the previous 12 years when there was almost an annual decline in mean weight at age.



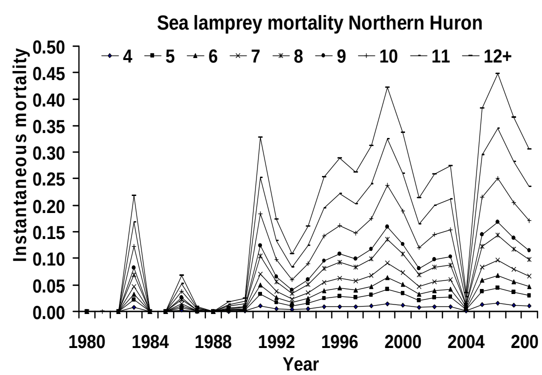
Recruitment at age 4 increased from the late 1970s to 1992 and has declined slowly since then, although recruitment remains at a high level. From 1976 through 1989 recruitment to the population averaged about 2.5 million fish, thereafter recruitment peaked at 6.1 million fish in 1993 and declined slowly to 3.9 million fish in 2008. 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 27.97 million pounds in 1994, one year later than peak recruitment, and since then fishable biomass has been declining and was 16.1 million pounds in 2008. Spawning biomass was estimated to be 12.0 million pounds in 2008.

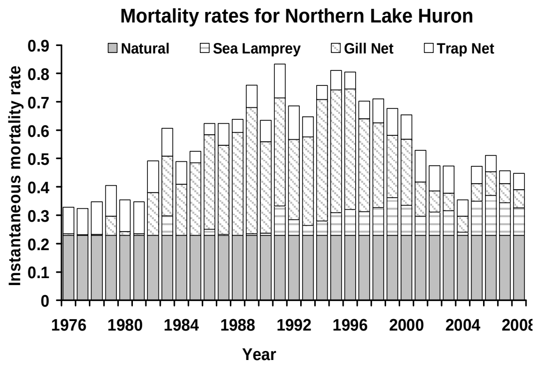


Using Pauly's relationship between average water temperature occupied by a fish (6^{o}C) and von Bertalanffy growth parameters L∞ (60.95 cm) and k (0.1686) natural mortality was estimated to be 0.23 y^{-1} in the stock assessment model. The von Bertalanffy growth model was updated with mean length-at-age 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. A mean length of 41 mm was used for age-0 whitefish in the growth model and represents the estimated mean value for fish caught in seines in Whitefish Bay and northern Lake Huron from May through mid October of 1993-2001. 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.



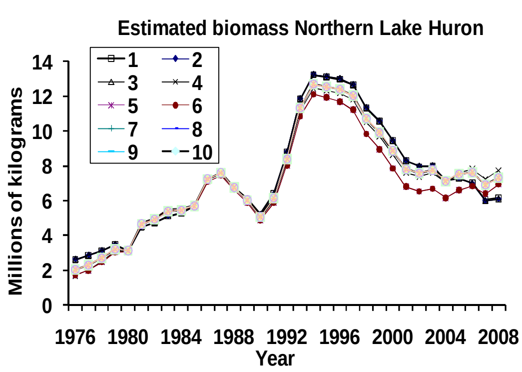
Total instantaneous mortality of lake whitefish in Northern Huron averaged 0.56 y^{-1} for ages 4+ during 1976-2008. Gill-net mortality of age 4+ averaged 0.20 y^{-1}, trap-net mortality averaged 0.08 y^{-1}, and sea lamprey mortality averaged 0.05 y^{-1} during 1976-2008. Total mortality peaked at 0.83 y^{-1} in 1991. Peak gill-net mortality averaged 0.44 y^{-1} in 1989 and trap-net mortality peaked at 0.12 y^{-1} in 1991 and 1992. Sea lamprey mortality equaled or exceeded fishing mortality during 2004-2008.

Total annual mortality on fully vulnerable age-classes was less than the target rate during 2006-2008 and the spawning potential reduction at current mortality rates and at the target mortality rate was greater than 0.20.



Consequently, the projection model estimated that fishing mortality could be increased 1.7 times. The projected harvest limit for 2010 under this increased fishing rate was estimated to be 2.81 million pounds, which was nearly two million pounds greater than the actual harvest in 2008.

Model fit for the Northern Huron SCAA model was reasonable, but estimated biomass did vary somewhat depending upon starting values or bounds on parameters (see figure below). Markov Chain Monte Carlo simulations for the Northern Huron model were poor, consequently the model rating was low.



<u>References:</u>

Ebener, M.P., Bence, J.R., Newman, K., and Schneeberger, P. 2005. Application of statistical catch-at-age models to assess lake whitefish stocks in the 1836 treaty-ceded waters of the upper Great Lakes. Pages 271-309 *in* Mohr, L.C. and Nalepa, T.F., eds. Proceedings of a workshop on the dynamics of lake whitefish (*Coregonus clupeaformis*) and the amphipod *Diporeia* spp. in the Great Lakes. Great Lakes Fishery Commission, Technical Report 66, Ann Arbor, Michigan.

Ebener, M.P., Brenden, T.O., Wright, G.M., Jones, M.L., and Faisal, M. 2010. Spatial and Temporal Distributions of Lake Whitefish Spawning Stocks in Northern Lakes Michigan and Huron, 2003–2008. *J. Gr. Lak. Res*. 36(supp 1): 38-51.

Summary Status Northern Huron Whitefish	**Value (Standard Error)**
Female maturity	
Size at first spawning	0.71 lb
Age at first spawning	4 y
Size at 50% maturity	1.30 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.167 lb (SE 0.004)
Current SSBR	0.80 lb (SE 0.01)
SSBR at target mortality	0.144 lb (SE 0.000)
Spawning potential reduction	
At target mortality	0.371 (SE 0.007)
Average yield per recruit	0.30 lb (SE 0.013)
Natural mortality (*M*)	0.230 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.081 y^{-1} (SE 0.007)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.057 y^{-1} (SE 0.004)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	0.138 y^{-1}
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.507 y^{-1} (SE 0.01)
Recruitment (age 4)	
(average 1999-2008)	4,125,300 fish (SE 312,300)
Biomass (age 3+)	
(average 1999-2008)	17,294,000 (SE 854,660)
Spawning biomass	
(average 1999-2008)	12,648,000 lb (SE 587,730)
MSC recommended yield limit for 2010	2,800,000 lb
Actual yield limit for 2010	1,663,000 lb

WFH-05 (Alpena)

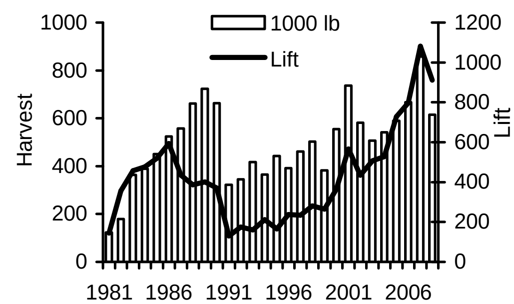
Ji X. He and Mark P. Ebener

WFH-05 runs from Presque Isle south to the southern end of grids 809-815 in US waters. The 2000 Consent Decree converted WFH-05 from an exclusive state-licensed commercial fishery unit to an exclusive CORA trap-net fishery unit beginning in August 2000. There are two areas in WFH-05 open to the tribal fishery. The first is the Southern Lake Huron Trap Net Zone (SLHTN) that is the southern end of 1836 Treaty Water within WFH-05. Only four CORA trap-net operations from two tribes can fish in SLHTN, 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 the depth of water where trap nets can be set. The second is a “grey” zone between SLHTN and a straight line running northeast from the tip of North Point of Thunder Bay to the international border. The four tribal fishers from SLHTN can apply for a permit from the state and fish up to a total of 16 trap nets in this “grey” zone, where the minimum length limit set by the State is 19 inches, and trap nets cannot be fished in waters deeper than 90 feet.

Annual trap-net harvest ranged from 123,651 lb in 1981 to a high of 858,627 lb in 2007 (Figure 1). The first peak was at the end of the 1980s (723,735 lb), and the second was at the beginning of the 2000s (736,877 lb). The 2008 harvest was 614,921 lb, slightly higher than the average (505,747 lb) since 1983.

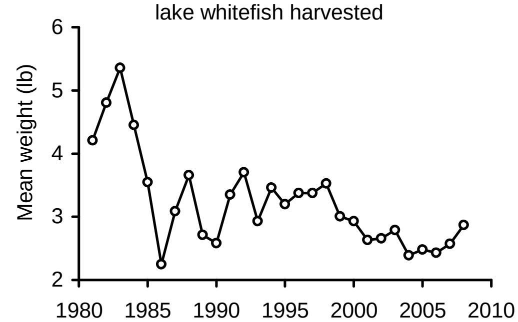
In general, annual trap-net harvest increased with fishing effort (Figure 1). The relationships differed among three periods. The first was 1981-1986; the second was 1987-2002, and the third was 2003-2008. Catch rates were higher during 1987-2002 than they were in the early and recent periods.

Figure 1: Trapnet effort and harvest



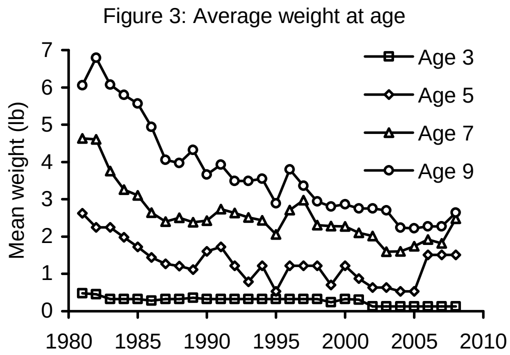
Mean weight of lake whitefish harvested in trap nets was 4.1 lb during 1981-1986, 3.1 lb during 1987-2002, and 2.6 lb during 2003-2008 (Figure 2). There were dynamic variations between 2.2-3.7 lb during 1986-1990, and a sharp decline from 3.5 lb in 1998 to 2.6 lb in 2001. The mean weight of a harvested lake whitefish was 2.9 lb in 2008.

Figure 2: Average individual weight lake whitefish harvested

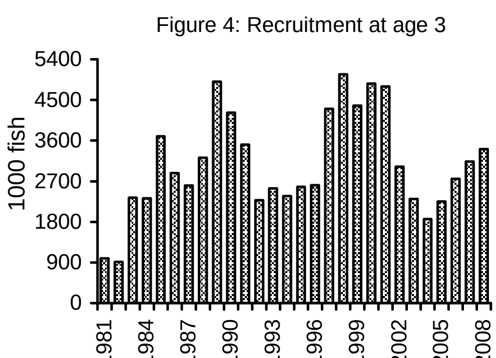


Weight-at-age declined sharply during 1981-1986, followed by some dynamic variations and slow decline during 1987-2002, but recent trends differed among age groups (Figure 3). For example, an age 7 lake whitefish weighed 4.6 lb in 1981 and 1982, decreased to 2.6 lb by 1986, and further declined to 2.0 lb by 2002. The mean weight for age 7 lake whitefish was only

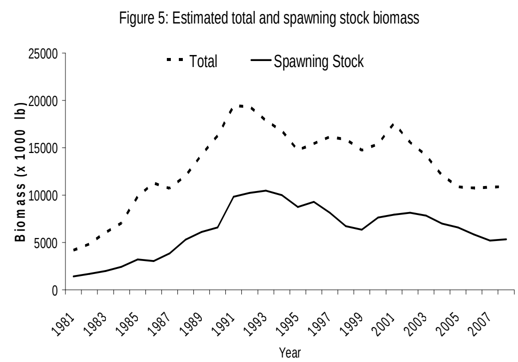
1.7 lb during 2003-2007, but increased to 2.5 lb in 2008.



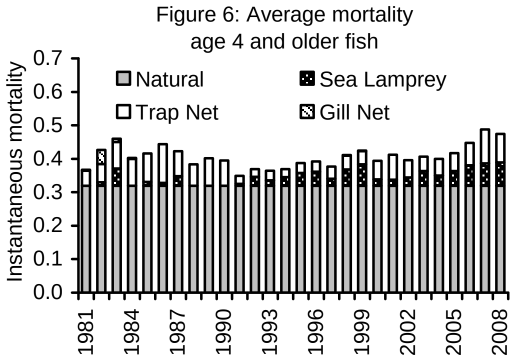
The estimates of recruitment at age 3 averaged 3.2 million during 1983-2008, and the estimates for 1981-1982 were apparently below the normal range of the latter time series (Figure 4). The first peak was 4.9 million in 1989, followed by a low period of 1992-1996, with an average of 2.5 million, and then a high period of 1997-2001 with an average of 4.7 million. The recent low was 1.9 million in 2004, which was in the normal range of this time series. The estimated recruitment for 2008 was 3.4 million, higher than the average of this time series.



Spawning stock biomass increased rapidly from 1.4 million lb in 1981 to 9.8 million lb in 1991, followed by (1) declines to 6.4 million lb by 1999, (2) the second peak of 8.2 million lb in 2002, and (3) further declines to 5.4 million lb by 2008 (Figure 5). 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, the biomass peaks were after the recruitment peaks (Figures 4-5). The second peak of biomass was lower than the first because the declines in biomass were caused by either declining weight at ages or low recruitment in previous years, or both (Figures 3-4).



For age-4 and older lake whitefish, natural mortality was the largest source of mortality, followed by trap-net fishing mortality and sea lamprey-induced mortality (Figure 6). 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 natural mortality was estimated to be 0.319 y^{-1}. The estimated trap-net fishing mortality was relatively high during 1981-1990 with an average of 0.076 y^{-1}, followed by a low point of 0.024 y^{-1} in 1991, and the increases to 0.085 y^{-1} by 2008. The overall pattern was similar to that of trap-net fishing effort. Sea lamprey-induced mortality increased cyclically over years, peaking at 0.064 y^{-1} in 1999, and peaking again at the all-time high of 0.07 y^{-1} in 2008.



The estimated average total mortality among ages was 0.474 y^{-1} for 2008, and the estimated average total mortality from 2006-2008 was 0.470 y^{-1}. Both were lower than the limit of 1.05 y^{-1}, so the projection model suggested that the trap-net fishing effort could be 1.95 times higher than the 2006-2008 average. The model recommended yield limit for 2010 was 1,075,000 lb, which was higher than the recommended limit of 962,000 lb for 2009. The harvest of 614,921 lb in 2008 was much lower than the recommended yield limit of 883,000 lb for 2008.

The assessment model converged to a unique solution with the maximum gradient of 0.0000675. MCMC chains for the objective function and model estimates looked good. Near future improvement of the assessment model should start with the use of a wide and realistic age structure based on the observation of recent years' fisheries. The model improvement should also build on detailed retrospective analyses.

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	1.238 lb
Current SSBR	0.781lb (0.742 – 0.820)
SSBR at target mortality	0.256 lb
Spawning potential reduction	
At target mortality	0.207
Average yield per recruit	0.214 lb (0.165 – 0.263)
Natural mortality (*M*)	0.319 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+	N/A
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.084 y^{-1} (0.055 – 0.114)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	0.066 y^{-1}
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.470 y^{-1} (0.440 – 0.499)
Recruitment (age 4)	3,278,300 fish
(average 1999-2008)	(2,357,551 – 4,199,049)
Biomass (age 3+)	13,306,000 lb
(average 1999-2008)	(9,651,972 – 16,960,028)
Spawning biomass	
(average 1999-2008)	6,795,300 lb (4,765,132 – 8,825,468)
MSC recommended yield limit for 2010	1,075,000 lb
Actual yield limit for 2010	962,000 lb

Lake Michigan

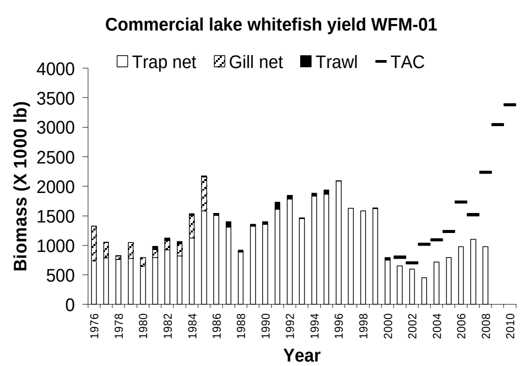
WFM-01 (Bays de Noc)

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.

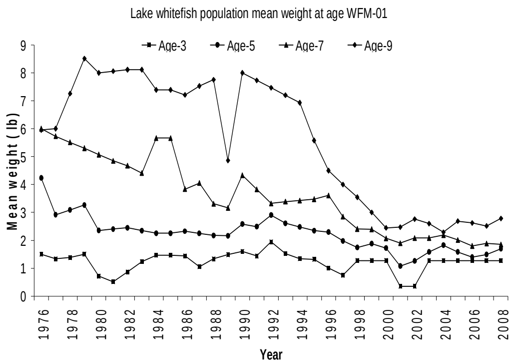
Waters in WFM-01 (380,652 total surface acres) offer extensive areas where suitable habitat is available and is likely used by spawning whitefish. The Big Bay de Noc Shoal is documented as being a very important area for lake whitefish reproduction. Consistent fairly favorable conditions on this shoal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

Trap-net yield for lake whitefish in WFM-01 was 975,000 lb during 2008, down 11% from 2007. Fishing effort was up 28% in 2008 over 2007 at 1,822 lifts per year. Yields in this management unit increased steadily between 2003 and 2007 prior to the drop in 2008. Catch-per-unit effort climbed from 284 lb lift^{-1} in 1999 to 780 lb lift^{-1} in 2007, then fell to a still very respectable 535 lb lift^{-1} in 2008. Commercial gill netting in this management zone ceased after 1985. Trawl yield was basically negligible through 2000 and has been non-existent thereafter.



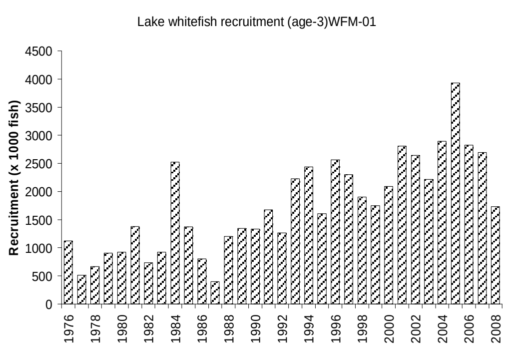
There was little change in weight-at-age for WFM-01 lake whitefish between 2007 and 2008 other than a slight upturn for fish aged 5 and 9+. Weight-at-age values have been relatively stable since

2003 following declines in the 1990s and early 2000s.

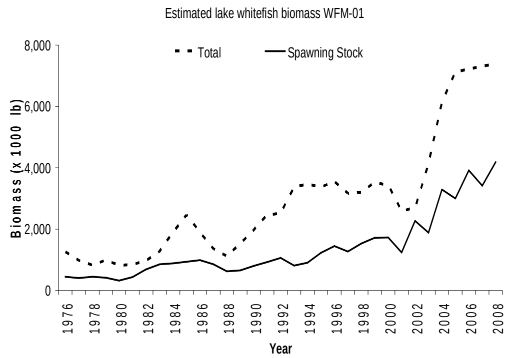


A von Bertalanffy growth model was developed using length-at-age data for individual lake whitefish in the combined state and tribal fisheries dataset over the entire time series. Model estimates for growth parameters L_∞ and k were 583 mm and 0.156.

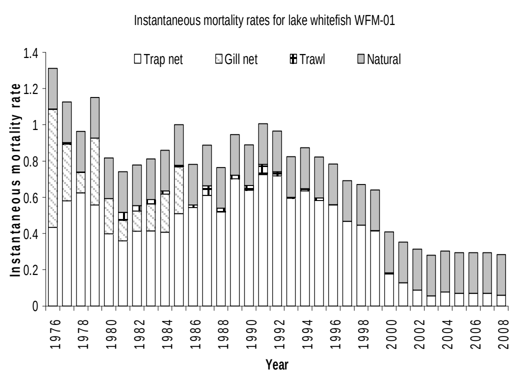
Estimated recruitment (numbers of age-3 fish) decreased 36% in 2008 compared to 2007. The 2008 recruitment estimate was 1.73 million (represents the 2005 year class). Recruitment estimates have been higher than 1 million fish every year since 1988 in WFM-01, with a high estimate of 3.9 million fish in 2005).



Based on the latest model estimates, fishable biomass was 7.4 million lb in 2008, up slightly from 2007. Spawning stock biomass (4.2 million lb) represented 57% of the total biomass estimate. Considering the entire data set, fishable biomass estimates have been highest during the years from 2005 through 2008. Spawning stock biomass has generally increased from year to year since 1976.



Estimates of total instantaneous mortality rate (*Z*) fell between 1999 and 2000 and have consistently remained relatively low ever since. The 2008 estimate was 0.28 y^{-1} with 0.22 y^{-1} attributable to instantaneous natural mortality rate (*M*) and 0.06 y^{-1} attributable to instantaneous fishing mortality rate (*F*).



The projected 2010 yield limit for WFM-01 is 3.4 million lb. This value is an 11% increase from the 2009 yield limit of 3.04 million lb. The 2010 yield limit is high, and the increase would at first seem counterintuitive when yield, CPUE, and recruitment all decreased in 2008 compared to 2007, based on estimates from the current model.

However, estimated total population biomass has increased every year over the past seven years of data and is 85% higher in 2008 than when the trend began in 2002. Further, comparing current model outputs to those from last year's model, much of the estimated increase in biomass was associated with "recalibrated" recruitment that was at substantially higher levels for all year classes that are currently in the fishery, particularly the 2002 year class, estimated from the number of 3-yr old fish in 2005. To illustrate, although recruitment was described on the previous page of this report as having fallen 36% from 2007 to 2008, this year's 2008 estimate of recruitment is 12% higher than the 2007 estimate that was generated from last year's model. Including an additional year of data boosted the estimated recruitment for 2007 (2004 year class) and it similarly elevated the 2006 and 2007 total biomass estimates. Three-year average estimates listed in the summary table below are considerably higher than those presented in last year's summary table for recruitment (+311,000 age-3 fish) and biomass (+1.4 million lb). In addition, mortality rates in WFM-01 have remained low for nearly a decade and there was modest evidence for increased growth for fish in the population. Considering all of these estimates and comparisons, the calculated increase for the 2010 yield limit appears to be within reason.

Summary Status WFM-01 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.41 lb
Age at first spawning	4 y
Size at 50% maturity	1.71 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	2.336 lb (2.328 - 2.344)
Current SSBR	1.23 lb (1.14 - 1.31)
SSBR at target mortality	0.2323 lb (0.2321 - 0.2325)
Spawning potential reduction	
At target mortality	0.525 (0.489 - 0.563)
Average yield per recruit	0.570 lb (0.531 - 0.607)
Natural mortality (*M*)	0.225 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	7
Fully selected age to trap nets	8
Fully selected age to trawls	6
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.0 y^{-1}
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.092 y^{-1} (0.077 - 0.108)
Trawl fishing mortality (*F*)	
Average 2006-2008, ages 4+	0
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.316 y^{-1} (0.301 - 0.332)
Recruitment (age 4)	
(average 1999-2008)	2,966,580 fish (1,936,900 - 4,819,270)
Biomass (age 3+)	
(average 1999-2008)	12,223,158 lb (9,513,340 - 16,364,400)
Spawning biomass	
(average 1999-2008)	6,069,857 lb (5,200,780 - 7,196,630)
MSC recommended yield limit for 2010	3,376,000 lb
Actual yield limit for 2010	3,376,000 lb

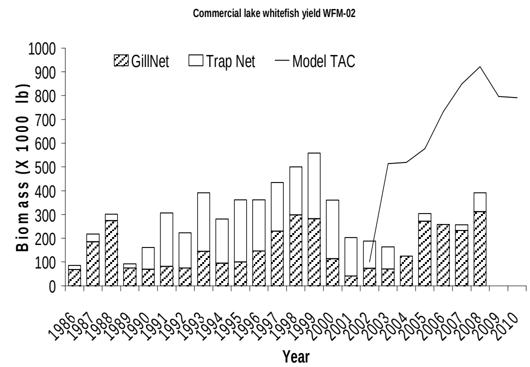
WFM-02 (Manistique)

Prepared by Stephen J. Lenart and Mark P. Ebener

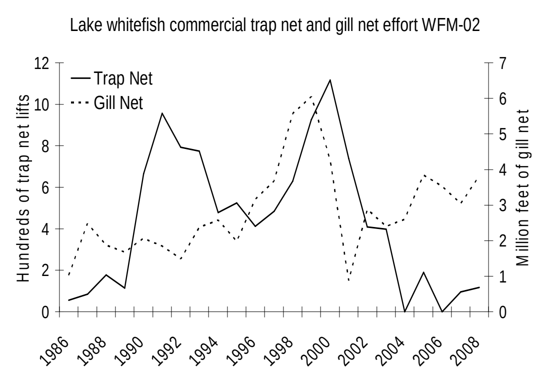
WFM-02 is located in the northwest portion of Lake Michigan. There are 387,000 surface acres of water less than 240 ft deep in the unit. The only known spawning population of whitefish in WFM-02 is located in Portage Bay; this population is not as abundant as other stocks in Lake Michigan. Many of the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

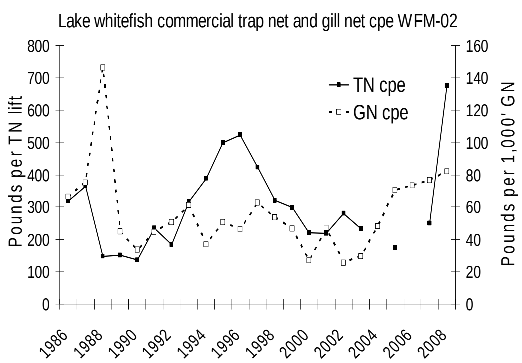
Commercial fishery yield from WFM-02 have averaged 284,000 lb per year during 1986-2008. As is the case in many Lake Michigan units, yield peaked in the mid to late 1990s. Average yield during 1990 to 1999 was approximately 386,000 lb, with peak yield occurring in 1999 at 558,000 lb. Since 2000, commercial yield has averaged 250,000 lb and the 2008 yield was the highest recorded since 1999. 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 27,000 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.



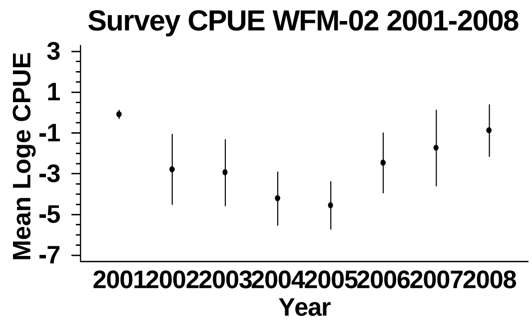
Trap-net effort has been highly variable throughout the time series modeled. During the 1990s, the trap-net fishery averaged more than 700 lifts. Effort peaked at 1,116 lifts in 2000. During 2001 to 2008, average effort declined to less than 250 lifts and effort has not exceeded 200 lifts since 2003. After reporting more than 6 million feet of effort in 1999, gill-net fishery effort declined to less than 1 million feet in 2001. Gill-net effort has increased steadily since then and average effort was 3.5 million feet during 2006 to 2008.



After reaching a peak in the mid-1990s, catch rates in the trap-net fishery steadily declined through 2005. With the sporadic nature of the fishery in the past few years, it is somewhat difficult to assign too much significance to the dramatic increase in catch rates that occurred in the 2008 trap-net fishery. (the highest in the modeled time series at 674 lb lift^{-1}). However, gill-net catch rates have increased substantially in the past five years and the 2008 gill-net CPUE of 82 lb lift^{-1} has only been exceeded once 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.



Fishery independent surveys, conducted in WFM-02 since 2001, provide a less biased means of tracking relative abundance. Surveys were conducted during late July to early September under the protocol established by the modeling subcommittee; i.e. graded mesh of 2.0 to 6.0 inch stretch mesh by ½-increments, random transects from a port, stratified by depth. Relative abundance in the surveys generally declined from 2001 to 2005, but increased thereafter. Relative abundance was greater in 2006-2008 than during the lower periods of 2004-2005. The recent increase in survey catch rates mirrors the trend observed in the fishery.



The stock assessment model projected a total allowable catch of 792,000 lb from WFM-02 for 2010, 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 2010. This is the third 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. For the 2010 assessment, the base code was changed to allow the descending limb of the gill-net selectivity curve to be estimated. In addition, the target age for gill-net and trap-net selectivity was changed to seven and six, respectively (from five and four). These changes were made to bring WFM-02 in line with the other Lake Michigan units. The changes had little impact on model performance. Beginning with the 2010 assessment, the MSC agreed to use the entire time series to estimate parameters for the Pauly equation (K, Linf). As a result, the estimate of *M* (0.37) was substantially higher than in previous years.

Although the 2010 assessment model met minimum convergence criteria, key diagnostics (fit to observed age composition, MCMC results, and retrospective analyses) suggest a low performing model. One key component of the assessment structure is likely driving performance. The last age modeled in WFM-02 is age nine. In 2005 and 2006, approximately 40% of the fish in the gill-net fishery were age 9+. The proportion increased to 65% in 2007 and then 79% in 2008. Without an expansion of the plus group, model performance is not likely to improve in the future (the plus group has recently been expanded in a number of other whitefish assessment models). Furthermore, the sporadic nature of the trap-net fishery has prevented samples from being obtained for the past five years. 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)

Summary Status WFM-02 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.32 lb
Age at first spawning	3 y
Size at 50% maturity	1.37 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	0.833 lb (SE 0.02)
Current SSBR	0.64 lb (SE 0.02)
SSBR at target mortality	0.073 lb (SE 0.00)
Spawning potential reduction	
At target mortality	0.764 (SE 0.016)
Average yield per recruit	0.177 lb (SE 0.012)
Natural mortality (*M*)	0.372 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+	0.053 y^{-1} (SE 0.005)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.007 y^{-1} (SE 0.001)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.432 y^{-1} (SE 0.007)
Recruitment (age 4)	
(average 1999-2008)	1,873,700 fish (SE 259,260)
Biomass (age 3+)	
(average 1999-2008)	4,835,700 lb (SE 407,360)
Spawning biomass	
(average 1999-2008)	3,378,800 lb (SE 265,210)
MSC recommended yield limit for 2010	792,000 lb
Actual yield limit for 2010	558,000 lb

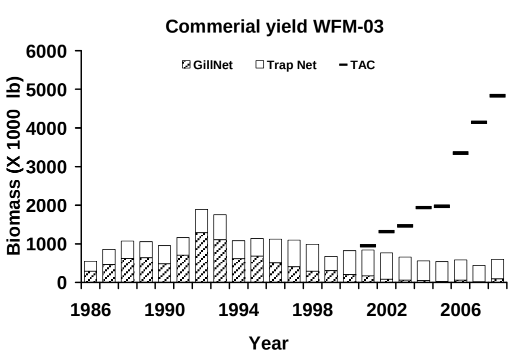
WFM-03 (Naubinway)

Prepared by Mark P. Ebener

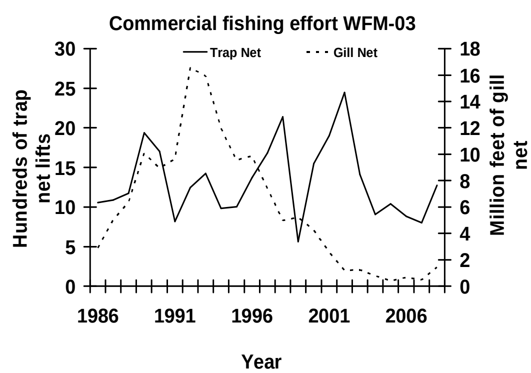
WFM-03 is located in northern Lake Michigan. The unit extends from the Straits of Mackinac west to Seul Choix Point and is bounded on the south by Beaver Island and a complex of shoals and islands that surround the island. Nearly the entire unit is shallow water less than 90 ft deep. There are 483,000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

WFM-03 has been an exclusive commercial fishing zone for the CORA fishery since 1985. It was an important commercial fishing area for most of the twentieth century, and remains so today. A trap-net and both large- and small-boat gill-net fishery operate throughout WFM-03.

The commercial fishery harvest from WFM-03 averaged 945,000 lb during 1976-2008. The trap-net fishery accounted for 59% of the harvest during 1976-2008. 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 594,000 lb in 2008. The total allowable catch was estimated to be 4.83 million lb in 2008 and the harvest regulating guideline was set at 2.55 million lb.

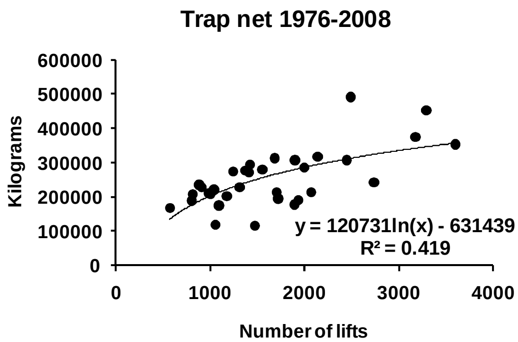


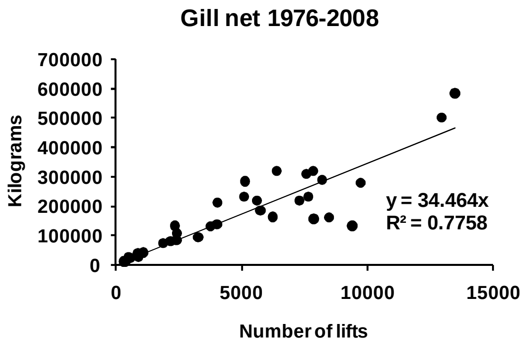
Both gill-net and trap-net effort has been declining in WFM-03 over the last 32 years. Gill net effort peaked at 16 million ft in 1992 and declined thereafter. Gill-net effort in 2008 was 1.4 million ft., which was substantially greater than during 2004-2007. Trap-net effort declined from a peak of 3,597 lifts in 1984 to only 571 lifts in 1999 and was 1,301 lifts in 2008. Trap-net effort has been highly variable but stable at around 1,300 lifts since 1986.

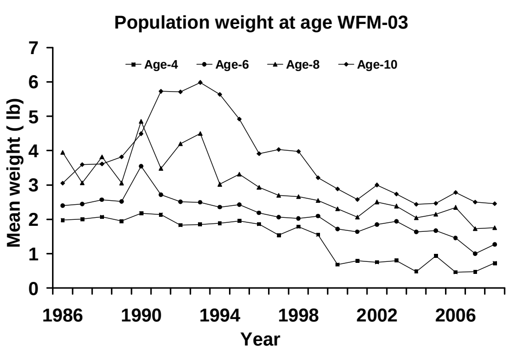


The relationship between fishing effort and harvest in WFM-03 is not as clear as in some other units. Trap-net effort explained only 42% of the variation in trap-net catch and there appeared to be an asymptotic level to harvest for trap nets. On the other hand, gill-net effort explained 78% of the variation in gill-net harvest during 1976-2008 and catch was linearly related to fishing effort. Average trap-net catch rate was 335 lb $lift^{-1}$ and average gill-net catch rate was 78 lb 1000 $ft.^{-1}$ during 1976-2008.

Mean weight at nearly all ages appeared to stabilize and increase slightly in 2008 since the decline began in the mid 1990s. Mean weight at age increased from 2007 to 2008 at all ages except age 9. Unfortunately, mean weight at age in 2008 was still substantially lower than during the 1980s.

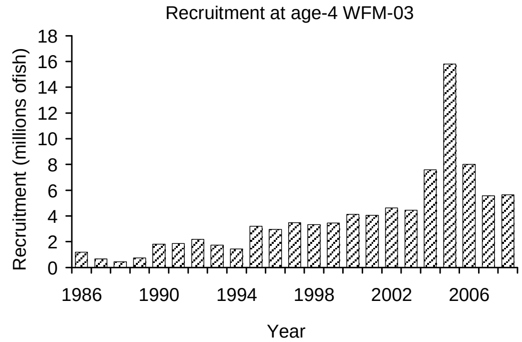




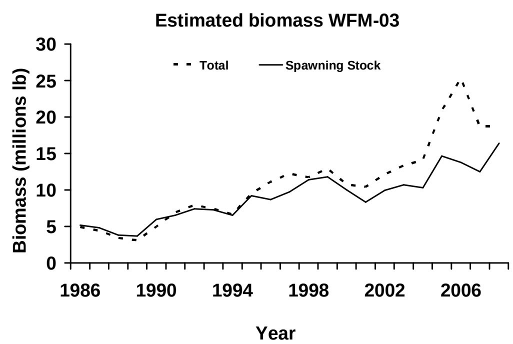


Estimated recruitment of age-4 whitefish to the fishable populations continued to be high in WFM-03 during 2008. Recruitment averaged 3.8 million age-4 whitefish during 1986-2008. The lowest recruitment was 452,000 fish for the 1984 year class in 1988, while the highest recruitment was 15.8 million fish for the 2001 year class in 2005. The 2004 year class was estimated to contain 5.6 million fish when it recruited in 2008.

Biomass of age-4 and older whitefish appeared to finally stabilize in WFM-03 during 2008. Fishable biomass

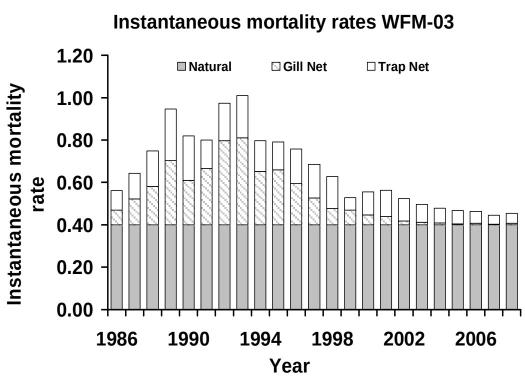


averaged 10.9 million lb during 1986-2008, while spawning stock biomass averaged 9.1 million lb during the same time period. Fishable biomass peaked at 25.3 million lb in 2006. Fishable and spawning stock biomasses were 18.7 and 16.4 million lb, respectively, in 2008.



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 55.0 cm total length for $L\infty$ and 0.38 for k produced an estimate of 0.40 y^{-1} from the Pauly relationship.

Changes in gill-net effort have been primarily responsible for the changes in total annual mortality of whitefish in WFM-03. Total instantaneous mortality averaged 0.66 y^{-1} in WFM-03 during 1986-2008. Gill-net and trap-net mortality averaged 0.13 y^{-1} and 0.12 y^{-1} in WFM-03 during 1986-2008. Gill-net mortality peaked at 0.41 y^{-1} in 1993 then continually declined to only 0.003 y^{-1} in 2007. Trap-net mortality peaked at 0.24 y^{-1} in 1989 and since then has fluctuated between 0.04 y-1 and 0.19 y^{-1}. Trap-net mortality was estimated to be 0.05 y^{-1} in 2008, compared to 0.008 y^{-1} for gill-net mortality in 2008.



Total annual mortality on fully vulnerable age-classes was less than the target rate during 2006-2008 and the spawning potential reduction at current mortality rates and at the target mortality rate was greater than 0.20. Consequently, the projection model estimated that fishing mortality could be increased 6.7 times. The projected harvest limit for 2010 under this increased fishing rate was estimated to be 3.4 million pounds. Total allowable catches for previous years were 2.82 million lb for 2009, 4.83 million for 2008, 4.16 million lb for 2007, 3.4 million for 2006, 1.97 million lb for 2005, 1.94 million lb for 2004, 1.46 million lb for 2003, 1.31 million lb for 2002, and 0.95 million lb for 2001.

Summary Status WFM-03 Whitefish	Value (Standard Error)
Female maturity	
Size at first spawning	0.55 lb
Age at first spawning	4 y
Size at 50% maturity	1.24 lb
Age at 50% maturity	6 y
Spawning biomass per recruit	
Base SSBR	0.96 lb (SE 0.002)
Current SSBR	0.79 lb (SE 0.01)
SSBR at target mortality	0.096 lb (SE 0.00)
Spawning potential reduction	
At target mortality	0.824 (SE 0.011)
Average yield per recruit	0.130 lb (SE 0.007)
Natural mortality (*M*)	0.402 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	9
Fully selected age to trap nets	9
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.007 y^{-1} (SE 0.001)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.055 y^{-1} (SE 0.005)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.464 y^{-1} (SE 0.005)
Recruitment (age 4)	
(average 1999-2008)	6,331,200 fish (SE 703,890)
Biomass (age 3+)	
(average 1999-2008)	15,738,000 lb (SE 1,375,000)
Spawning biomass	
(average 1999-2008)	11,848,000 lb (SE 912,100)
MSC recommended yield limit for 2010	3,400,000 lb
Actual yield limit for 2010	2,820,000 lb

WFM-04 (Beaver Island)

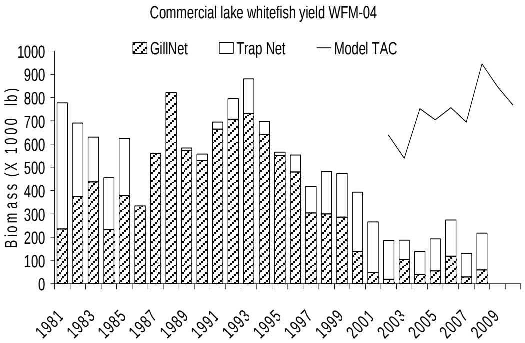
Prepared by Stephen J. Lenart

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.

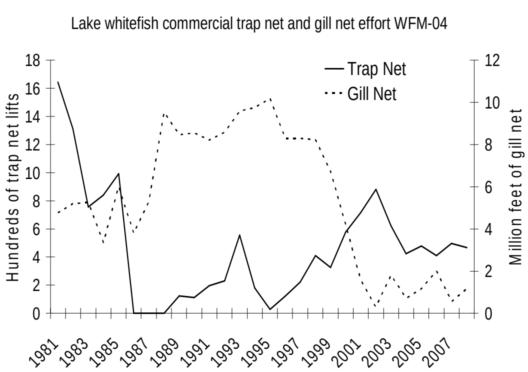
At least several reproductively isolated stocks of whitefish inhabit WFM-04, and most, if not all, of these are associated with the large northern reef complex. One stock spawns in Sturgeon Bay along the northeast side of the unit, while another stock is found at Hog Island.

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.

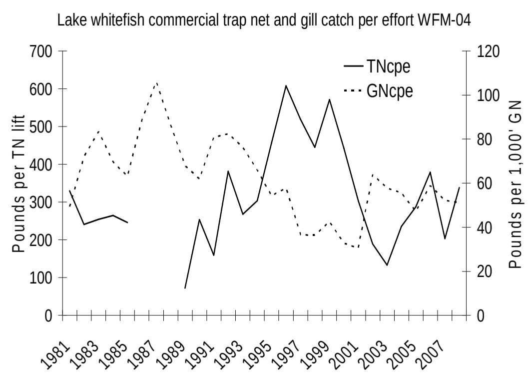
In the four years prior to implementation of the 1985 Agreement between the State and the three COTFMA tribes, the trap-net fishery accounted for a substantial proportion (30–70%) of the total commercial yield. Average commercial yield was 636,000 lb during this period. After 1985, the gill-net fishery 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 peaked at 880,000 lb in 1993, but has since steadily declined. Since 2000 commercial yield has averaged just over 200,000 lb. The steady decline in overall yield can be attributed to a shrinking gill-net fishery, which has harvested, on average, 68,000 lb of whitefish per year during 2000 to 2008. By comparison, average gill-net harvest was 524,000 lb during 1985 to 1999. Total yield was approximately 217,000 lb in 2008, a substantial increase from 2007, when the lowest yield in the time series was reported (130,000 lb). Since the inception of the 2000 Decree, yield has typically averaged about 20-35% of the model-derived yield limit for this unit.



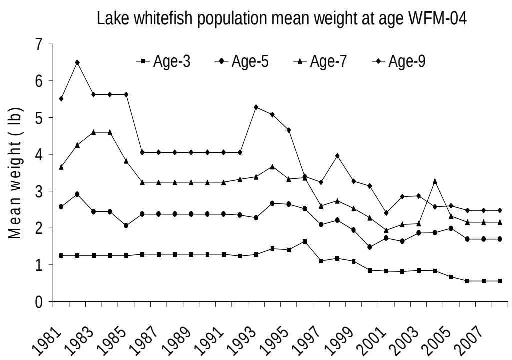
During the late 1980s and throughout the 1990s, the gill-net fishery was the dominant fishery in WFM-04. Average gill-net effort was approximately 8 million feet during 1985 to 1999 and gill-net yield routinely exceeded 500,000 lb. Since 2000, gill-net effort has declined substantially, averaging approximately 1.2 million feet over the past decade (range 0.3 to 2 million feet). Trap-net fishery effort has been quite variable over the years, but was generally low when the gill-net fishery was at its peak. After averaging more than 1,100 lifts per year during 1981 to 1985, the trap-net fishery was inactive for a three-year period. Effort remained low through the mid-1990s (average of 200 lifts during 1989 to 1996). During the period 1997 to 2002, trap-net effort steadily increased, reaching 881 lifts in 2002. Trap-net effort then declined to 623 lifts in 2003. Since 2004 reported effort has been quite stable, ranging from 412 to 498 lifts.



Since rebounding in 2002 after a decade-long decline, catch rates in the gill-net fishery have been quite steady in recent years, averaging 55 lb per 1,000 feet of effort during 2002 to 2008 (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. Recent trap-net catch rates are still quite variable and show little relationship with gill-net catch rates. In recent years, both fisheries have had to contend with adverse fishing conditions (such as seasonal accumulations of benthic algae) that have likely influenced catch rates.

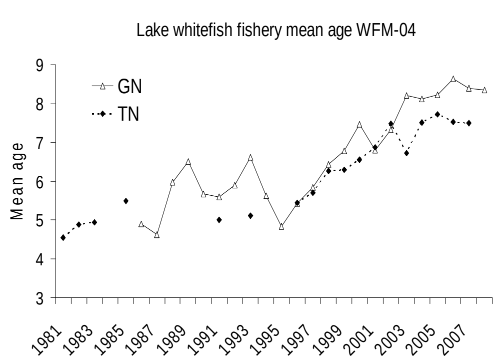


Growth of whitefish in WFM-04 has followed the long-term trend evident across all of northern Lake Michigan-fish are much smaller at a given age than they were during the late 1980s and early 1990s. For example, age-7 whitefish weighed, on average, 3.8 lb during the 1980s. This declined to an average of 3.1 lb in the 1990s and then to 2.3 lb during 2001 to 2008. 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 and values are often carried forward from prior years.

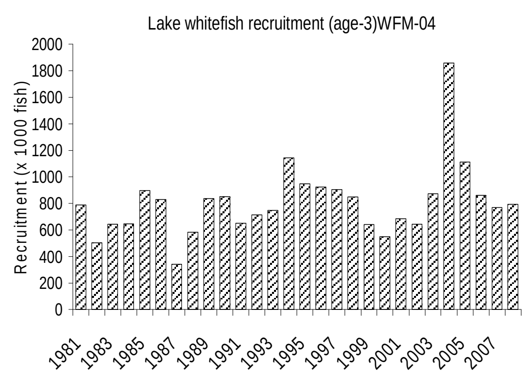


The annual mean weight of a whitefish harvested in the trap-net fishery ranged from 2.0 to 3.3 lb during 1981 to 2008, but recent values have been fairly uniform, in the 2.0 to 2.5 lb range. The mean weight of a whitefish harvested in the gill-net fishery ranged from 2.6 to 3.5 lb during 1981 to 2008. 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 2008 gill-net fishery was 3.0 lb, the highest since 1994.

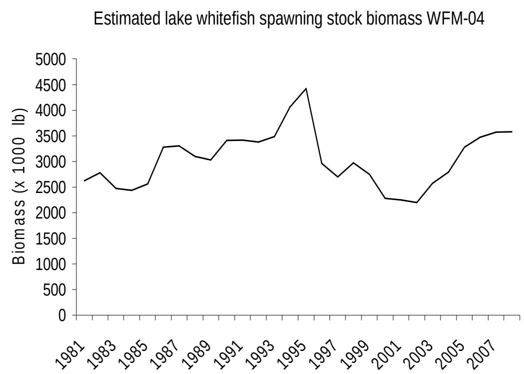
Another indicator of the long-term change in growth can be gleaned from the fishery age composition. During the 1980s, the mean age of a whitefish harvested in the trap-net and gill-net fisheries was approximately five years. By 2005, the mean age in both fisheries had increased to approximately eight years. The recent stabilization in fishery mean age is likely tied to a strong 2001 cohort that entered the fishery in 2007.



Estimated recruitment of age-3 whitefish to the population in WFM-04 has been markedly stable over time. During the period 1981 to 2003, average estimated recruitment of age-3 whitefish was 747,000 fish (range 342,000 to 1,143,000). 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. Of particular interest is the estimate for the 2001 year class (age-3 fish in 2004). This estimate (1.86 million fish) is more than 60% greater than the next largest in the time series and is more than double the long-term average for the unit. A strong signal for this cohort exists in the age composition of both fisheries, although these fish are not yet fully selected in either gear type.



Spawning stock biomass (SSB) has been fairly stable in WFM-04, a consequence of the consistent recruitment. From 1981 to its peak in 1995, estimated spawning stock biomass increased from 2.6 to 4.4 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 2.2 million lb, 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 3.6 million lb, on par with estimates from the early 1990s.

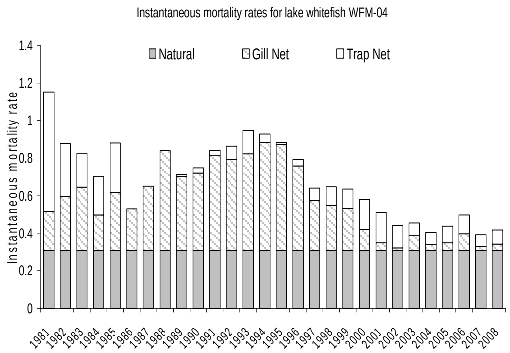


A significant factor in this increase in spawning stock biomass was the general decline in fishing mortality rates since the mid-1990s, particularly in the gill-net fishery. During 1987 to 1996, instantaneous gill-net mortality on ages-4+ ranged between 0.34 and 0.57 yr^{-1} (average 0.48). After 1996, gill-net mortality declined for six consecutive years, reaching its lowest point in the time series in 2002 (0.014 y^{-1}). During 2006 to 2008, average instantaneous gill-net mortality was 0.048 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 0.079 y^{-1} during 2006 to 2008. Total mortality (*Z*) of age-4 and older whitefish in WFM-04 has steadily declined since the mid-1990s and recent total mortality rates remain among the lowest in the time series. Since 2000, natural mortality has been the primary mortality component in this unit. The natural mortality rate (*M*) is estimated using the Pauly equation after deriving growth parameters (K, L-infinity) for each stock. The rate is assumed to be constant over time, but is updated annually during each stock assessment. Growth parameters and associated estimates of *M* for recent stock assessments are included in Table 1. Prior to the 2010 TAC assessment, growth parameters were derived from available trap-net and survey data for the most recent three-year time block (i.e. 2005 through 2007 for the 2009 TAC assessment). Beginning in 2010, the MSC agreed that it would be more appropriate to utilize the entire time series to derive growth parameters. Utilizing this methodology resulted in a higher estimate of natural mortality, one thought to be more consistent with recent empirical estimates obtained for certain individual stocks in northern lakes Huron and Michigan. This methodology is expected to result in less annual variability in future estimates of M.

Table 1. Growth parameters and estimates of *M* from WFM-04 model assessments

TAC Year	Linf	K	M
2010	56.9	0.257	0.308
2009	58.7	0.199	0.258
2008	59.3	0.203	0.261
2007	57.6	0.238	0.348
2006	60.3	0.193	0.253

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 average total mortality rate of age-4 and older whitefish was 0.435 y^{-1} during 2006 to 2008, well below the maximum target rate of 1.05 y^{-1}. The spawning potential reduction was estimated at 0.713, indicating that the fishery could support an increase in effort during 2010 (effort multipliers are 2.4 for the trap-net fishery and 4.5 for the gill-net fishery). The 2010 model-generated yield limit of 768,000 lb represents a 9% decrease over the 2009 model-generated limit. As in all units in which the available whitefish yield is allocated wholly to the CORA tribal fishery, the final harvest limit for WFM-04 is determined by CORA according to the process detailed in the Tribal Management Plan for the 1836 Treaty waters.

Model Changes and Diagnostics

The basic model structure was maintained during the 2010 TAC assessment. The only major procedural change was the use of the entire time series of data in estimating growth parameters for the Pauly equation. As mentioned previously, this resulted in higher estimates of M. After updating the source file to include 2008 data, the base model was optimized. The model met minimum convergence criteria, provided a reasonable fit to the observed fishery parameters (age composition, effort, and harvest) and biomass estimates were insensitive to changes in start values for key parameters. Although model performance was satisfactory, fishery selectivity estimation using the double-logistic function remains problematic. MCMC simulations could not be run to completion (bounding issues) unless gill-net selectivity parameters for the descending limb were fixed prior to running the simulations. This was done by fixing them at the values freely estimated during the base assessment. Although the results were quite satisfactory, problems associated with modeling selectivity remain. The MSC hopes to address this (and other long-standing technical issues) prior to the 2011 TAC assessment. 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 temporal patterns, but these are not considered terribly problematic at this time. A retrospective analysis of *F* displayed no temporal patterns and a very tight fit.

The 2010 WFM-04 model performance was rated as “medium”, primarily due to the issues related to MCMC simulations and a slight lack of fit to the gill-net age composition in the past two years of the model. Future technical changes will include evaluating the use of random-walk catchability and the gamma function for selectivity.

Summary Status WFM-04 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	0.56 lb
Age at first spawning	3 y
Size at 50% maturity	1.70 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	1.748 lb (1.741 – 1.754)
Current SSBR	1.25 lb (1.205 – 1.283)
SSBR at target mortality	0.216 lb (0.216 – 0.216)
Spawning potential reduction	
At target mortality	0.713 (0.689 – 0.735)
Average yield per recruit	0.302 lb (0.282 – 0.323)
Natural mortality (*M*)	0.308 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 2006-2008, ages 4+	0.048 y^{-1} (0.041 – 0.055)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.079 y^{-1} (0.069 – 0.090)
Sea lamprey mortality (ML)	
(average ages 4+, 2006-2008)	N/A
Total mortality (*Z*)	
(average ages 4+, 2006-2008)	0.435 y^{-1} (0.420 – 0.452)
Recruitment (age 3)	
(average 1999-2008)	878,170 fish (746,646 – 1,055,630)
Biomass (age 3+)	
(average 1999-2008)	3,635,700 lb (3,221,840 – 4,152,070)
Spawning biomass	
(average 1999-2008)	2,873,400 lb (2,560,150 – 3,263,260)
MSC recommended yield limit for 2010	768,000 lb
Actual yield limit for 2010	768,000 lb

WFM-05 (Grand Traverse Bay)

Prepared by Erik J. Olsen and Stephen J. Lenart

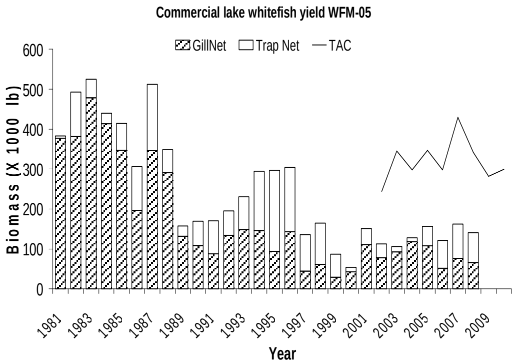
Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including the both the east and west arms of Grand Traverse Bay. The deepest parts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

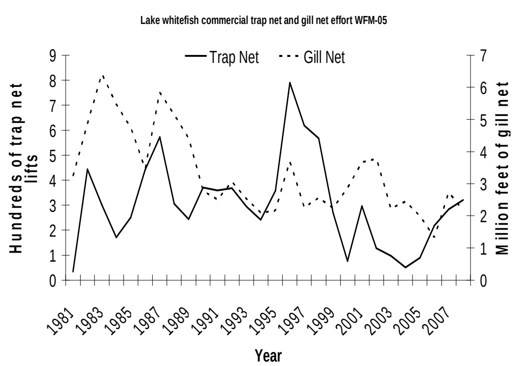
WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. Tribal small-boat fishers relied on Grand Traverse Bay as an important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

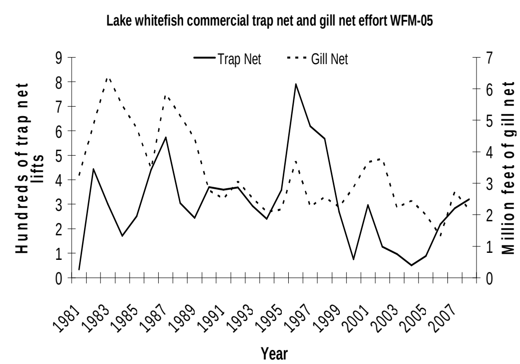
Commercial yields of lake whitefish during the 1990s were substantially less than during the 1980s. The commercial yield averaged 383,000 lb from 1980 to 1989 and 205,000 lb during 1990 to 1999. The fishery declined through the late 1990s, with the lowest recorded yield coming in 2000 at 53,000 lb. The fishery has rebounded slightly through 2008, averaging 135,000 lb during the timeframe. The large-mesh gill-net yield has exceeded the trap-net yield in every year except the period from 1994 to 1999. An increase in trap-net effort beginning in 2006 has resulted in trap-net yield again surpassing that of gill net through 2008.



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 1990. Gill-net effort declined from an average of 6.4 million ft from 1983 through 1990. Since then, the large-mesh gill-net fishery has averaged 2.6 million feet annually, with an all-time low of 1.3 million feet in 2006. Trap-net effort has varied annually between 200 and 800 lifts during 1982-1999. Through the 1990s, trap-net effort averaged 423 lifts per year, peaking at 790 lifts in 1996. Trap-net effort has declined since, averaging 185 lifts since 2000, with an all-time low of 51 lifts in 2004.



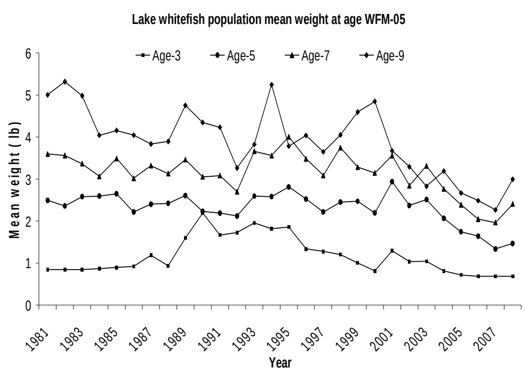
The decline in yield of whitefish in WFM-05 has generally mirrored the decline in lake whitefish recruitment within this management unit. CPUE of whitefish in the large-mesh gill-net fishery declined from 116 lb per 1,000 ft. of gill net in 1981 to a low of 13 lb per 1000 ft. in 1999. Since 2000, gill-net CPUE has been increasing. Except for some relatively high catch rates in 1994-95, from 1981-2004 the CPUE of whitefish in the trap-net fishery was relatively stable, averaging between 150 and 300 lb lift^{-1}. From 2000-2004, trap-net CPUE averaged 183 lb, but jumped significantly to 546 lbs lift^{-1} in 2005, before dropping back to around 300 lbs during the past two years. Gill-net fishers in WFM-05 claim the long-term decline in catch rates is 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.



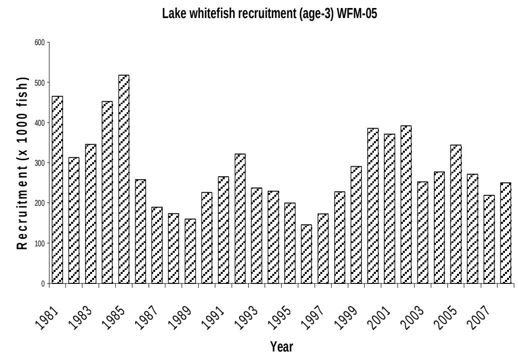
Whitefish from WFM-05 are currently of small to moderate size. Mean weight at age is trending down in recent years. From 2000 to 2008, the proportion of the yield made up of the three size classes of whitefish were 76% No.1 (< 3 lb), 19% mediums (3-4 lb), and 5% jumbos (≥ 4 lb). In comparison, from 1980 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 (2006-2008). 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 (2006-2008).

Mean weights of lake whitefish (ages 3-9) from WFM-05 have been slowly declining since 1981, with a recent uptick in 2008. This pattern of declining growth is also being observed in other areas of Lakes Michigan and Huron, including substantial declines in areas adjacent to this management unit.

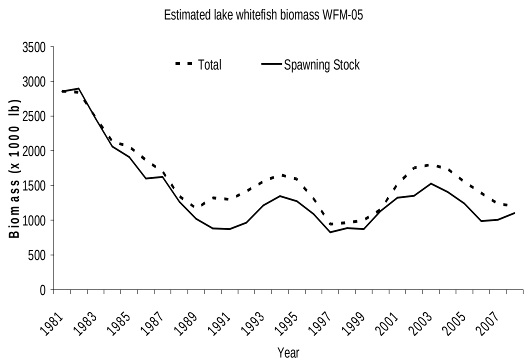


Recruitment of age-3 whitefish to the population in WFM-05 is highly variable based on estimates from the stock assessment model. Following relatively high recruitment of age-3 whitefish into the population at the beginning of the time-series, estimated recruitment declined significantly, but has held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



During 1981-1985 average estimated recruitment of age-3 fish entering the fishery was 418,000 fish (range 313,000 to 517,000). Through the 1990s, the average declined to 221,000 fish, with estimates ranging between 145,000 and 321,000 annually. This has increased through the 2000s, averaging 307,000 fish annually recruiting through 2008.

Biomass of whitefish estimated with the stock assessment model declined in response to decline in recruitment in the early 1980s. Annual biomass of whitefish ≥ age 3 (calculated at the beginning of each year) peaked at the beginning of the 1981-2008 timeframe with 2.9 million lb. Biomass steadily declined to 943,000 lb in 1997. Stable recruitment has allowed biomass to rebound, averaging 1.4 million lb through 2008. Spawning stock biomass followed the same trend, peaking at 2.9 million lb in 1981 before declining through the remainder of the decade. Since 1990 spawning stock biomass has held relatively stable, averaging 1.1 million lb, ranging between 823,000 and 1.5 million lb.



From 1981-1998, the combined commercial fishing mortality (*F*) met or exceeded natural mortality in this unit. Since l998, *F* has decreased below natural mortality. Fishing mortality within this unit has been dominated by gill nets; however, during the late 1990s (1994-1999) and in more recently (2006-2008) trap-net mortality 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 from 2006-2008. Instantaneous fishing-induced mortality on whitefish ≥ age 4 averaged 0.084 for the large-mesh gill-net fishery and 0.098 for the trap-net fishery during 2006-2008. Gill net-induced fishing mortality ranged from 0.36 in 1983 to 0.05 in 2006, while trap-net-induced fishing mortality ranged from 0.01 in 1981 to 0.28 in 1998. The gill-and trap-net mortality level has declined from a combined rate of 0.57 in 1996 to a low of 0.12 in 2000.

Total instantaneous mortality on the fishable stock in WFM-05 during 2006-2008 was substantially less than the target rate of 1.05. Total instantaneous mortality was estimated to be 0.46 during 2006-2008 and the spawning potential reduction value was 0.55.

Stock Assessment Model

To generate the 2010 yield limit, the model .dat file was updated with biological data through 2008. Due to low sample size, weights-at-age for the first three ages in the population were based on a recent averages from survey data. In accordance with a decision reached by the MSC in 2009, von Bertalanffy growth parameters were calculated using the entire time series of data, as opposed to running, five-year time blocks. The resulting estimate of *M* was 0.283 yr^{-1}, which is slightly higher than previous estimates. No other substantive changes were made to the model code during the 2010 harvest limit assessment.

Historically, selectivity in the gill-net fishery has been modeled as a double logistic function, while a simple logistic function was used to describe trap-net selectivity. This structure was carried forward in this latest assessment since the model for this unit has generally been quite stable. 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. To overcome this, parameters for the descending limb of the gill-net selectivity curve were fixing at the values freely estimated during the base assessment. Although the MCMC results were satisfactory when using this approach, problems associated with modeling selectivity will remain until the MSC can agree on a different methodology. The model provided a reasonable fit to harvest and effort, but the fit to the trap-net age composition was slightly problematic Concerns remain about a lack of fit between gill-net fishery harvest and effort since the late 1990s. One option for addressing this issue would be to down-weight the gill-net fishery effort for this time period, but a better option might be to develop a mixed-model type estimate of fishery CPUE based on individual fisher catch and effort to replace the aggregate catch/effort approach currently employed.

A retrospective analysis of biomass demonstrates that estimates of biomass in the last few years of the model are higher than those estimated from previous assessments. This is likely due to the contribution of the relatively large 1997–1999 year classes, which are only now fully recruited to the fishery. A retrospective analysis of recruitment showed a similar pattern, while a retrospective of *F* revealed good agreement with recent assessments. The 2010 assessment model was given a medium rating.

The 2010 model-generated yield limit of 299,000 lb represents a 6% increase from the 2009 limit and was accepted as the HRG for this unit. The increase can be attributed to a period of steady recruitment in the late 1990s and a small increase in weight-at-age. Since overall mortality is well below target, the projection model estimated that fishing effort could be increased approximately three-fold in WFM-05 during 2010 from the average during 2006-2008.

Summary Status WFM-05 Whitefish	Value (95% Probability Interval)
Female maturity	
Size at first spawning	1.13 lb
Age at first spawning	4 y
Size at 50% maturity	1.48 lb
Age at 50% maturity	5 y
Spawning biomass per recruit	
Base SSBR	2.12 lb (2.11 – 2.13)
Current SSBR	1.17 lb (1.11 – 1.23)
SSBR at target mortality	0.157 lb
Spawning potential reduction	
At target mortality	0.55 (0.52 – 0.58)
Average yield per recruit	0.464 lb (0.438 – 0.488)
Natural mortality (*M*)	0.283 y^{-1}
Fishing mortality rate 2006-2008	
Fully selected age to gill nets	11
Fully selected age to trap nets	11
Gill net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.084 y^{-1} (0.074 – 0.095)
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.098 y^{-1} (0.085 – 0.111)
Sea lamprey mortality (ML) (average ages 4+, 2006-2008)	N/A
Total mortality (*Z*) (average ages 4+, 2006-2008)	0.464 y^{-1} (0.443 – 0.486)
Recruitment (age 3) (average 1999-2008)	305,150 fish (272,398 – 352,815)
Biomass (age 3+) (average 1999-2008)	1,434,600 lb (1,320,090 – 1,585,790)
Spawning biomass (average 1999-2008)	1,194,500 lb (1,100,190 – 1,315,600)
Model Recommended yield limit in 2010	299,000 lb
Actual yield limit for 2010	299,000 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). One important change since 2000 was a modification of the depth restriction allowing state-licensed trap-net fishers to fish in water depths up to 130 feet (instead of restricted to 90 feet) starting in 2005.

There was only 90 lb of harvest by tribal fishermen in this unit in 2008, and no harvest by state-licensed fishermen. This data limitation prevented the assessment of this stock through a statistical catch at age model. A TAC for 2010 was projected based on the last functioning model, which was completed in 2008 using 2007 data. The resulting TAC was unchanged from the previous year, and the recommendation of 145,000 lb for the tribes and 62,000 lb for the State was adopted by the Parties.

WFM-07 (Ludington)

Prepared by Archie W. Martell Jr.

Lake whitefish management unit WFM-07 is located within the 1836 Treaty Ceded Waters of east 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 that would be distinguishing features relevant to whitefish biology, but 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 and is 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 large-mesh trap nets for commercial lake whitefish exploitation.

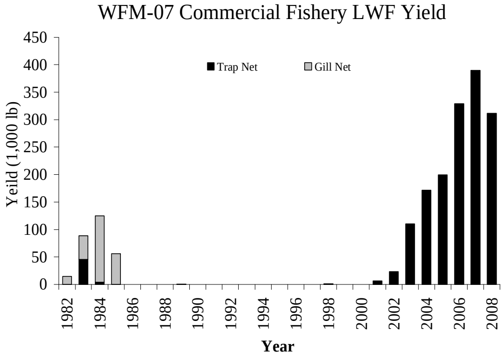
There has been no statistical catch-at-age modeling of the lake whitefish stock in WFM-07 due to a lack of long-term commercial catch-at-age information. Pursuant to the 2000 Consent Decree, the tribes had three years of allowable commercial fishing without harvest limits in this unit during 2001-2003.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

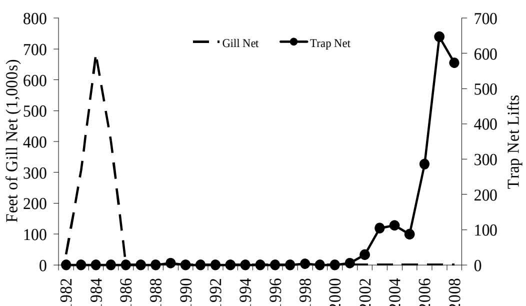
The 2001-2008 average lake whitefish commercial harvest within this unit was 192,701 lb. In 2001 Tribal commercial fishing activities began, with effort only occurring in October and November and a total harvest of 6,361 lb from 5 trap-net lifts. In 2002 Tribal commercial harvest was 23,165 lb with 29 trap-net lifts. By 2003, Tribal commercial effort was distributed across the fishing season and harvest and effort increased to 110,080 lb and 154 trap-net lifts, respectively. Commercial lake whitefish harvest increased in 2004 to 171,755 lb, but effort decreased to 112 trap-net lifts. A similar pattern was observed in 2005 as harvest increased

(199,570 lb), but effort declined (87 trap-net lifts). In 2006, both harvest (329,270 lb) and effort (286 trap-net lifts) increased. In 2007, commercial harvest from WFM-07 reached the highest level in recent years (389,997 lb), as did effort (647 trap-net lifts). In 2008, lake whitefish harvest was 311,413 lb, with an effort of 573 trap-net lifts, a decline from both the 2006 and 2007 harvest and effort levels. Commercial trap-net CPUE for lake whitefish reached a peak of 2,294 lb lift^{-1} in 2005 and has shown a declining trend to 543 lb lift^{-1} in 2008. The 2001-2008 average trap-net CPUE was 1,157 lb lift^{-1}.

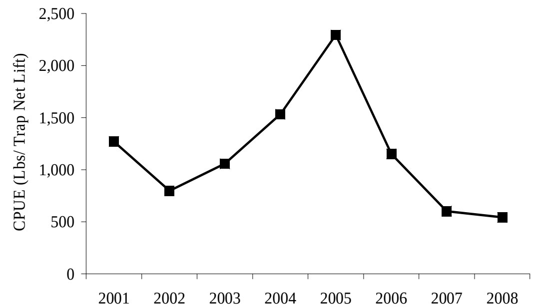
WFM-07 Commercial Fishery LWF Yield



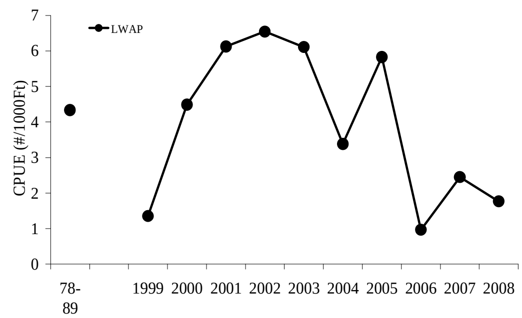
WFM-07 Commercial Fishing Effort



WFM07 Trap Net Lake Whitefish CPUE



WFM-07 Lake Whitefish Survey CPUE



Fishery-independent surveys were conducted following the Lakewide Assessment Plan (LWAP) using graded-mesh gill nets (GMGN). From 1999 through 2008, GMGN CPUE (number per 1,000 feet) for lake whitefish in spring assessments were 1.4, 4.5, 6.1, 6.5, 6.1, 4.3, 5.8, 0.97, 2.45, and 1.77, respectively. The average LWAP GMGN survey CPUE of lake whitefish in WFM-07 was higher during 2000-2005 compared to historical levels (represented by the 1978-1989 average using similar survey gill nets). During 1978-1989, average graded-mesh gill-net CPUE was 4.3 fish per 1,000 feet for lake whitefish. However, in 1999, 2004, 2006, 2007 and 2008, the LWAP CPUE was lower than the historical average.

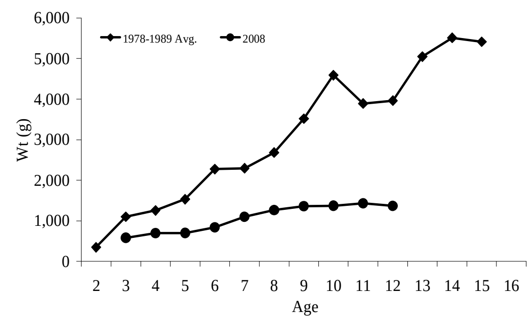
The mean length of lake whitefish sampled in spring GMGN surveys in 2008 decreased to below 20 inches, and is similar to what has been observed in recent surveys. The 2004-2008 samples of commercial lake whitefish have shown that whitefish are maintaining a mean length of over 20 inches and are larger than the 2001-2003 observations. The mean length of the lake whitefish within this unit are still below those of the 1978-1989 survey average and 1983 commercial samples that averaged over 23 inches.

Similar to average length, the mean weight of lake whitefish from both the GMGN surveys (2.89 lb) and commercial fishery (2.74 lb) in 2008 are currently lower than the 1978-1989 survey average (6.84 lb) and the 1983 commercial fishery (5.54 lb). The mean age of lake whitefish from the 2008 GMGN survey is 8.3 y and 8.6 y from the commercial fishery. The current data suggests that the lake whitefish population has an older mean age as compared to the 1978-1989 GMGN survey mean of 4.8 y and the 1983 commercial fishery of 7.3 y.

Lake whitefish mean weight at age from 2008 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 as compared to historical levels.

WFM07 LWF Age Class Distribution

WFM-07 Lake Whitefish Mean Weight at Age



The instantaneous total annual mortality rates for WFM-07 lake whitefish were estimated using catch curve analysis. The estimated instantaneous total annual mortality rate (*Z*) for 1978-1989 spring graded-mesh gill-net survey averaged 0.20 y^{-1} for ages 3 through 15. The 2006 lake whitefish total instantaneous mortality rate (*Z*) from all assessment GMGN surveys and commercial samples combined was estimated to be 0.339 y^{-1} for ages 7-13. In 2007 the rate was estimated to be 0.386 y^{-1} for ages 7-14, and in 2008 it had declined to 0.281 y^{-1} for ages 7-12. The estimated total annual mortality rates calculated for this lake whitefish stock have been below the target maximum total annual mortality rate of 65% 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 2010 WFM-07 lake whitefish HRG of 500,000 lb was developed and recommended by the LRBOI and adopted by CORA, and is a continuation of the 2004 HRG. The HRG was established by examining the current status of the lake whitefish population (e.g., catch rates, mean size at age) and the harvest limits established by the Technical Fisheries Committee's Modeling Subcommittee 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

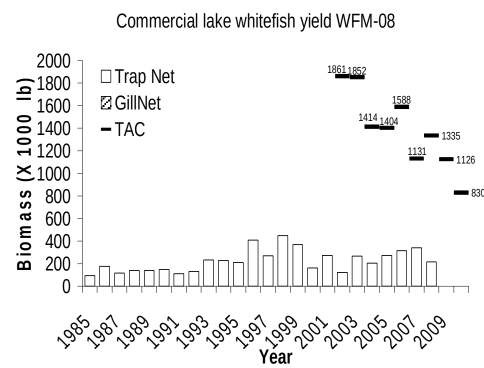
GMGN – Graded mesh gill net survey, CF – Commercial fish surveys

WFM-08 (Muskegon)

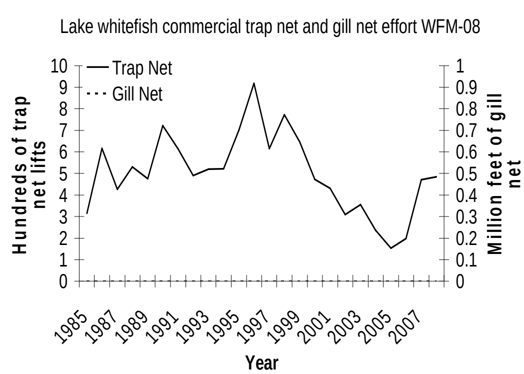
Prepared by Randall M. Claramunt

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.

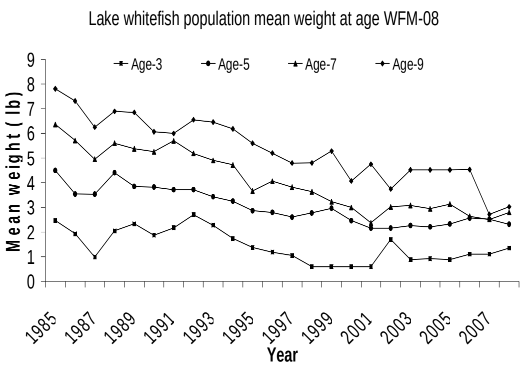
Two state-licensed trap-net fishers operate in WFM-08, where minimum length for whitefish in commercial catches was 19 inches total length (TL) through 1999, then changed to 17 inches TL in 2000. Other management zones have had a 17-inch minimum TL size limit throughout the time series. Through 2005 there has been no gill-net harvest of lake whitefish in WFM-08. One 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). Lake whitefish yield from WFM-08 in 2008 was 217,000 lb. In 2008, yield decreased from 2007 (341,000 lb), and was just below the 1985-2007 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, and 484 in 2008.



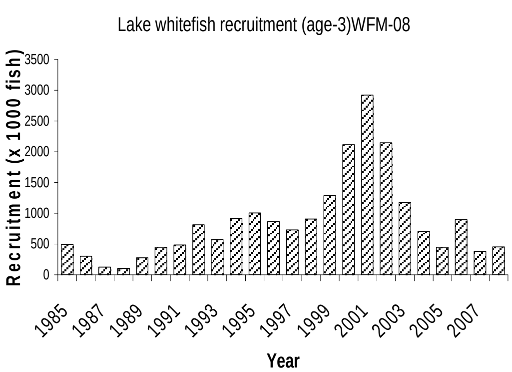
Although trap net effort increased in 2008, the current level of commercial effort is approaching the long-term average for this unit of 501 lifts from 1985-2007.



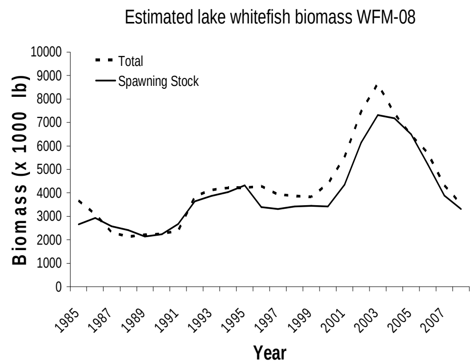
Weight-at-age data have trended downward from 1985 through 2003. After 2003, weight-at-age increased or appeared to have stabilized for most of the age groups, although biological data for the older age groups is limited. Overall, weight-at-age values in 2008 are relatively unchanged from 2007 and approximately 25 % lower than the long-term average for ages 4-9 from 1985 - 2007.



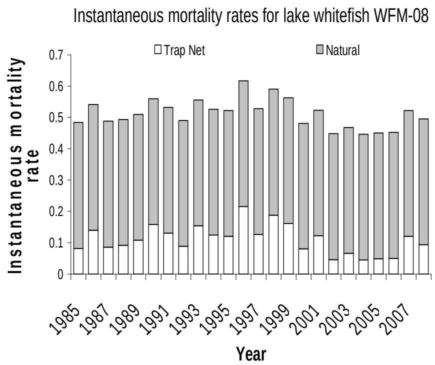
Recruitment, based on the estimated number of age-3 fish, was 450,855 in 2008. Estimates of recruitment were considerably higher during 1999-2003 (averaged 1,927,526 and peaked at 2,918,680), but the estimate for 2008 was slightly lower than the 1985-2007 average of 872,613 age-3 fish.



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 2007 suggests that the stock may be experiencing density-dependent controls as total biomass decreased from 8.6 million lb in 2003 to an estimated 3.5 million lb in 2008. Spawning stock biomass followed a similar decline from 7.3 million lb in 2003 to 3.3 million lb in 2008. The ratio of spawning stock biomass to fishable biomass was close to 1.0 in 2008 (0.94), slightly higher than the 1985-2007 average ratio of 0.93.

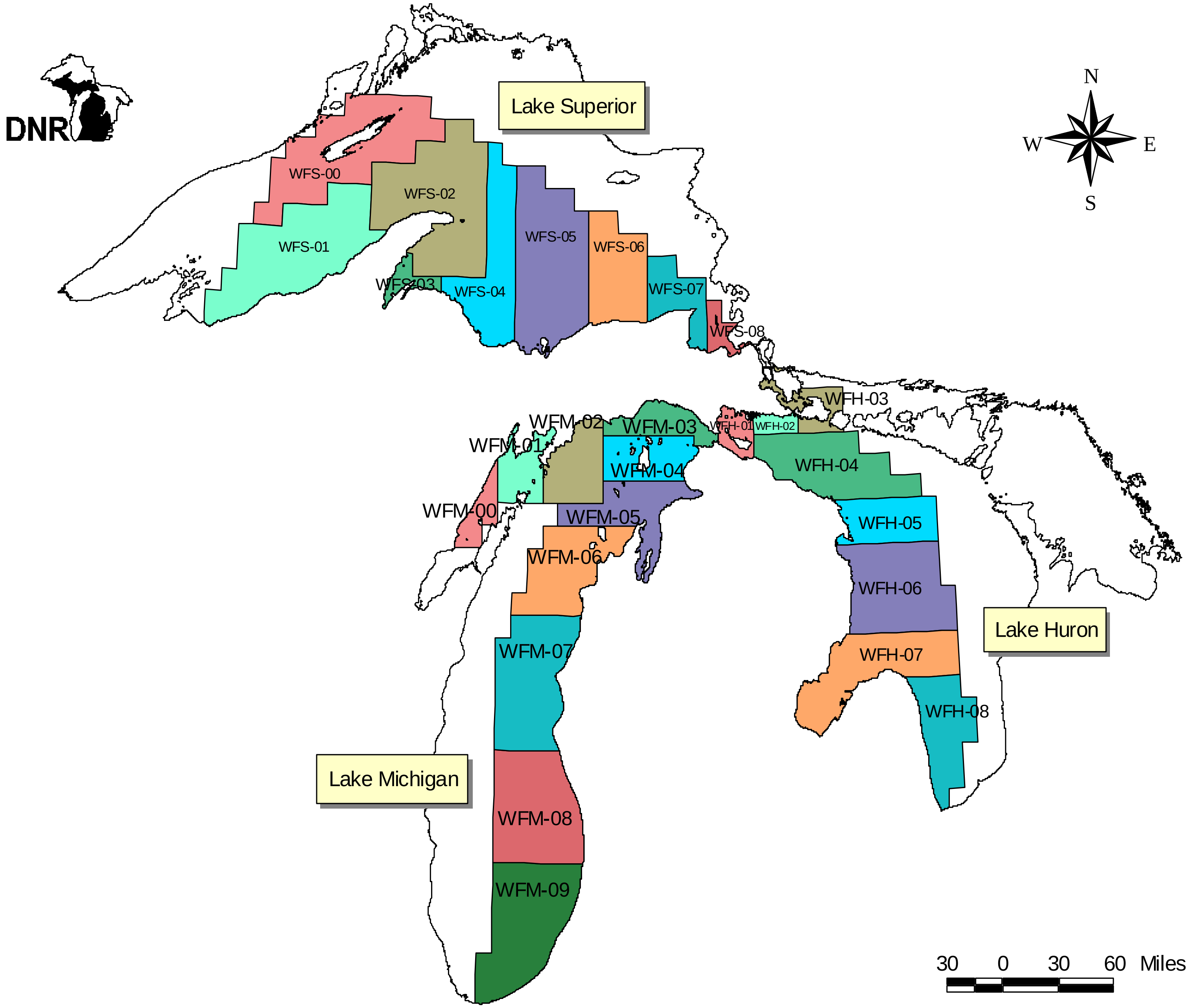


Mortality rates have been relatively stable throughout the time series. Instantaneous total mortality rate (*Z*) was estimated at 0.495 y^{-1} during 2008. Components of the total rate consisted of 0.094 y^{-1} for instantaneous trap-net-fishing mortality (*F*) and 0.401 y^{-1} for instantaneous natural mortality (*M*). Estimates of mortality have been very consistent from 1985-2007 and the ratio of *F* to *Z* averaged 0.274 from 1985 through 2008. 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 2008, the growth parameters were estimated at 55.3 for L∞ and 0.38 for K based on survey and commercial data from the entire time series (1985-2008) to better represent growth conditions for this stock.

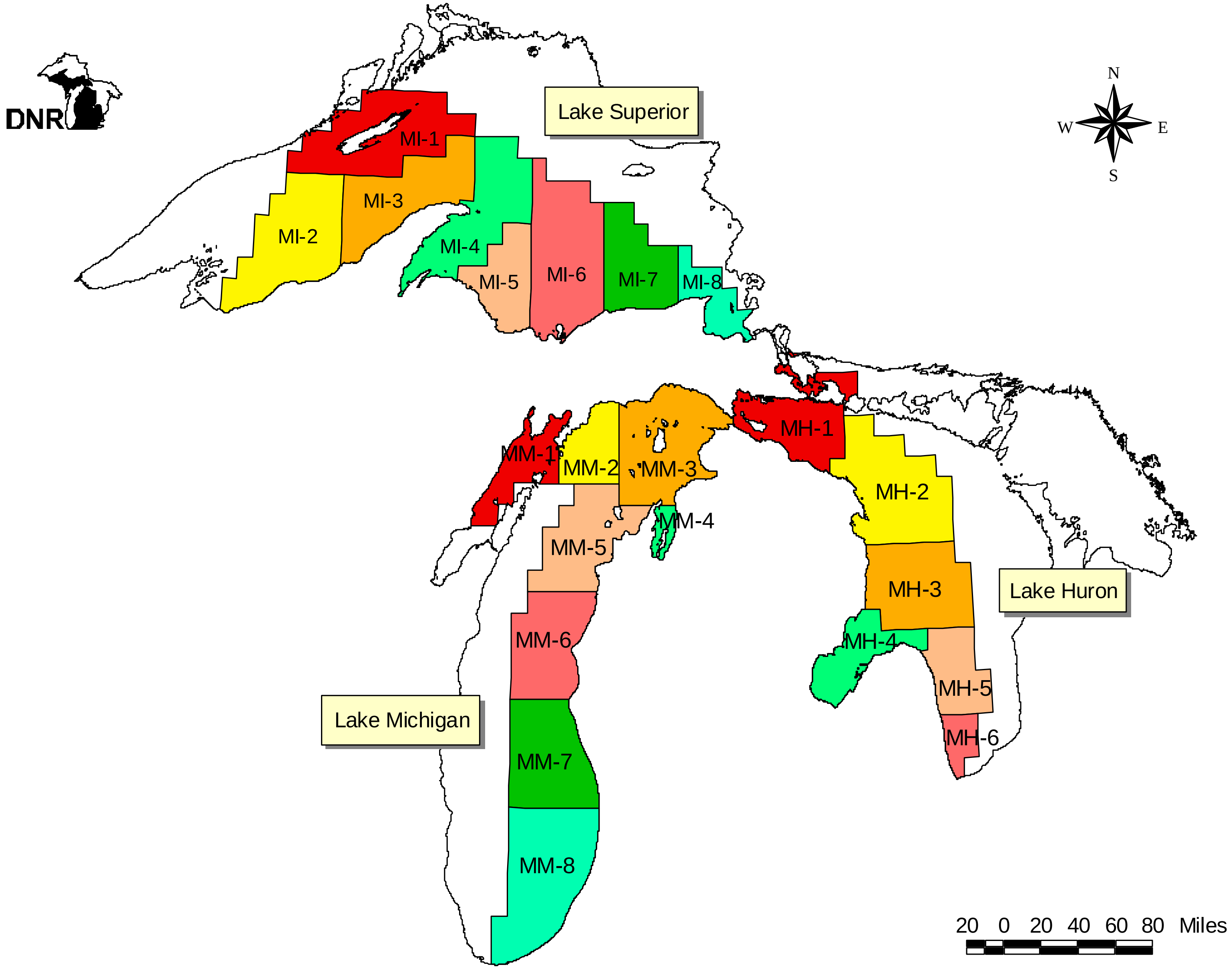


The 2010 yield limit for WFM-08 was 831,000 lb (374,000 lb for state-licensed fishers and 457,000 for tribal fishers), calculated using the projection model.

Summary Status WFM-08 Whitefish	**Value (95% probability interval)**
Female maturity	
Size at first spawning	1.18 lb
Age at first spawning	3 y
Size at 50% maturity	2.25 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.63 lb (1.63 – 1.64)
Current SSBR	1.31 lb (1.25 – 1.31)
SSBR at target mortality	0.39 lb (0.38 – 0.40)
Spawning potential reduction	
At target mortality	0.80 (0.76 – 0.80)
Average yield per recruit	0.23 lb (0.23 – 0.28)
Natural mortality (*M*)	0.402 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 2006-2008, ages 4+	0 y^{-1}
Trap net fishing mortality (*F*)	
Average 2006-2008, ages 4+	0.081 y^{-1} (0.07 – 0.11)
Sea lamprey mortality (ML)	
(average 2006-2008, ages 4+)	N/A
Total mortality (*Z*)	
(average 2006-2008, ages 4+)	0.483 y^{-1} (0.480 – 0.508)
Recruitment (age 3)	
(average 1999-2008)	1,251,000 fish (1,049,030 – 1,254,350)
Biomass (age 3+)	
(average 1999-2008)	5,720,700 lb (4,700,600 – 5,758,460)
Spawning biomass	
(average 1999-2008)	5,074,300 lb (4,140,060 – 5,125,650)
Recommended yield limit in 2010	831,000 lb
Actual yield limit for 2010	831,000 lb



Appendix 1. Lake whitefish management units.



Appendix 2. Lake trout management units.